Natural and Life Sciences teachers' affective development during an indigenous knowledge professional development intervention

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DECLARATION

I the undersigned, hereby declare that the work contained in this dissertation / thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature:

Date: November 2018

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In the middle of difficulty lies opportunity – Albert Einstein.

I thank God for being a pillar of strength through the entire process.

I dedicate this research to my family - my husband Kevin Darrell Jackson, my father Kevin Noel Pretorius, my brother Kevin George Pretorius and especially to my mother Dr Erica Delores Pretorius. Thank you for all the encouragement, patience, support and love you gave me. I would not have been able to pursue these studies if it had not been for your reassurance and inspiration.

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ABSTRACT

South Africa hosts a diverse and rich cultural diversity (resulting in a variety of indigenous knowledge systems), as well as a rich biodiversity. This provides the opportunity for learning and teaching nature of science (NOS) skills and indigenous knowledge as part of the Natural Sciences and Life Sciences curricula. This research looked at teacher professional development and teacher pedagogical content knowledge (PCK) development from a 'warm' lens (Pintrich *et al.*, 1993), highlighting the role of the affective domain in teachers' conceptual change and PCK development for self-directed learning (SDL). The indigenous knowledge professional development intervention, which was the focus of this research, showed teachers the significance of indigenous knowledge and allowed them to see its merit and change their attitudes towards teaching indigenous knowledge and become lifelong learners.

Furthermore, this research also provided views on Natural Sciences and Life Sciences teachers' affective development during and after two indigenous knowledge professional development interventions. The affective domain has been one of the spheres in education which has been neglected, in comparison to the other two domains, namely, the cognitive domain and the psychomotor domain.

Indigenous knowledge is a controversial topic which must be infused into the curriculum as prescribed by the Department of Basic Education. In this research the affordances of indigenous knowledge allow Natural Sciences and Life Sciences teachers to better contextualise CAPS curriculum themes in the classroom. Using Krathwohl's taxonomy for the affective domain, this research exemplified teachers' assumptions, attitudes, values and beliefs in relation to indigenous knowledge. This research also focuses on teachers' experiences of engaging in classroom action research (CAR), and its value in making teachers more reflective practitioners, who also centre-stage the affective domain. The data highlighted the role of the interventions in providing teachers with a more nuanced view of the nature and affordances of indigenous knowledge. Furthermore, another aspect of this research investigated the use of Foldscopes in the Natural Sciences and Life Sciences classrooms, and its affordances in addressing affective outcomes. Professor Manu Prakash, the developer of the Foldscope said, "*It's important to bring open-ended tools for discovery to a broad spectrum of users without dumbing down the tools*". Scientific equipment in the school laboratory is often very expensive, and only available to those who can afford it. 'Frugal science' is a trend in education that researches, develops and introduces economical, quality scientific resources to developing countries. In South Africa, many underprivileged schools lack quality practical resources, such

as microscopes, to perform simple tasks. Furthermore, the lack of laboratory investigations could lead to learners not enjoying Natural Sciences and Life Sciences.

During the indigenous knowledge intervention hosted by the North-West University, teachers were provided with the $1 Foldscopes (paper microscopes) to utilise in their classrooms. This research also provides views of Natural Sciences and Life Sciences learners and teacher experiences of using Foldscopes in the Natural Sciences and Life Sciences classroom during a practical. An aspect investigated in this research was how such problem-based approaches could enhance affective outcomes and provide learners with an appreciation of the role of Science in our daily lives.

This research followed a generic qualitative research design with elements of design-based research, as well as participating teachers engaging in classroom action research (CAR). Data was collected using the views on the nature of indigenous knowledge (VNOIK) questionnaire developed by Cronje (2015), pre- and post-intervention questionnaires with reference to the affective domain, personal teacher interviews, focus group interviews with teachers, observations during the intervention, classroom visits using the Reformed Teaching Observation Protocol (RTOP), artefacts, teacher and learner reflections as well as teacher portfolios.

From an affective stance, this qualitative study used Engeström's (2009) third-generation Cultural-Historical Activity Theory (CHAT) as a research lens, to identify factors that promoted or inhibited affective development in the teaching of indigenous knowledge as well as identifying factors that promoted or inhibited the use of Foldscopes in the Natural Sciences and Life Sciences classroom during a practical.

Indigenous knowledge should be fully integrated into Natural Sciences and Life Sciences education and bring about affective affordances of assisting with the introduction and entrenchment of indigenous knowledge into society. Learning about relevant indigenous knowledge will in turn give value to and create respect for local culture (Fien, 2010). The intervention offered assisted change with regard to the attitudes of teachers towards teaching indigenous knowledge, and thus influenced their teaching methodology. Ultimately, the study's aim was for teachers to become empowered, responsible, self-directed (Knowles, 1975) and excited about incorporating indigenous knowledge into their lessons.

In general, the results indicated that teachers have an increased positive attitude towards indigenous knowledge; and were more excited, motivated and interested in incorporating indigenous knowledge into their teaching and in their classrooms after the interventions.

However, data also indicated that continuous professional development (within communities of practice) is needed for sharing resources and for continued scaffolding of teachers' pedagogical content knowledge (PCK). Some classroom observations demonstrated what Ziechner and Tabachnick (1981) call the 'wash out' effect, namely, where teachers disregard newly acquired knowledge and skills and fall back on previous practices.

KEY WORDS

affective development, affective domain, classroom action research, conceptual change, controversial conceptual change, cultural-historical activity theory, indigenous knowledge, Krathwohl's taxonomy, pedagogical content knowledge, professional development intervention, reflection and reflective practices, self-directed learner, teacher professional development

LIST OF COMMON ABBREVIATIONS USED IN THIS RESEARCH

CAPS	Curriculum and Assessment Policy Statement
CAR	Classroom action research
CCC	Controversial conceptual change
CHAT	Cultural-Historical Activity Theory
CPTD	Continued professional teacher development
COP	Community of practice
DoE	Department of Basic Education
ESDC	Embodied, situated and distributed cognition
ICT	Information and communication technology
IK	Indigenous knowledge
IIK	Indian indigenous knowledge
INSET	In-service training
NOS	Nature of science
NRF	National Research Foundation
PCK	Pedagogical content knowledge
RTOP	Reformed teaching observation protocol
SLP	Short learning programme (the indigenous knowledge intervention)
STEM	Science, technology, engineering and mathematics
STEAM	Science, technology, engineering, arts and mathematics
TMHCC	Teaching model for hot conceptual change
TIMSS	Trends in International Mathematics and Science Study
VNOIK	Views on the nature of indigenous knowledge
$	United States Dollar

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CHAPTER 1: OVERVIEW OF THE STUDY

1.1 Introduction

South Africa is a country of various cultures and abundant biodiversity, which creates an ideal learning environment for Natural Sciences and Life Sciences learners and teachers to engage in contextualised science (De Beer & Mothwa, 2013). In contrast to these opportunities, South African education also has many challenges such as poverty; scarcity of scientists due to the poor state of science education; limited access to quality education; unemployment; and food insecurity, to name a few (De Beer & Mothwa, 2013). According to the World Economic Forum's competitiveness index for 2017–18, South African mathematics and science education ranks 128th out of 137 counties (Schwab, 2018:269). Furthermore, South Africa is graded one of the lowest three countries in the Trends in the Mathematics and Science Study (TIMSS, 2015:48). This represents a major educational crisis in South Africa, as we are not globally competitive.

Yüksel and Sezer (2017) indicate that there are three predominant factors influencing learner performance in TIMSS, namely: (a) the teacher; (b) the curriculum; and (c) resources and textbooks. These factors suggested are also relevant in the South African context. The study by Pretorius (2015:5) indicate that teachers are often not fully prepared for the complex task they are tasked with. It is, therefore, vital to recognise the significance of quality Natural and Life Science teaching and teachers (Schneider & Plasman, 2011). The McKinsey Study (2007) states that no education organisation (such as a school) can rise above the restrictions imposed by the quality of its teachers. The South African Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education, 2011) suggests that, as subjects, Natural Sciences and Life Sciences should not only concentrate on theories and facts, but should also emphasise the nature of science (NOS) (Pretorius, De Beer & Lautenbach, 2014), because the NOS integrates *"the values and assumptions inherent to the development of scientific knowledge"* and *"facilitates the understanding of science subject matter*" (Lederman, 2006:3; Lederman & Zeidler, 1987:3). In addition, the inclusion of indigenous knowledge (IK) can make Natural Sciences and Life Sciences more pertinent and relevant to the everyday lives of learners (Cronje, De Beer & Ankiewicz: 2014). More emphasis, therefore, should be placed on indigenous knowledge in the Natural Sciences and Life Sciences curricula and classroom to stimulate learner curiosity and to create an authentic learning environment in which learners share and learn about various cultures in the classroom (Cronje *et al*., 2014). The contextualisation of science in the curriculum may address learner performance and interest

(Cronje *et al*., 2014), thus making the resources and examples in the textbooks more relevant to the lives of South African learners.

The context of this research, therefore, includes three aspects: teacher professional development; contextualising the curriculum (through indigenous knowledge); and providing relevant teaching-and-learning material for teachers. This research emphasises the affective domain and how a short learning programme (SLP), focusing on indigenous knowledge, assisted teachers in teaching for the affective domain. The rich indigenous knowledge of South Africa can encourage connections between science and culture by, for example, playing indigenous games such as ‘Morabaraba’ to stimulate interest amongst learners (Jautse, Thambe & De Beer, 2016:140). Therefore, incorporating indigenous knowledge into the curriculum might better prepare Natural Sciences and Life Sciences teachers in South Africa for the teaching of indigenous knowledge with scientific content, to stimulate an interest in science amongst learners.

Odora Hoppers (2015:16) emphasises that African institutions need to *“integrate knowledge systems, social and intellectual capital of local communities”.* The emphasis is placed on creating curiosity amongst learners using indigenous knowledge examples while teaching specific concepts. This contextualisation of learning is what Gibbons (2000) calls ‘mode 2’ knowledge production. Such contextualisation approaches might contribute toward learners’ global competitiveness. Thus, a perceptual change is required of teachers in order for them to see the educational value of incorporating indigenous knowledge into the curriculum and developing the skill to do so.

Natural Sciences and Life Sciences are two separate South African subjects in school. Natural Sciences is a combination subject of Physical Sciences and Life Sciences at junior level (Grades 7, 8 and 9). Life Sciences is a subject which leaners choose from Grade 10 to 12. Natural Sciences and Life Sciences have their own Curriculum and Assessment Policy Statements (CAPS). Indigenous knowledge is prescribed as part of the Curriculum and Assessment Policy Statement for Natural Sciences and Life Sciences (CAPS) (Department of Basic Education, 2011). The inclusion of indigenous knowledge in the curriculum and into the classroom, presents many challenges for Natural Sciences and Life Sciences teachers (Cronje *et al.*, 2014). Many teachers lack the relevant content knowledge (Mothwa, 2011; Cronje, 2015) and, therefore, omit the infusion of indigenous knowledge into Natural Sciences and Life Sciences concepts. The challenge is for Natural Sciences and Life Sciences teachers to recognise the indigenous knowledge of the child and to build on leaners' pre-knowledge (De Beer & Mothwa, 2013). Research indicates that Natural Sciences and Life Sciences teachers are not equipped with the pedagogical content knowledge (PCK) to enable them to recognise pre-knowledge and incorporate indigenous knowledge into the classroom, and this creates hurdles for quality teaching of Natural Sciences and Life Sciences content (De Beer & Mothwa, 2013; Cronje, 2015). Thus, there is a need for indigenous knowledge interventions or short learning programmes (SLPs) aimed at creating interest and motivation (the affective domain) among Natural Sciences and Life Sciences teachers in order for them to include indigenous knowledge in their teaching. Such SLPs can elevate stress and confusion with regard to teaching indigenous knowledge concepts and content. This integrated approach can allow teachers to find value in, and appreciation of, (the affective domain) indigenous knowledge.

1.2 Defining key terms

The key concepts of this research are defined below and will be discussed in more detail in the literature review (Chapter 2).

Pedagogical content knowledge (PCK)

Pedagogical content knowledge (PCK) was initially suggested as an important component of teaching expertise, and a knowledge base that teachers should possess, by Lee Shulman (Shulman, 1986). According to Shulman, (1986:9) pedagogical content knowledge (PCK) includes representations of ideas, comparisons, illustrations, examples and presentations in formulating subject matter to make it comprehensible to others (the learners). PCK entails *"the manner in which teachers relate their pedagogical knowledge (what they know about teaching) to their subject matter knowledge (what they know about what they teach)"* (Cochran, DeRuiter & King, 1993:4). This relationship is shown in Figure 1-1.

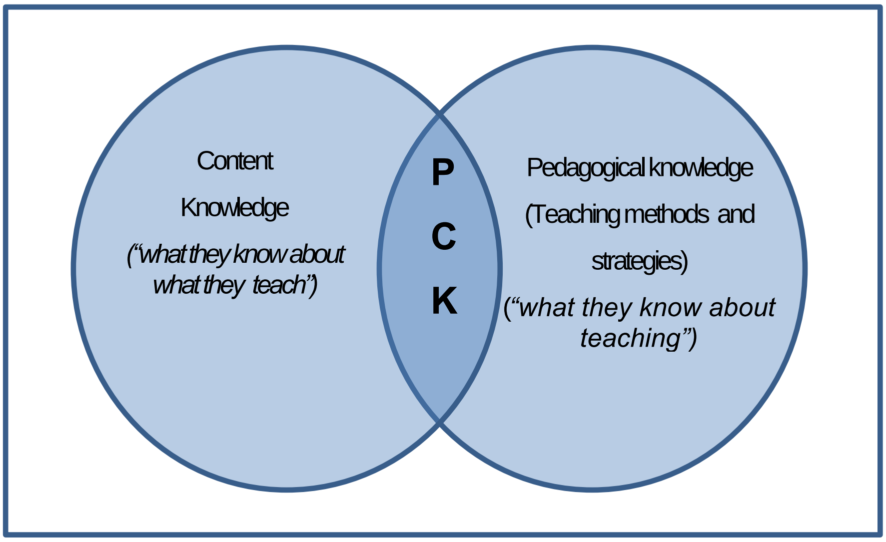

Figure 1-1: Simple representation of pedagogical content knowledge (Pretorius, 2015)

Conceptual change

In this research, focus is placed on another dimension of PCK development – that of the affective domain and affective development. The development of PCK includes teaching for conceptual change. Pintrich, Marx and Boyle (1993) state that we often look at conceptual change through a 'cold' and exclusively cognitive lens. The cold cognitive domain constitutes factual teaching and learning, whereas 'warm' conceptual change focuses on the affective domain, and can shape attitudes and perceptions with regard to indigenous knowledge. Thus, warm conceptual change, as opposed to cold conceptual change, acknowledges that human emotions, worldviews and belief systems influence how conceptual change occurs (De Beer & Henning, 2010). Hynd (2003) refers to 'true' conceptual change, which implies acceptance of the construct of study. Therefore, if teachers do not affectively embrace indigenous knowledge, there cannot be true conceptual change.

Indigenous knowledge (IK) and Science

Indigenous knowledge and science are types of knowledge viewed in different perspectives. Louise Grenier (1998) defines indigenous knowledge as *"the unique, traditional, local knowledge existing with and developed around the specific conditions of women and men indigenous to a particular geographic area".* Similarly, Fien (2010) and Odora Hoppers (2015) suggest that indigenous knowledge is unique to specific cultures within a particular society and environment. This unique knowledge is transferred from one generation to the next, either by repeated traditional rituals or stories told. This knowledge has benefited that society in respect of farming, medicinal practices, education and the conservation of biotic and abiotic factors (biodiversity) (Jackson, De Beer & White, 2016:495). Indigenous knowledge comprises the rules of your own culture, how you were raised and what you have learnt in terms of traditional practices including languages, values, ethos, and health practices.

Science has origins in Ancient Greek and European culture, thus seen as western practices (Cobern & Loving, 2001:53). Science is engagement in understanding nature. However, there is no set definition of science, as it is viewed in many different spheres, e.g. science can stretch from astrometry to evolution. Cobern and Loving (2001:54) suggest that post-modernism influenced the connection between science and culture. Furthermore, there is no specific way of deriving scientific knowledge, thus indigenous knowledge can be considered as scientific knowledge, as it is imbedded in culture.

Teacher professional development and professional development interventions or short learning programmes (SLPs)

Teacher professional development includes various learning activities such as professional development interventions, in-service training (INSET), courses and workshops supporting the process of professional growth. The South African Council for Educators (SACE) requires teachers to continually develop professionally. Teachers are required to register online and collect points for their professional development status. This is stipulated in the SACE vision and mission statements. Its vision statement is "*to promote professionalism amongst all educators in South Africa, by ensuring that its services are easily accessible, continuously empowering through development, ensuring commitment to the profession and adherence to the ethos of education as enshrined in the South African constitution".* Its mission statement is to *"strive to ensure that the education system is enriched, by providing properly registered and professionally developed educators who would display professionalism" (SACE, 2017).*

A professional development intervention is aimed at teachers in order that they may learn new skills or improve skills or pedagogies (Jackson *et al.,* 2016). According to Kennedy (2016), it is an approach to encourage and promote the professional development of teachers. In the case of this research, it refers to a three-day short learning programme that was facilitated by the North-West University (NWU).

Affective domain

The affective domain comprises one of the three domains of human development, together with the cognitive domain and the psychomotor domain. The affective domain refers to the simple awareness of internal organisation which guides teacher behaviour (Birbeck & Andre, 2009) and addresses the "*internalisation of values*" (Lynch, Russell, Evans & Sutterer, 2009:47). The affective domain refers to teacher beliefs, perceptions and attitudes. This includes ethos and the ideals of moral value. Krathwohl (1964) is known for his research within the affective domain.

Krathwohl (1964) developed a continuum for affective development which consists of five categories including *receiving*, *responding*, *valuing*, *organising* and *characterising by a value complex* (Lynch *et al.*, 2009). *Receiving* refers to a state of being aware of, or sensitive towards, a particular phenomenon. *Responding* refers to some commitment toward a phenomenon. V*aluing* is the ability to support or approve the particular phenomenon. *Organising* refers to some internalisation of the phenomenon into a teacher's own philosophy. C*haracterising by a value complex* refers to the phenomenon being fully internalised as a value set (Lynch *et al.*, 2009). Krathwohl's taxonomy focuses on the concept of internalisation, emphasising that values, attitudes and motivation need to be internalised to become part of a person's world view (Krathwohl, 1964).

Affective development

Affective development is perceived as a process of teachers' internal growth (reflection) of personal feelings, opinions, beliefs, motivation, emotions, morals, attitudes and ethics (Martin & Reigeluth, 2013). Affective development is embedded in culture, which creates identity, depicts behaviour and forms memories.

Reflection and reflexive practices incorporate serious thought or consideration for one's own understanding of self and the experiences one encounters. During reflection teachers think methodically about their practice and learn from their experiences (Rodgers, 2002); and during reflexivity they revert to inward reflection, which is an integral part of the lifelong learning process to promote self-directed learning (Knowles, 1975; Ryan, 2015). According to Zembylas (2014:210) *" 'reflective practice' and 'critical reflection' have been deemed as desirable activities of teaching practice, and have become part and parcel of teacher professional development internationally, emphasising the value of teachers' capacity to reflect upon their teaching to improve the quality and effectiveness of their teaching practice".* This indicates that teacher reflection ties in with the affective domain concept and affective development, as greater emphasis is placed on the role of teacher emotions in the reflection practice (Zembylas, 2014), as well as their pedagogical content knowledge (PCK). The stance taken in this research is that affective development is necessary for true conceptual change (Hynd, 2003).

Classroom action research

Gravett and De Beer (2015: 344) explain classroom action research (CAR) as "*more data-based and systematic than reflection, but less formal and controlled than traditional educational research".* During the intervention on the infusion of indigenous knowledge into the Natural Sciences and Life Sciences classroom, teachers were introduced to CAR and how to engage in CAR. This action research focussed on the use of Foldscopes in the classroom, and the affordances of the use of Foldscopes.

There are various steps that should be followed during the CAR cycle. Firstly, teachers are required to identify a problem in the classroom. In this case, the problem the two participating teachers identified was the lack of curiosity and interest amongst learners (Pretorius *et al.*, 2014) during the teaching and learning of the topic of Ecology. Secondly, teachers were required to plan their research. In this case, the teachers planned a water quality project using the Foldscopes.

Ethical considerations were vital. Teachers, being employees at the school, had to obtain consent from learners, parents and the school principal.

Thirdly, the teacher had to take action and collect data. The water quality activity was conducted, and learners completed the practical handout, which was then analysed. The data was transcribed and coded by the researcher to determine the affordances of Foldscopes.

Reflection is an important component of CAR and teachers had to continually reflect during the lesson, as well as during the entire CAR process. These reflections were also used as data in this research. Such reflections can assist teachers to become self-directed learners (SDL) (Knowles, 1975) and agents of change (Van der Heijden *et al.*, 2015).

1.3 The research paradigm

1.3.1 Theoretical framework

The study used social constructivism. The theoretical framework was regarded as a higher level of conceptual organisation. In this research, the focus was on the scaffolding of teachers' learning across the zone of proximal development. The social-constructivist work of Vygotsky (1978) also served as impetus for the use of Cultural-Historical Activity Theory (CHAT). Cultural-Historical Activity Theory was used as a research lens in this research. This lens allowed for analysis of various tensions that could prevent Natural Sciences and Life Sciences teachers from fully comprehending indigenous knowledge. The intermediate theories used (which form the conceptual framework) consist of Krathwohl's taxonomy for the affective domain, and views on the nature of indigenous knowledge as conceptualised by Cronje, De Beer and Ankiewicz (2015). Although, according to Shuford, Howard and Facundo (2006), there are numerous developmental psychologists associated with social development theory, Vygotskyan theory was chosen. Vygotskyan theory describes the role of social interaction within a community to 'make meaning' and thus develop cognition, skill, values and attitudes (Vygotsky, 1978). Language and culture are vital for cognitive and affective development, as well as for how reality (worldview) is understood (Powell & Kalina, 2009). As suggested by Vygotsky (1978), learning is mainly a social phenomenon and is, therefore, constructed through language and culture.

Lev Vygotsky is the promoter of the notion of 'the zone of proximal development' (Vygotsky, 1978). 'Actual development' is the learners' knowledge that they achieve on their own, with no support from an adult. If the learner receives support from a proficient adult (a teacher, parent or guardian) the learner can realise their 'potential development'. Therefore, the zone of proximal development can be explained as the zone between the potential and the actual development. The zone of proximal development can be bridged if valuable intervention occurs (Vygotsky, 1978).

This research focused on the zone of proximal teacher development of Natural Sciences and Life Sciences teachers (Warford, 2011) during a professional development intervention offered by the North-West University in South Africa (Jackson *et al.,* 2016). The zone of proximal teacher development (ZPTD) proposed by Warford (2002) incorporates Vygotskyan theory into Western models of teacher education. The ZPTD is the gap between what teachers can do by themselves and the proximal level they may obtain with the assistance of capable others, such as the Head of Department or the Principal (Warford, 2011).

This research focused on the affordances of affective development of teachers during an intervention. The intervention attempted to bridge the gap between their actual development and their potential development with regard to the development of the teachers' affective domain when teaching indigenous knowledge.

Activity theory was pioneered by constructivist Lev Vygotsky (Vygotsky, 1978). According to Kaptelinin, Kuutti & Bannon, 1995), Leontiev built upon the Vygotskyan-pioneered activity theory, which lead to the development of third-generation Cultural-Historical Activity Theory by Engeström (2000). This research made use of Engeström's Third Generation Activity Theory (CHAT) as a research lens. The CHAT lens was used to identify tensions or contradictions, as illustrated in Figure 1-2. These tensions related to the development of teachers' affective domain in relation to indigenous knowledge in a professional development intervention (activity system 1); and the transfer of this knowledge in the classroom (activity system 2).

This research also sought to identify any affective development amongst Natural Sciences and Life Sciences teachers during the indigenous knowledge intervention (Jackson *et al.,* 2016). Therefore, Krathwohl's taxonomy for the affective domain was used as an intermediate theory (part of the conceptual framework) to ascertain any change in teacher affective development. Additional concepts in the literature were used to make sense of data collected. Concepts such as conceptual change (Pintrich *et al.*, 1993; Hynd, 2003); nature of science (NOS) (Lederman, 1999); embodied, situated and distributed cognition (ESDC) (Hardy-Vallée & Payette, 2008); and self-directed learning (SDL) (Knowles, 1975) form part of the conceptual framework. The data analysed was compared with these concepts, which are discussed in Chapter 2.

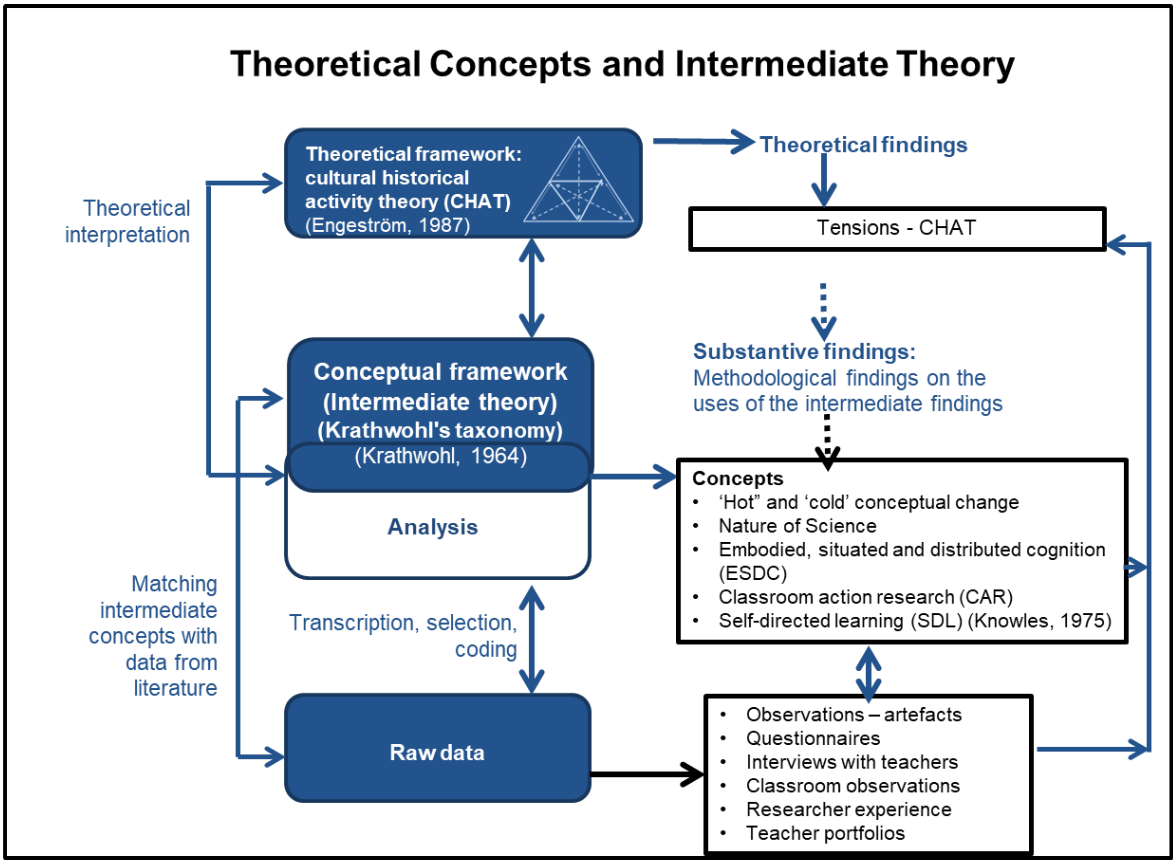

Figure 1-2: Theoretical and conceptual frameworks used in this research (adapted from Pretorius, 2015; Engeström, 2009 & Krathwohl, 1964)

1.3.2 Krathwohl's taxonomy for the affective domain

The affective domain, one of three domains identified by Bloom (1956) and Krathwohl (1964), is described as the values, attitudes, morals, motivation, self-esteem, beliefs and academic self-concept that people hold (Pierre & Oughton, 2007; Buma, 2015). Research refers to the affective domain as the 'gateway to learning' (Pierre & Oughton, 2007:1). Affective learning according to Kearney (1994) is "*an increased internalisation of positive attitudes toward content or subject matter*" (Rovai, Wighting, Baker & Grooms, 2009:8). It is necessary to emphasise teachers' capacity to think critically, as well as reflexively and reflectively (Ryan, 2005). Teachers' emotions, such as their levels of motivation during reflective and reflexive practices, influence their own identities, professional development and teaching practices (Zembylas, 2014).

Krathwohl's taxonomy (1964) of the affective domain (Krathwohl, 1964), was utilised to determine if any affective development occurred during the SLP. This construct determined whether incorporation of indigenous knowledge into a teacher's value system occurred, and whether teacher perceptions had changed positively or negatively toward indigenous knowledge. The affective domain consists of five internalisation levels, namely: receiving, responding, valuing, organising, and characterising by a value set (Birbeck & Andre, 2009).

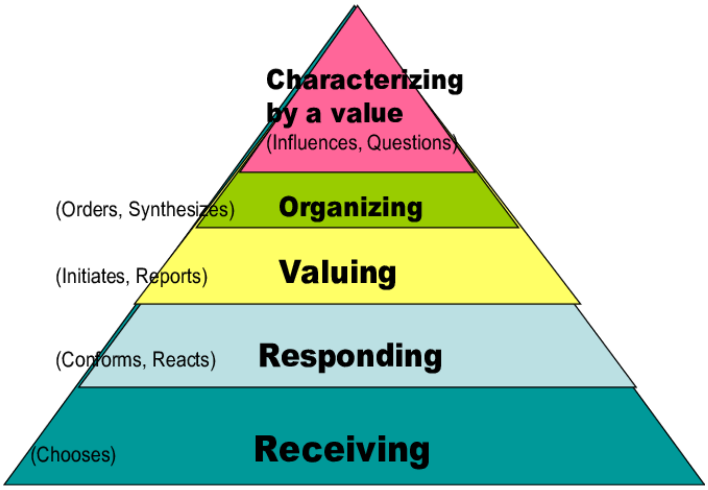

Figure 1-3: Krathwohl's Taxonomy of Affective Learning (Neuman & Friedman, 2010)

1.3.3 Views on the nature of indigenous knowledge

Cronje, De Beer & Ankiewicz (2015) developed the views on the nature of indigenous knowledge (VNOIK) instrument, informed by the framework developed for the nature of science (NOS) by Lederman, Abd-El-Khalick, Bell and Schwartz (2002). This instrument was utilised in this research. The VNOIK instrument is suitable for capturing the views that teachers hold on the nature of indigenous knowledge. This therefore, indicates whether there is 'affective buy-in' from teachers, and whether they are keen to incorporate indigenous knowledge into their Natural Sciences and Life Sciences teaching.

1.4 The gap that this research addresses

This research formed part of a larger NRF (National Research Foundation) funded research project, in which teachers are being trained in infusing indigenous knowledge into the CAPS curriculum. This larger project includes a variety of research-niche area, such as cooperative learning, blended learning, problem-based learning, etc. This research focused specifically on the affective domain. The affective domain has been neglected for many years, and a large and growing body of literature emphasises the importance of the affective domain (Birbeck & Andre, 2009; Buma, 2015; Wormeli, 2015). The research field also stresses the importance of teacher reflections, which forms a vital part of teacher development (Rodgers, 2002); as well as indigenous knowledge, which assists in contextualising various scientific concepts (Odora Hoppers, 2015; Webb, 2016). Yet, there is limited literature on the intrinsic value of affective learning on the affective development of Natural Sciences and Life Sciences teachers (Jackson *et al.,* 2016:496), and their continued professional development (Pretorius, 2015), as related to indigenous knowledge (Cronje, 2015). This gap in the literature is addressed in this research. As a result, this research revealed teachers' affective development in terms of indigenous knowledge, and bridged the gap between their own indigenous knowledge and what they learnt during an intervention; and how some perceptions shifted.

In this research, the focus is on a dimension of PCK development that is often neglected, namely, the affective domain. PCK development entails conceptual change (Pintrich *et al.*, 1993), since teachers need to develop more nuanced understanding of concepts or themes within the curriculum. For a field such as indigenous knowledge, which can be considered controversial, the affective domain should be considered. Zinyeka, Onwu and Braun (2016: 257) said *"authors put forward the proposition that on the one hand there is the inclusive perspective where IK systems are regarded as part of science, and on the other hand there is the exclusive perspective in which IKS and science are treated as separate domains of knowledge"*. The scientific community views science as the physical world only and no reference is made to the supernatural, whereas indigenous knowledge does (Zinyeka *et al.,* 2016). This indicates that indigenous knowledge is seen as a controversial topic among researchers and should not only be viewed in one dimension but rather in interconnecting dimensions (Zinyeka *et al.,* 2016), thus making the affective domain relevant. As previously mentioned, conceptual change cannot be viewed exclusively through a cold cognitive lens (Pintrich, Marx & Boyle, 1993). The same could probably be said of a teacher's PCK development.

1.5 Research considerations

1.5.1 Aim of the study

The aim of the research was to investigate the affordances of an indigenous knowledge professional development intervention for Natural Sciences and Life Sciences teachers' affective development. Through engagement with the tenets of both science and indigenous knowledge, teachers were scaffolded in their learning to facilitate epistemological border-crossing in the classroom. The rationale for such border-crossing is to better contextualise science topics, and so appeal to the affective domain. The short learning programme (SLP) presenters realised that a key element in achieving this was to focus on teachers' reflective practice. For this reason, teachers were introduced to classroom action research (CAR). After the SLP, teachers were asked to conceptualise classroom action research, which could, among other options, include the implementation of Foldscopes. These Foldscopes were one of the resources provided to teachers during the intervention. The focus of the action research and the Foldscopes were aligned with the focus of this research, namely, the realisation of affective outcomes in the Natural Sciences and Life Sciences classroom.

1.5.2 Objectives of the study

The objectives of the research were to explore:

- The Natural Sciences and Life Sciences teachers' values, beliefs, perceptions and attitudes during and after the short learning programme regarding the teaching of indigenous knowledge (i.e. their affective stance);
- The role of the affective development on Natural Sciences and Life Sciences teachers' perceptions of their own pedagogical content knowledge development;
- Why teachers' pedagogical content knowledge and conceptual change cannot be studied only through a cold cognitive lens, but why the focus on the affective domain is so important;
- The affordances of classroom action research (and Foldscope microscopes) on the affective outcomes in the Natural Sciences and Life Sciences classroom;
- Natural Sciences and Life Sciences teachers' engagement in classroom action research (CAR) and their experiences of researching the affective affordances of Foldscopes.

1.5.3 Research questions

The research addressed the following questions:

1.5.3.1 Primary question

What are the affordances of an indigenous knowledge professional development intervention for the affective development of Natural Sciences and Life Sciences teachers?

1.5.3.2 Secondary questions

- How do Natural Sciences and Life Sciences teachers' values, beliefs, perceptions and attitudes change towards the teaching of indigenous knowledge during and after the intervention (i.e. their affective stance)?
- How could the affective development of a Natural Sciences and Life Sciences teacher influence their pedagogical content knowledge (PCK)? (This question further interrogates

the role of the affective domain and conceptual change in the PCK development of the teacher.)

- Why teachers' pedagogical content knowledge and conceptual change not be studied only through a cold cognitive lens, and why is the focus on the affective domain so important?
- What are the affordances of utilising Foldscope microscopes on affective outcomes in the Natural Sciences and Life Sciences classroom?
- What are teachers' experiences of engaging in classroom action research (CAR) on Foldscopes and what are the affective affordances of such CAR?

1.6 Research design and methodology

This research followed a generic qualitative approach with elements of design-based research (DBR) (Lather, 2006). Qualitative research according to Patton (2005) strives for depth of understanding. The interpretive qualitative approach can create an understanding of how specific participants (Natural Sciences and Life Sciences teachers) make sense of a specific phenomenon (indigenous knowledge) (Merriam, 2002). This qualitative inquiry provides an understanding of teacher motivations, attitudes and opinions (affective development) in respect of indigenous knowledge (Jackson *et al.,* 2016).

The design-based research forms part of the larger NRF-funded project. This research consists of three cycles. Cycle 1 involved two indigenous knowledge interventions held at the University of Limpopo and North-West University (Potchefstroom). Cycle 2 consisted of an improved 'version' of the intervention held in Lenasia, Gauteng. Cycle 3 was the most fruitful intervention. Cycle 3 was built on the previous interventions and was held in Calvinia, Northern Cape. The researcher attended two of the interventions to collect qualitative data relating to the affective domain, but still utilised some relevant data from all the interventions hosted by the North-West University.

The data collected was of a qualitative nature, including participant observation during the SLP; personal interviews; reflections; classroom observations (using the RTOP instrument); portfolios; the VNOIK questionnaire; a generic questionnaire on teacher's experience of the SLP; and an affective domain questionnaire, to capture real-life circumstantial perceptions of the Natural Sciences and Life Sciences teachers' world (Henning, Van Rensburg & Smit, 2004; Creswell, 2013). This combination will, through triangulation, lead to a rich description of the phenomenon studied (Merriam, 2002). This research utilised two short, three-day and two-day professional development interventions hosted by the North-West University (NWU) to develop

Natural Sciences and Life Sciences teachers' pedagogical content knowledge (PCK) of indigenous knowledge (Jackson *et al.,* 2016). The interventions offered teachers who were interested in engaging with indigenous knowledge, content and hands-on activities to assist in incorporating indigenous knowledge into their own classrooms. The study specifically drew from Vygotsky's social constructivist ideas (Hodson & Hodson, 1998) and utilised Engeström's (2000) third-generation Cultural-Historical Activity Theory (CHAT) as a research lens to identify any areas of development with regard to the affective development of teachers. This allowed for better insight regarding the attitudes, beliefs and values of Natural Sciences and Life Sciences teachers about indigenous knowledge.

During the teacher intervention, Krathwohl's (2002) taxonomy was used as a set of criteria (levels of internalisation) to streamline the complexity of the thinking and reflection processes (Jackson *et al.,* 2016:499). This taxonomy was used to guide the researcher during the process of developing the affective domain of Natural Sciences and Life Sciences teachers and was expected to stimulate, inspire and motivate teachers in their teaching of indigenous knowledge topics (Lynch *et al.*, 2009; Anon, 2010).

1.6.1 Sampling strategy and participant selection

The sampling in this research will only indicate two interventions, namely, the North-West University intervention and the Lenasia intervention. The data utilised from the other interventions was used to ensure that data saturation was reached, and that the findings were validated.

Teachers who decided to attend the short learning programme (SLP) completed the VNOIK questionnaire before and after the intervention (pre- and post-intervention questionnaires). From the two interventions, five teachers were randomly selected for face-to-face interviews (until data saturation was achieved). Two focus group interviews were conducted. Two willing participant teachers were selected for the school visits after the SLP. Furthermore, two participants volunteered to have their 'classroom action research' (CAR) task observed. The task involved Foldscopes and water quality in the Natural Sciences and Life Sciences classroom. Teachers completed portfolios as part of the SLP requirements and these portfolios were analysed.

A purposeful sampling strategy was utilised during this research (Creswell, 2013) as the study was aimed specifically at Natural Sciences and Life Sciences teachers from high schools in the

North-West and Gauteng Provinces. All the schools around North-West University and the University of Johannesburg were notified of the short learning programme through adverts on Facebook and the Department of Basic Education. Data was collected from four separate interventions, although the researcher only attended the North-West University intervention held from 18 to 20 July 2016. There were 32 Natural Sciences and Life Sciences teachers who attended the intervention.

The second intervention attended by the researcher was held at the Nirvana Secondary School, Lenasia, Gauteng from 2 to 3 July 2017. There were 23 Natural Sciences and Life Sciences teachers who attended this intervention. Teachers were from different ethnic groups and cultural backgrounds and there was also a wide spectrum in terms of teaching experience, from novice to those with more experience (see Table 1-1).

Table 1-1: Table showing a summary of the sampling strategy.

Cycle of DBR	Intervention	Dates	Number of Natural Sciences and Life Sciences teachers (n) attended the course	Researcher attended
1	Limpopo (Polokwane) intervention	27 - 29 June 2016	62	No
	NWU intervention (Potchefstroom)	18 - 20 July 2016	32	Yes
2	Lenasia intervention (Gauteng)	2 - 3 July 2017	23	Yes
3	Calvinia intervention (Northern Cape)	28 - 29 July 2017	95	No

1.6.2 Role of the researcher

As a qualitative researcher, the researcher acted as an 'insider' (emic) (Simon, 2011), who actively engaged in the indigenous knowledge intervention (SLP). The researcher also observed, interviewed and assisted as a facilitator where needed during the SLP. Classroom visits are an important part of the research process, as it is important to see if teachers take what they have learnt from the intervention and incorporate it into their teaching. Therefore, part of the role of the researcher in this research was to investigate the infusion of indigenous knowledge into the classroom from an affective stance.

1.6.3 Methods of data generation or collection

Qualitative data collection instruments consisted of the following:

- Views on the nature of indigenous knowledge (VNOIK) questionnaire, developed by Cronje (Cronje *et al.*, 2015). The VNOIK questionnaire was administered at the commencement of the SLP (pre-intervention questionnaire) and at the end of the SLP (post-intervention questionnaire), to measure teachers' understanding and views on indigenous knowledge. This also elicited teacher attitudes towards indigenous knowledge.
- A short open-ended questionnaire (pre- and post-intervention) on the affective domain was utilised. This questionnaire was administered at the commencement of the SLP (pre-intervention questionnaire) and at the end of the SLP (post-intervention questionnaire), to determine if any affective development or affective learning had taken place.
- A generic questionnaire on how teachers experienced the short learning programme was also utilised.
- Teachers submitted portfolios after the SLP. These portfolios included teacher reflections which were analysed to determine whether affective development had taken place. Teacher portfolios handed in for assessment were marked and teachers were notified whether they had obtained the requirements to pass the course. These portfolios were a vital tool to ascertain if any affective development had occurred.
- Face-to-face interviews (Creswell, 2013) were conducted with five randomly selected teachers from the group. Various questions relating to the affective domain, affective development and affective learning were used. The semi-structured interviews were conducted before, during or after the intervention depending on the intervention schedule. Confidentiality during the interviews was ensured by moving into a quiet area, where no other teachers were present.
- Two focus group interviews (Creswell, 2013) were conducted during the SLP. The aim of the focus group was to gather views and understandings of the affective domain and indigenous knowledge from several people in the group.
- Three classroom observations were conducted with the researcher acting as 'complete observer'. This indicates that the researcher observed without participating (Creswell, 2013). During the classroom observation the Reformed Teaching Observation Protocol (RTOP) instrument was utilised (Piburn & Sawada, 2000; Sawada *et al.*, 2000). The researcher limited classroom visits due to the willingness of the participants as well as own work commitments and available time. Observations were conducted during both interventions (North-West University and Lenasia interventions) with the researcher in the role of

'observer as participant', which means the researcher's role is known (Creswell, 2013). This allowed for information to be gathered or recorded as it occurred.

- Artefacts such as photographs (qualitative audio-visual material), audio recordings, personal documents (portfolios), teacher reflections, and learner reflections as artefacts were collected (Creswell, 2013). Videos were made from the interventions – see zipped files accompanying this research (extra resources) for intervention videos.

1.6.4 Methods of data analysis

Data analysis is an attempt to make sense of text and image data (Creswell, 2013) which will provide answers to the original primary and secondary research questions (Merriam & Tisdell, 2015). Saldaña's (2015) code-to-theory model was an appropriate tool to use as it demonstrated relevant relationships from the data collected. It also allowed the researcher to analyse complex phenomena. Interviews and questionnaires were transcribed and the coding-to-theory approach was used, as suggested by Saldaña (2015). Coding was utilised to identify words or short phrases to create categories, which were then grouped into sub-themes, and finally into themes to obtain a better understanding of the data that was collected.

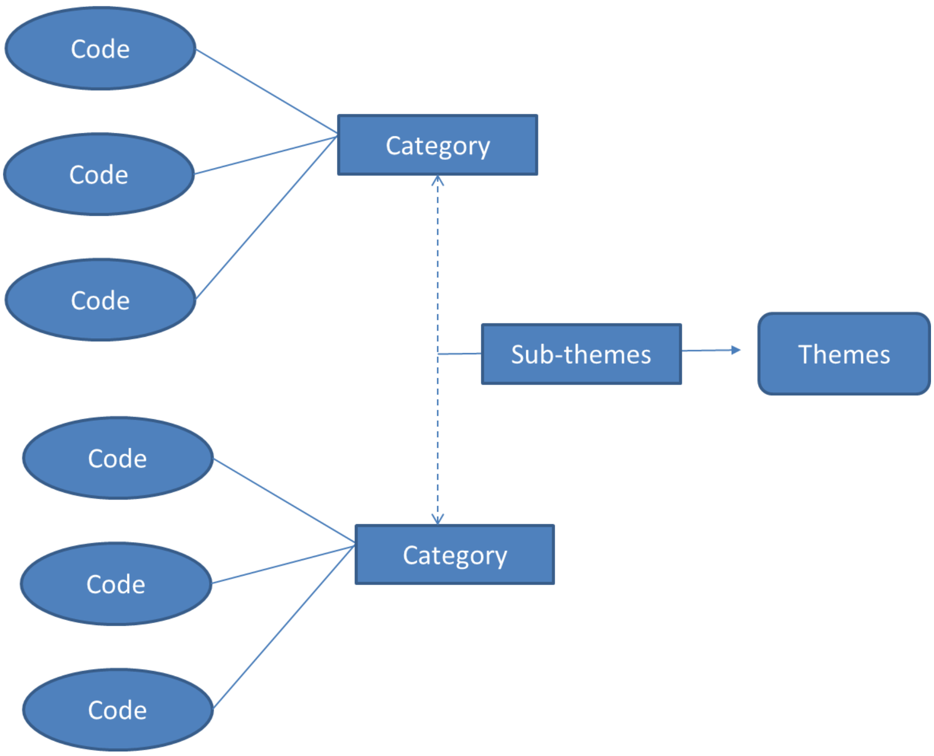

Figure 1-4: Figure illustrating code-to-theory model (Saldaña, 2013:12).

The VNOIK questionnaires were analysed using the method described by Cronje *et al.* (2015). A rubric (see Appendix S) was used to code teachers' responses to the questions according to an informed view, a partially informed view, or an uninformed view (Cronje *et al.*, 2015:329). Each participant was allocated a weighting for their responses, namely, 0 for an uninformed view, 1 for a partially informed view, and 2 for an informed view. To obtain the predominant category for each teacher, an average was calculated and rounded off (Cronje *et al.*, 2015) (refer to Table 1-2).

Table 1-2: Example of the table to code teacher responses to the VNOIK questions (Cronje *et al*., 2015: 329).

Participant	Qu 1	Qu 2	Qu 3	Qu 4	Qu 5	Qu 6	Qu 7	Qu 8	Qu 9	Qu 10	Score

Note: Qu = Question; N/A = not answered; UI = uninformed view (0); PI = partially informed view (1); I = informed view (2)

Artefacts, such as photographs, were used as authentic evidence from the interventions and indicated various activities in which the teachers participated during the SLP. Observations were also noted. See the attached CD for the photographs and videos taken. The portfolios were assessed, and data was collected.

1.7 Reliability, validity and trustworthiness of data

Validity and reliability are significant aspects to consider while conducting qualitative research. Internal validity denotes to the accurate presentation of the research results: the results should be presented in the same context as the study (Niewenhuis & Maree, 2007). The variety of data collection methods such as questionnaires, observations and interviews did, in essence, ensure validity as data triangulation was used (Huberman & Miles, 2002; Meijer & Hartell, 2009; Creswell, 2013). Data collected was linked and compared to the different data collection methods, and to literature, using data triangulation (Denzin & Lincoln, 2008; Abowitz & Toole, 2010). The different types of data, such as teacher reflections and data from questionnaires, were compared to existing literature to support the validity and trustworthiness of this research (Golafshani, 2003), and to avoid bias. Construct validity was ensured by asking a panel of experts to peruse the affective questionnaire, the generic questionnaire, and the interview protocol (Jackson *et al.,* 2016:501).

The trustworthiness of qualitative data can be guaranteed through credibility, transferability, dependability, and confirmability (Babbie & Moutin, 2002). Trustworthiness should ensure that the results obtained are credible by their adherence to the literature and to the context of the study.

1.8 Ethical considerations

According to Creswell (2013), ethical issues should be considered throughout the study, not only during the data collection stage. In essence, research involves collecting data from people (Punch & Oancea, 2014) and, thus, research participants (Natural Sciences, and Natural Sciences and Life Sciences teachers) should not feel intimidated, but should feel safe (Creswell, 2013). Ethical clearance for this research was obtained from the Ethics Committee at the North-West University (NWU). Generic ethical clearance for the larger project was obtained (certificate reference: NWU-00271-16-A2) and individual ethical clearance (certificate reference: NWU-00357-18-A2 (see appendix T) was obtained as there was a customised interview protocol and affective questionnaire. Permission was obtained from the North-West Province Department of Basic Education, the participating teachers, and the school principal. Ethical considerations and principles required by the university were followed. Participants were asked to give informed consent (see Appendix B), with regard this research (the affective domain and affective development). Confidentiality agreement forms were completed by all the respondents (Natural Sciences and Life Sciences teachers) involved in the research study (part of a generic confidential agreement covered by the project). These forms ensured confidentiality of the respondents. The researcher used pseudonyms when referring to the participants in the data analysis. Participation was voluntary, and they could withdraw at any stage during the study. The teachers could choose if they wanted to complete the VNOIK questionnaire, the affective questionnaire, the personal teacher interviews, the focus group interviews, or the classroom visits. The participants who declined to participate were not penalised in any way. Confidentiality was important, especially during the interviews and the questionnaire analysis. The research participants will have access to the final the research study. The potential benefits of this research are improved teacher PCK, a more comprehensive understanding of indigenous knowledge, and affective and professional growth and development.

1.9 Chapter outlines

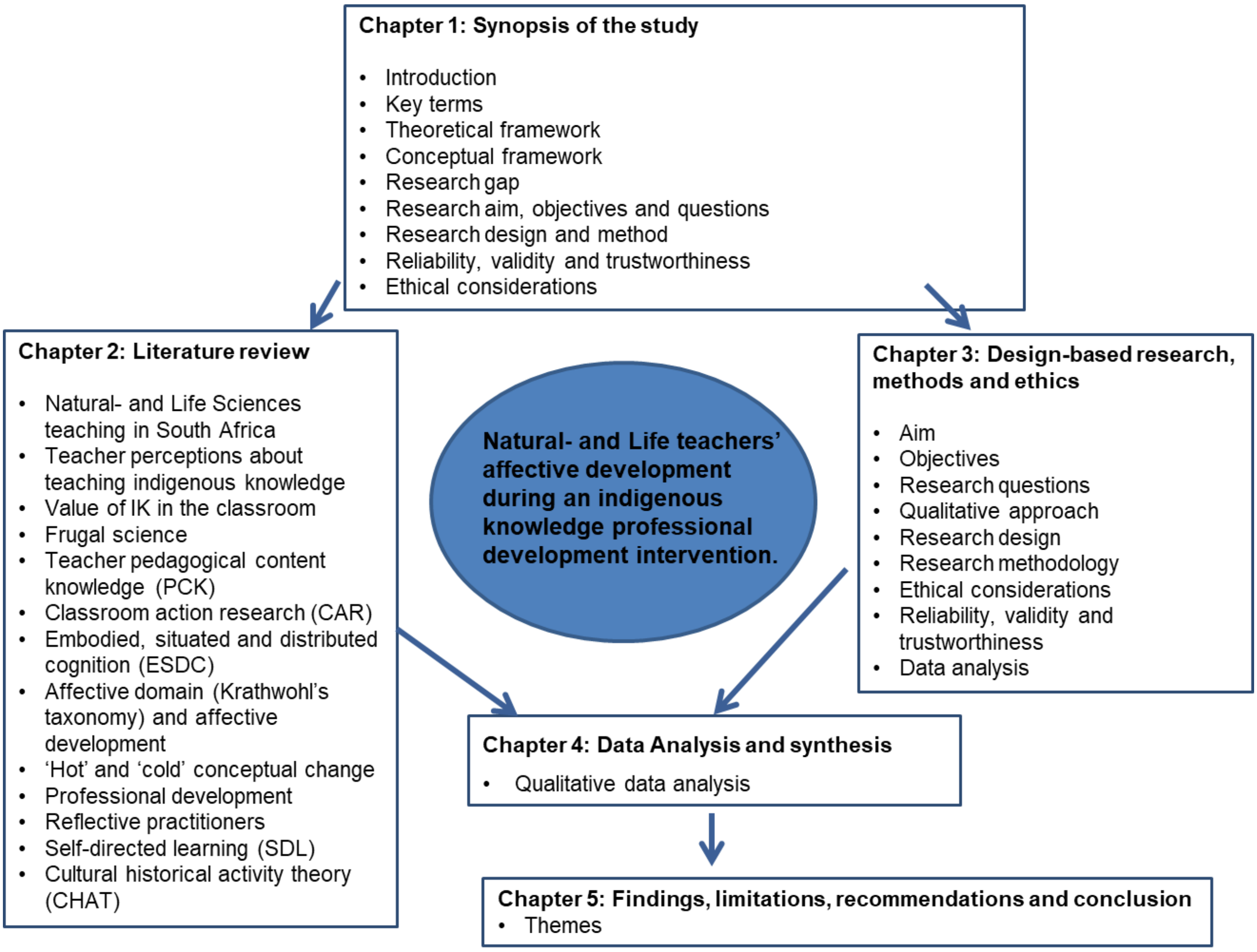

Figure 1-5: Overview of the chapters in this research.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews the literature that underpins this inquiry into Natural Sciences and Life Sciences teachers' affective development during an indigenous knowledge professional development intervention.

2.1 Introduction

The literature review provides a theoretical foundation aimed at addressing the primary research question, secondary questions, aim, and objectives to provide a better understanding of teacher perceptions with regard to indigenous knowledge, and teacher affective development during and after a professional development indigenous knowledge intervention.

South African teachers have a lot to consider, including teaching 21st century skills (such as Foundational Knowledge, Meta Knowledge and Humanistic Knowledge) (Kereluik, Mishra, Fahnoe & Terry, 2013), following the curriculum, managing teaching time, and administrative duties. South African teachers also teach multicultural learners from various backgrounds. All told, this is a great deal of responsibility to carry. Various controversial topics in Natural Sciences and Life Sciences content can create uncertainty amongst teachers, and one of these topics is indigenous knowledge (De Beer & Mothwa, 2013).

Teachers and learners hold diverse views on the various indigenous knowledge perspectives, and some indigenous knowledge practices may even be considered to be 'witchcraft' (Keane, 2015). Teachers need to change such negative perceptions and develop a more nuanced understanding of indigenous knowledge as it is prescribed in the CAPS curriculum for Natural Sciences and Life Sciences (Department of Basic Education, 2011). Indigenous knowledge must be valued and taught to recognise South African history (Department of Basic Education, 2011: 5). This research is part of a broader NRF-funded project, which focuses on the affordances of a short learning programme on indigenous knowledge for teachers' cognitive development (developing more nuanced understandings of the tenets of indigenous knowledge); psychomotor development (developing skills to teach IK in scientific rigorous ways, e.g. acquiring laboratory skills such as the Kirby-Bauer technique); and the affective domain (developing positive attitudes and values). The latter is the focus of this research.

Teachers can change their perceptions and attitudes (affective domain) towards indigenous knowledge by understanding its value and learning more about it through an intervention

(Jackson *et al.,* 2016:501). If teachers show positive attitudes towards indigenous knowledge, and value it, they might be more willing to promote it in their classrooms. The outcome of this indigenous knowledge intervention (the short learning programme or SLP) strives to develop the affective domain of Natural Sciences and Life Sciences teachers so that they might be more motivated to use indigenous knowledge in their classrooms, and various teaching pedagogies to infuse indigenous knowledge and stimulate curiosity amongst their learners. The focus of this research was to research how teachers experience this SLP and how the SLP assisted in their affective development.

South Africa is a culturally diverse country, with numerous ethnic groups and thus a variety of indigenous knowledge systems; and eleven official languages (Hattingh, 2013). Consequently, South Africa is known as the 'Rainbow Nation' (Hattingh, 2013) and this creates difficulties for teachers teaching multicultural learners (Meier & Hartell, 2009). According to Meier and Hartell (2009), many teachers still lack the skills and knowledge to manage and teach diverse learners, as the teachers themselves do not have a good understanding of the learners' cultural backgrounds, values and indigenous knowledge. The indigenous knowledge background of learners might not be embedded in a teacher's pedagogical content knowledge or in their intrinsic value systems (affective domain).

Some researchers advocate for the inclusion of indigenous knowledge in the classroom from an embodied, situated and distributed cognition (ESDC) (Hardy-Vallée & Payette, 2008; De Beer, 2016; Reddy, De Beer & Petersen, 2016). ESDC refers to a paradigm of learning where cognition is deeply embedded within a person's mind, while also depending on interactions from artefacts around them, as well as social interactions (Hardy-Vallée & Payette, 2008). However, many teachers do not have these insights imbedded in their PCK, and this often results in teachers being less sensitive to cultural traditions other than their own culturally engrained mental models. They find it difficult to accept a view different to their existing mental models (Gentner & Stevens, 2014).

As an example, a traditional healer in South Africa, commonly known as a herbalist or *Sangoma* (Jackson *et al.,* 2016:494), may be seen from a western point of view as practising 'witchcraft' (Keane, 2015). Moreover, teachers do not necessarily see indigenous knowledge as a scientific discipline (Keane, 2015). Additionally, Webb (2016) specified that Natural Sciences and Life Sciences teachers have hesitations with regard to teaching indigenous knowledge in their classrooms. In this research it is noteworthy that the affective domain needs to be addressed, as teachers are not comfortable with using concepts of indigenous knowledge in their teaching pedagogies due to misconceptions as noted from the authors above. It is vital that teachers are made aware of the nature of indigenous knowledge through the interventions offered through this research and their skewed perceptions are addressed.

Based on the discourse above, the theoretical framework that underpins the larger NRF project is social constructivism. The focus is on scaffolding teachers' learning across the zone of proximal teacher development, Warford's (2011) adaptation of the well-known Vygotskian (1978) concept of the zone of proximal development. The various constructs that form the conceptual framework of the study are: teacher pedagogical content knowledge (PCK), a construct of Shulman (1986); embodied, situated and distributed cognition (ESDC) (Hardy-Vallée and Payette, 2008); the tenets of nature of indigenous knowledge (Cronje, De Beer and Ankiewicz, 2015); self-directed learning (Knowles, 1975); and the affective domain (Krathwohl, 1964). Third generation Cultural-Historical Activity Theory (CHAT) was used as a research lens to analyse the data. Figure 2-1 below is a tool to explain the theoretical aspects in this research. It provides a visual guideline of the intermediate constructs and filters in context of the theoretical framework.

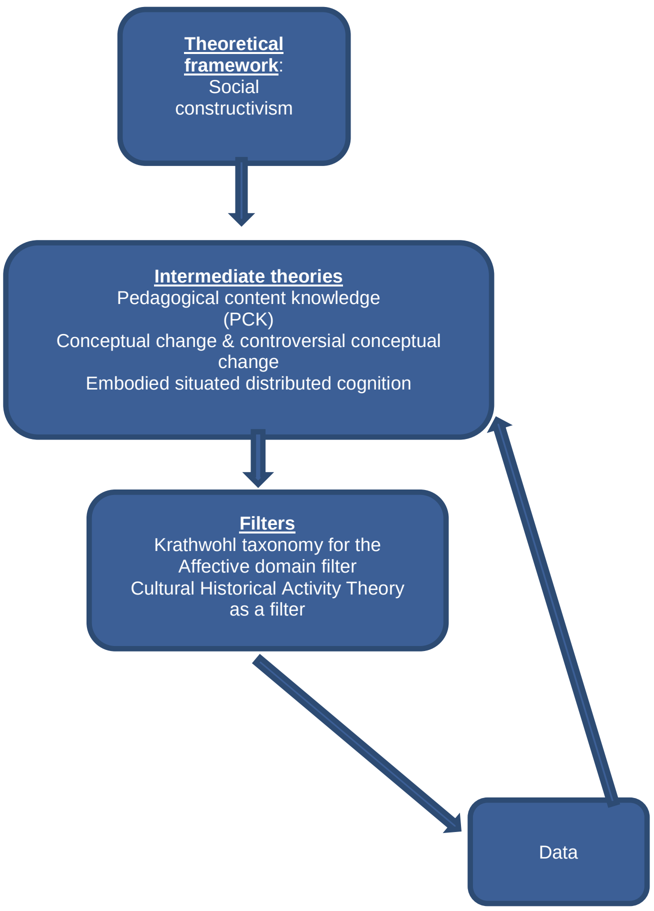

Figure 2-1: Tool to allocate intermediate constructs and filters in context of the theoretical framework.

This research should also be seen against the background of the student protest movement that started in 2015 at tertiary institutions, with learners demanding more relevant, 'decolonised and Africanised' curricula, this may radiate and influence basic education. 'Decolonisation and Africanisation' was used as different concepts in this research. The term 'decolonisation' denotes the change of 'colonial governance' whereby a country accomplishes independence (Le Grange, 2019:3), this is applicable to worldwide settings. South African education has a legacy of inequality and limited access to quality education and these issues have not been addressed currently (post-apartheid) (De Beer & Petersen, 2016), thus a drive to create a sense of autonomy in the South African curriculum by incorporating indigenous knowledge systems. Incorporating African traditions, such as African medicinal plants into the curriculum, leads to an 'Africanised' curriculum. This movement may therefore have an impact on basic education in a positive manner to contextualise learning within the South African sphere.

In 2008 Keane explored the notion of 'relevant science' focusing on the importance of indigenous knowledge integration into the science curricula, as well as the ROSE project (Relevance of Science Education). This author stresses that science be part of human venture, traditions and history (Cronje, 2015). In a similar vein, Gibbons (2000) speaks of context-sensitive science, which he calls 'Mode 2' knowledge production. Although it is argued that learners might view science as more relevant when it is better contextualised (Gibbons, 2000), and despite the fact that the inclusion of indigenous knowledge is one way of better contextualising science, not all researchers are in agreement. Hattingh (2013) questions which indigenous knowledge should be included in the South African classroom and curricula, given the multiple ethnic groups found in this country.

The concern, however, is that the South African Curriculum and Assessment Policy Statement (CAPS) for Natural Sciences and Life Sciences stresses the importance of including a variety of African indigenous knowledge in the classroom (Jackson *et al.,* 2016:495), without stipulating a specific ethnic group (Department of Basic Education, 2011). The CAPS for Natural Sciences and Life Sciences (Department of Basic Education, 2011:5) states that *"valuing indigenous knowledge systems: acknowledging the rich history and heritage of this country as important contributors to nurture the values contained in the constitution",* should receive attention. Having said this, the CAPS provides very little guidance on how teachers should do this.

The CAPS stresses that indigenous knowledge such as medicinal plant use and food preservation (agriculture), and many more, are at risk of becoming extinct due to changes brought about by a progressive society (Department of Basic Education, 2011). Experts such as botanists, biologists, pharmacists and archaeologists are documenting this knowledge to be preserved for future generations (Department of Basic Education, 2011). Therefore, the assumption is that a combination of different types of ethnic indigenous knowledge should be selected for inclusion in daily teaching pedagogies of scientific (Natural Sciences and Life Sciences) content (Jackson *et al.,* 2016).

Indigenous knowledge is considered as an important national resource and can promote conservation, biodiversity (Warren, 1996) and a sense of unity within the South African diverse cultural setting (Jackson *et al.,* 2016:495). Learners, as well as teachers, should understand this notion of preserving indigenous knowledge, and show consideration for the relationship between science, Western society, cultural traditions, technology and the environment

(Ogunniyi, 2002); and understand the value thereof, hence culturally inclusive science (Mudaly & Ismail, 2013).
Nonetheless, the Department of Basic Education requires Natural Sciences and Life Sciences teachers to incorporate indigenous knowledge into the classroom (Department of Basic Education, 2011), but does not provide teachers with sufficient content knowledge and skills, nor the values of indigenous knowledge, to include in their teaching (Jackson *et al.,* 2016). Teachers educated in Western education systems lack sensitivity towards indigenous knowledge systems (Shizha, 2008) and have a poor understanding of the nature of indigenous knowledge, as there was little emphasis on these phenomena in their education.

Research and the model used by Cronje, De Beer and Ankiewicz (2015) has shown that some teachers have limited understanding of the nature of indigenous knowledge. Professional development programmes and resources, such as textbooks offered by the Department of Basic Education, do not include knowledge, skills and attitudes that can aid teachers in gaining a better view of indigenous knowledge and the nature of science; and the epistemological and ontological similarities and differences between these constructs (Cronje, 2015). Therefore, it is crucial for teachers to develop their PCK in order to understand and teach indigenous knowledge, creating a more nuanced view of the nature and affordances of indigenous knowledge (Jackson *et al.,* 2016). Teachers should be able to facilitate the border-crossing between Western science and indigenous knowledge in the classroom (De Beer, 2016). Teachers' understanding of the NOS and indigenous knowledge can assist learners in acquiring and valuing scientific and indigenous knowledge and skills, allowing them to solve problems practically inside and outside the classroom (Ogunniyi, 2002) and even creating future entrepreneurs (Brits; De Beer & Mabotja, 2016).

The recent development in information communication technologies (ICT) tends to limit learning opportunities for learners to engage with their elders on indigenous knowledge (Buckingham, 2013), but if ICTs are used properly they may improve opportunities for engagement. Learners are more stimulated by multimedia devices and have lost interest in social family gatherings which include story telling. Consequently, the Natural Sciences and Life Sciences classrooms need to be designed to provide opportunities for teachers to incorporate indigenous knowledge before the knowledge is lost (Gibbons, 2000). Teachers can employ smart pedagogies with the use of information communication technologies (ICTs) to incorporate indigenous knowledge, such as a plant identification App[1]. Subsequently, teachers need to be well equipped with knowledge and understanding of indigenous knowledge to ensure the transmission of this valuable resource before it vanishes (Jackson *et al.,* 2016:496).

Consequently, Natural Sciences and Life Sciences teachers need to design and contextualise learning activities to provide appropriate learning opportunities for learners. Teachers need to incorporate indigenous knowledge into the curricula before the knowledge is lost (Gibbons, 2000). According to Gibbons (2000:159), mode 1 knowledge production refers to *"problems set and solved in a context governed by the, largely academic, interests of a specific community".* In contrast, mode 2 knowledge production is more *"socially accountable and reflexive than mode 1".* Mode 2 knowledge production (context-sensitive science) as suggested by Gibbons (2000), incorporates society into science learning. This could create motivation and interest amongst the learners, rather than mode 1 knowledge which only concentrates on the cognitive domain (Gibbons, 2000). If teachers learn, value, internalise, and make indigenous knowledge (Krathwohl, 2002) relevant for themselves it could inspire them to integrate these concepts into the real-life context of learners (Ogunniyi, 2002). The CAPS document emphasises this notion in Aim 3 where learners *"relate to understanding the applications of Natural Sciences and Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and science"* (Department of Basic Education, 2011:13).

2.2 Indigenous knowledge (IK) and Western knowledge

According to De Beer and Whitlock (2009:210), *"IK is the total of the knowledge and skills which people in a particular area possess, and which enable them to get the most out of their natural environment".* Furthermore, indigenous knowledge comprises the values and wisdom (Jacobs, 2015) of knowledgeable elders who have received and shared traditional knowledge over generations. South Africa is considered a natural hotspot in terms of biodiversity, abundant traditional customs and vulnerable indigenous knowledge systems. Indigenous knowledge is specific to a society and is very broad, as every culture has its own particular indigenous knowledge identity. For example, the Afrikaner community has its own indigenous knowledge known as *boererata*, the Indian culture has a healing practice called *Ayurveda* (Reddy *et al.*, 2016) and many medicinal plants are used by herbalists or *Sangomas* in the African culture (De Beer & Whitlock, 2009; De Beer & Van Wyk, 2011). These particular indigenous practices are

[1] An application, especially as downloaded by a user to a mobile device (Dictionary, 2017).

important to society and have been practiced for years and taught over generations. It is vital to preserve rich indigenous knowledge for forthcoming generations.

However, during the apartheid era this African indigenous knowledge was devalued (Mudaly & Ismail, 2013), leaning instead towards Western influences and Western science as set by the 'hegemonic norm' (Western model) (Letsekha, Wiebersiek-Pienaar & Meyiwa, 2013:2). Western knowledge systems according to Odora Hoppers (2015:2) are also known as 'cosmopolitan knowledge'. Western knowledge is described as Western culture or Western civilisation practices (Europeans and their descendants) (Hammersmith, 2009). This Western knowledge encompasses particular social norms, technological aspects and ethical values within a Western sphere, which can influence indigenous knowledge practices of various traditional cultures (Hammersmith, 2009).

The South African science curricula have undergone many changes since 1994 (Reddy *et al.*, 2016). These changes were aimed at inclusive education, culturally inclusive science (Mudaly & Ismail, 2013) and *Ubuntu*, creating a united vision of African morals (Odora Hoppers, 2015).

The aim of including indigenous knowledge in the Natural Sciences and Life Sciences curricula is to create social identity amongst learners (De Beer & Whitlock, 2009). Nevertheless, these changes, which include indigenous knowledge in the current curriculum, are still not being implemented properly, according to Odora Hoppers (2015:17), and this is known as 'knowledge apartheid'. Research shows that this is due to a lack of skills and resources, which leads to issues, worries, and a lack of interest amongst Natural Sciences and Life Sciences teachers regarding how to implement indigenous knowledge in their teaching practices (De Beer & Mothwa, 2013; Mudaly & Ismail, 2013; Cronje, 2015; De Beer, 2016).

Teachers need to realise that there is a relationship between indigenous knowledge systems and Western knowledge systems. Indigenous knowledge shares tenets, such as its empirical base, with Western science. Many pharmaceutical companies have recognised the medical properties of various medicinal plant species (De Beer & Whitlock, 2009). One example of this is the 'cancer bush', *Sutherlandia frutescens,* which could serve as an appropriate exemplar in the Natural Sciences and Life Sciences classroom. This medicinal plant has various properties that combat symptoms of influenza and sexually transmitted diseases, and improve immunity (Van Wyk *et al.*, 1997; Van Wyk & Gericke, 2018). Western research (testing in a laboratory using the so-called 'scientific method') shows that this plant has properties that can combat retroviruses and is used to treat HIV/AIDS patients today (De Beer & Whitlock, 2009). If teachers are aware of such examples of medicinal plants, they can incorporate these indigenous knowledge examples into Natural Sciences and Life Sciences topics such as microorganisms in Grade 11 (Viruses, Bacteria and Protista). This could promote learner curiosity and interest, as well as a shift in negative perceptions of indigenous knowledge.

2.2.1 Teacher perceptions on teaching indigenous knowledge

Teaching is an exceptionally complex profession within a dynamic environment. Shulman (2004:504) describes classroom teaching as "*perhaps the most complex, most challenging, and most demanding and frightening activity our species has ever invented*". No pre-service programme or education programme can prepare teachers fully for the demands that they will face in their future careers. With the 'decolonisation of the curricula' debate, comes a new challenge, requiring of teachers to be able to facilitate a new border-crossing in the classroom.

Teachers are guided by the curricula and are required to teach various forms of African indigenous knowledge (Department of Basic Education, 2011:17). Many Natural Sciences and Life Sciences teachers do not support the inclusion of African indigenous knowledge into the Natural Sciences and Life Sciences curricula, as they find it difficult to incorporate it into their lessons (Cronje, 2015). Many teachers leave out certain 'hot' topics such as evolution (De Beer & Henning, 2010) and concepts surrounding African indigenous knowledge. The Department of Basic Education expects a lot from teachers and many teachers do not have the time nor do they have the motivation, confidence, or subject knowledge to implement indigenous knowledge systems (IKS) in the classroom (Mudaly & Ismail, 2013). Teachers have specific work schedules (pacesetter), lesson plans, and assessment schedules, that make it very restrictive and time consuming for Natural Sciences and Life Sciences teachers (Department of Basic Education, 2011). This may be due to the fact that these teachers do not have the necessary support in terms of indigenous knowledge resources such as books and pedagogies from the Department of Basic Education (De Beer & Mothwa, 2013; Cronje, 2015), and they do not have the know-how to explain indigenous knowledge examples in their teaching or where to use the examples in the content. Therefore, there is a need for continuing professional teacher development (Cronje, 2015; Pretorius, 2015), specifically with regard to the inclusion of indigenous knowledge in the classroom and shifting teacher perceptions and stereotypes about indigenous knowledge.

Firstly, some Natural Sciences and Life Sciences teachers already find it problematic to follow investigative methods such as the scientific method (De Beer & Mothwa, 2013) as prescribed in Specific Aim 2 in the CAPS curricula: *"relate to doing sciences or practical work and investigations"* (Department of Basic Education, 2011:13). This aim includes investigative questioning, hypothesising, utilising an experimental method, collecting and analysing information, and deriving conclusions. The Department of Basic Education's expectation of Natural Sciences and Life Sciences teachers to include indigenous knowledge in their investigations creates *"a feeling of lack of control over own practices"* (De Beer & Mothwa, 2013: 461).

Secondly, teachers struggle to understand the tenets of both the nature of science (Abd-El-Khalick, Bell & Lederman, 1998), and the nature of indigenous knowledge (Cronje, De Beer and Ankiewicz, 2015). Research shows that if teachers do not have a good understanding of the tenets of the nature of indigenous knowledge and science, this lack of understanding may form a barrier that prevents teachers from using pedagogies that reflect the true nature of science (Cronje *et al.*, 2015). Nature of science as defined by De Beer and Mothwa (2013:455) *"is the way of knowing and the characteristics of scientific knowledge which are intrinsic or internal ideas guiding all scientific investigations".* Therefore, it is crucial that teachers understand the nature of science and the nature of indigenous knowledge.

Teachers need to realise that the nature of science (NOS) (Abd-El-Khalick *et al.*, 1998; Schwartz *et al.*, 2004) and the nature of indigenous knowledge (NOIK) go hand in hand (Cronje *et al.*, 2014). In an era where there is a call for more contextualised science, epistemological border-crossing between the NOS and the NOIK is becoming important in science education (Cronje, 2015:15). Therefore, Natural Sciences and Life Sciences teachers require a sound understanding of the importance of the tenets of the NOS and the NOIK (Dekkers & Mnisi, 2003; Cronje, 2015). Table 2-1 below gives a comparison between the NOS and the NOIK and how some of the tenets overlap; as well as the epistemological and ontological differences. Teachers who recognise that NOIK has a place in the Natural Sciences and Life Sciences classroom will be more confident and motivated to incorporate both the NOS and NOIK in their pedagogy.

Table 2-1: Table showing the tenets of NOS and NOIK (adapted from Lederman, 1999:917 & Cronje, 2015:42)

Tenet	Nature of science (NOS)	Nature of indigenous knowledge (NOIK)	
1	Scientific facts can be altered over time by critique and technological changes, hence they are *tentative.*	*Resilient* yet *tentative,* IK is constantly changing due to knowledgeable elders' experiences and storytelling.	Ontology (What is?)
2	NOS is *empirical* knowledge resulting from the natural world through observations and experiments.	NOIK is *empirical* and *metaphysical.* Herbalists follow the scientific method through observations and experiments.	
3	NOS is *inferential hence* deductions made from experimental procedures and observations.	NOIK is *inferential*. Conclusions and interpretations made from investigational procedures and observations.	
4	NOS is *socially* and *culturally* entrenched. Science is a human venture, whereas scientific theories and laws are evaluated by others.	*Socially* and *culturally* entrenched, IK encompasses traditions followed by a specific culture, spread through social gatherings.	
5	NOS is *subjective* (theory based). Scientists try to be objective but are human and will remain subjective due to prior knowledge and beliefs.	NOIK is *subjective.* Knowledgeable elders are inspired by prior knowledge, beliefs and spiritual influences.	
6	Approached in a reductionist manner.	Approached in a holistic manner and includes a strong metaphysical character.	
7	Scientific knowledge is based on facts, theories and laws from observation of nature expressed through textbooks.	The way of knowing knowledge through shared cultural tradition by observation of nature, expressed through song, dance, rituals.	Epistemology (ways of knowing nature)

8	Drive by step-by-step scientific method. Many methods are used through experimental designs to test and solve problems. Typically, experiments are conducted in a laboratory with scientific equipment.	Practical engagement in everyday life in nature. Methods used are trial and error and constantly repeated and tested.	Methodology (method or wisdom in action)
9	NOS involves human interpretation, invention and imagination; hence NOS is *creative*.	NOIK involves human understanding, myths and imagination; hence NOIK is *creative*.	Volition (values and beliefs)

As a multicultural country, there are many different African cultures within the African community, as well as Indian, Afrikaans and Chinese South African communities. Each has its own indigenous knowledge perspectives, but lacks knowledge of the other cultures (De Beer & Mothwa, 2013). This can create a clash between their indigenous knowledge and the various African indigenous knowledge perspectives prescribed by the Department of Basic Education.

Some teachers with many years of teaching experience find it extremely difficult to teach indigenous knowledge systems as it is seen as 'taboo' (De Beer & Mothwa, 2013), due to perceptions that indigenous knowledge includes practices such as making contact with the ancestors. As can be seen in the Table 2-1 indigenous knowledge includes metaphysical aspects which fall outside the domain of science.

The Suppression of Witchcraft Act, under the Apartheid government states that *"under the Suppression of Witchcraft Act, indigenous belief systems were, in most cases referred to as pagan (heathen) belief systems and viewed as something that derails the society" (*De Beer & Mothwa, 2013: 454). This view has created animosity towards indigenous knowledge as a whole and teachers may see it as 'witchcraft'[2] (Keane, 2015). This makes teachers insensitive to the topic. Many Western societies think that indigenous knowledge, including herbalists[3] or *sangomas*[4] of African societies, are based on the supernatural and associated negative entities

[2] Witchcraft is the practice of magic, especially black magic; the use of spells.
[3] Herbalist is a dealer in medicinal herbs.
[4] Sangoma is a traditional healer in South Africa (Dictionary, 2017).

such as vicious and violent creatures, e.g., the '*tokoloshe' (Horsthemke, 2008)*. Western societies steer away from the supernatural.

The South African classroom not only houses a variety of cultures, but learners and teachers hold their own worldview and religious beliefs (Le Grange, 2007), such as Christians, Muslims, Hindus, Jews, and the beliefs of the ZCC (Zion Christian Church). Religion may also prevent teachers from incorporating indigenous knowledge into the classroom and learners may be reluctant to be receptive to indigenous knowledge examples. One such religious objection is that many Christians find the contact with ancestors in African medicine offensive (De Beer & Mothwa, 2013). Religious belief systems of teachers may hold stereotypes, as they may equate cultural practices with ancestral communication (De Beer & Mothwa, 2013). According to Le Grange (2007:581), *"it is crucial that teachers working in these contexts (especially Western teachers) be aware of this interaction and understands the way it could complicate the learning process".* This may add even more pressure on teachers, as they have their own religious beliefs and also need to be sensitive to the religious beliefs of their learners (Meier & Hartell, 2009).

This conflict highlights the affective domain, as teachers need to affectively embrace and show affective commitment to indigenous knowledge, which will be transferred to the learners. However, it also asks for a nuanced understanding of the shared tenets of indigenous knowledge and Western science, and to focus on shared commonalities in the classroom, rather than on the differences. If teachers are motivated and excited to incorporate indigenous knowledge and not change learners' religious beliefs, then learning can take place.

Natural Sciences and Life Sciences teachers may also view indigenous knowledge practices as 'pseudo-science' (De Beer & van Wyk, 2012), as it has not been scientifically tested and is not grounded on fact and theories. As an example, Westerners will generally be more comfortable with a qualified medical doctor to cure various ailments, rather than a traditional herbalist who may have years of experience with medicinal plants, but has no degree. Western knowledge explanations are based upon hypothesis, theories and laws, while indigenous knowledge explanations are often based on examples, anecdotes and parables told over generations. This could be seen as unscientific.

According to De Beer and Mothwa (2013), many teachers have negative perceptions toward indigenous knowledge, thus creating a lack of understanding of various cultures represented in the classroom, as well as a lack of collaboration amongst fellow colleagues. Therefore, it is vital to tap into teachers' affective domain and allow them to truly value and embrace indigenous knowledge systems, affectively embracing indigenous cultures. This knowledge could change these negative connotations held by the teachers.

2.2.2 South African educational challenges

As mentioned in Chapter 1, South African mathematics and science education is ranked 128 out of 137 countries, according to the World Economic Forum's competitive index for 2017 to 2018 (Schwab, 2018). One of the reasons for South Africa's dismal performance, is the marginalisation of the affective domain (De Beer, 2016). One of the educational issues that teachers in the Natural Sciences and Life Sciences classroom face is that some learners do not enjoy, engage with, or academically prosper in Natural Sciences and Life Sciences as a subject (Hidi & Harackiewicz, 2000). Hidi and Harackiewicz (2000:151) identified two factors which influence learner academic performance and interest in the classroom, namely, 'lack of ability' and 'lack of effort'. These factors halt affective learning in the classroom. Learners might find these topics in Natural Sciences and Life Sciences too difficult, or learners might find the teacher or topic too boring (Pretorius, De Beer & Lautenbach, 2014). Many teachers still use content-based, conventional transmission-mode teaching methods such as chalk and talk (Riga *et al.*, 2017) which do not favour 'out of the box thinking' and autonomous learning (Farahani, 2014). Teachers should become more aware of modern approaches that prepare learners for 21^{st} century thinking and skills. The 21^{st} century learning skills includes foundational knowledge (to know), meta knowledge (to act) and humanistic knowledge (to value) (Kereluik *et al.*, 2013).

Inquiry-based methods (using heuristic methods) are not new to the teaching of Natural Sciences and Life Sciences (Riga *et al.*, 2017). Heuristic methods allow teachers and learners to have a sense of discovery and enhance their own sense of learning (becoming self-directed learners). This concept is also commonly known as the 'Armstrong method' (Riga *et al*., 2017: 247). Scientific methods cannot be taught using transmission-mode teaching, but require hands-on practical methods and self-discovery. Many teachers neglect using practical-based teaching or problem-based learning (PBL) as well as cooperative strategies (Jacobs, De Beer & Petersen, 2016) as teachers feel that they may be taken out of their comfort zones. Teachers also do not have the relevant pedagogical content knowledge (Mothwa, 2011) to implement cooperative learning strategies to contextualise learning. Furthermore, some teachers do not have a sound understanding of the nature of science (Ogunniyi, 2002). Teachers may also avoid problem-based learning as they are not confident or comfortable in conducting hands-on practical sessions with learners (De Beer & Petersen, 2016). Many studies have been done to indicate that teachers avoid problem-based learning and cooperative learning due to a full curriculum and time constraints (Cronje, 2015; De Beer, 2017).

Another issue in South African education is the lack of quality resources including practical equipment in the Natural Sciences and Life Sciences classroom (Cronje, 2015; Jacobs, 2015; Pretorius, 2015), thus the need for quality 'shoestring approaches' (De Beer & Petersen, 2016) and 'frugal science' (Ahuja, 2014). Teacher agency requires constructive thought processing and improvising various approaches to reach the aims of the content in the Natural Sciences and Life Sciences curricula.

2.2.3 Value of incorporating IK in the classroom

It is vital that teachers understand the importance of including indigenous knowledge into their teaching pedagogies. Indigenous knowledge can create a mindfulness and sensitivity to different cultures and viewpoints in South Africa (Cronje, 2015), thus creating an emotionalised learning experience. According to Cronje (2015:18) *"indigenous knowledge contains valid and valuable knowledge to address problems of sustainable development and the environment".*

According to Warren (1996:2) *"…the active role that rural communities in Africa and other parts of the world have played in (a) generating knowledge based on a sophisticated understanding of their environment, (b) devising mechanisms to conserve and sustain their natural resources, and (c) establishing community-based organisations that serve as forums for identifying problems and dealing with them through local-level experimentation, innovation, and exchange of information with other societies".* When teachers incorporate indigenous knowledge examples, it may allow learners to respond positively to diversity (respect nature), admire cultural values (Schafer *et al.*, 2004), and address global issues such as the conservation of biodiversity within their own cultural community (Warren, 1996).

The community plays a major role in a learner's life. The value indigenous knowledge brings to the classroom is priceless. The quote above by Warren (1996) stands testament to the fact that indigenous knowledge can assist learners to love, understand and care for nature. Learners can bring their own indigenous knowledge from their community into the classroom, and this knowledge exchange can be continuous and create social identity amongst the learners.

Teachers who attended the indigenous knowledge intervention received a variety of learning resources to use for indigenous knowledge infusion into their teaching practices. These resources included books, namely, *Medicinal Plants of the World* written by Ben-Erik van Wyk and Michael Wink, and *People's Plants* (a guide to useful plants of Southern Africa) written by Ben-Erik van Wyk and Nigel Gericke; as well as HIV simulation kits, a variety of worksheets and the Foldscopes. (The cost of the Foldscopes was $1 per scope. These were imported by the North-West University from America, with thanks to Fuchs Foundation funding). Teachers will be able to utilise all these resources to improve their teaching practices.

Teachers who express affective commitment can be creative in designing learning materials within an indigenous knowledge context. Teachers can develop innovative ethno-botanical projects (De Beer & Van Wyk, 2011) within the prescribed Natural Sciences and Life Sciences curricula content, for example, a hands-on learning experience which expects a learner to find a medicinal plant, grow the plant and perhaps even test its efficacy (by using a simplified Kirby Bauer technique[5]). This learning experience could hold affordances for cognitive, psychomotor and affective learning in the Natural Sciences and Life Sciences classroom. This can create entrepreneurial attitudes and skills amongst learners. For instance, *Lippia javanica* (the 'fever tree') is a plant that has been used for decades in the Giyani district as an insect repellent (Mothwa, 2011; De Beer, 2016), and such a plant could be used in candles, which repel insects when burnt. There may also be an opportunity for other subjects, such as Business Studies, to be involved in the project, creating cross-curricular opportunities.

Learners can also prepare, identify and create a herbarium voucher specimen for the classroom (De Beer & Van Wyk, 2011). Authentic experiences, such as a visit to the Botanical Gardens, can enhance learner curiosity as learners engage with a variety of medicinal plants in their geographical environment; or a visit to the *Muti* Market[6] in their region to get a 'feel' for the variety of medicinal plant available. Some plant samples may even be taken back to the classroom where anti-microbial testing of plant extract can be done in the school laboratory. In this experiment, medicinal plant extracts are placed on bacterial agar plates. If there is a clear zone around the plant extract then the plant may have anti-microbial properties (De Beer & Whitlock, 2009). This investigative technique may validate indigenous knowledge claims (Cronje, 2015) and could boost learner interest in plant studies.

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[5] Kirby Bauer technique is a microbiological procedure where extracts can be tested for their anti-microbial properties. This technique forms part of the SLP for teachers.

[6] *Muti* Market is where traditional African medicine is sold to the public.

These learning opportunities can be infused with cooperative learning techniques (Johnson & Johnson, 1987). Collaborative learning techniques are grounded in social constructivism (learning within a social context) and stems from the African indigenous knowledge practice of doing, which branches from the idea of 'humanness' known as *Ubuntu* (Cronje, 2015). Collaborative learning such as the De Bono's Hat's (De Beer & Whitlock, 2009) allows learners to express their own knowledge and views. Edward de Bono is the mastermind behind the six De Bono's Thinking Hat's and he believes this method allows learners to unbundle thinking which allows separation of different modes of thinking. This may improve communication and decision making skills (De Bono, 2017). There are six coloured hats including white, red, black, yellow, green and blue. Each represents a way of thinking about a specific topic. The white hat represents factual thinking; the red represents emotions; the black represents critical thinking (negatives); the yellow represents positive, optimistic thinking; the green represents creative aspects where learners explore various possibilities (i.e. lateral thinking) and the blue allows for an overview of the topic considering all the other hats and finding possible solutions to dilemmas (i.e. holistic thinking) (De Bono, 2017). This cooperative technique allows for difficult topics such as indigenous knowledge to be tackled from various perspectives. It allows learners and Natural Sciences and Life Sciences teachers to express facets of indigenous knowledge without risk, which can create multiple perspectives allowing learners to become critical thinkers and validate indigenous knowledge ideologies. This can create a contextualised learning opportunity.

There is value in incorporating indigenous knowledge aspects in the Natural Sciences and Life Sciences classroom. According to De Beer and Mothwa's findings (2013), some teachers do see the importance and relevance of indigenous knowledge in the Natural Sciences and Life Sciences classroom. However, some teachers doubt whether IK should be included in the curricula. Across this spectrum, teachers do not have the necessary knowledge and skills to teach indigenous knowledge. Therefore, it is vital to inform teachers about IK content and provide interventions to allow teachers to become self-directed learners, and to infuse indigenous knowledge aspects into the Natural Sciences and Life Sciences curricula. Self-directed learning and its relevance to this research is discussed in 2.11.

2.2.4 Frugal science - Foldscopes

Many South African schools do not have the privilege of quality school resources (Mampane & Bouwer, 2011) including laboratory equipment for practical work in the Natural Sciences and Life Sciences classroom. ‘Frugal science’ is a concept in education which introduces cheap, accessible scientific educational tools within developing countries (Ahuja, 2014). The Foldscope (Figure 2-2) is a cheap optical paper microscope which was designed and developed by Professor Manu Prakash and his students at the Stanford University School of Medicine (Ahuja, 2014). The paper Foldscope can magnify up to 2000X, which is more than the normal light (compound) microscope (400X); this allows for greater detail when viewing unicellular organisms. It is also portable and can be used for fieldwork anywhere in nature, without needing electricity. It can be an affordable and useful tool in the Natural Sciences and Life Sciences teaching, especially in schools which do not have the available resources to conduct practical sessions. The Foldscope can provide learners, who do not have access to light (compound) microscopes, with practical skills as well as the opportunity to view the unicellular world (Cybulski *et al.*, 2014). Following the instructions to assemble the paper Foldscope, it can easily be assembled by folding various cardboard parts including a lens (2000X). Teachers can design hands-on activities (classroom action research) using the Foldscope as part of the infusion of indigenous knowledge into the Natural Sciences and Life Sciences curricula.

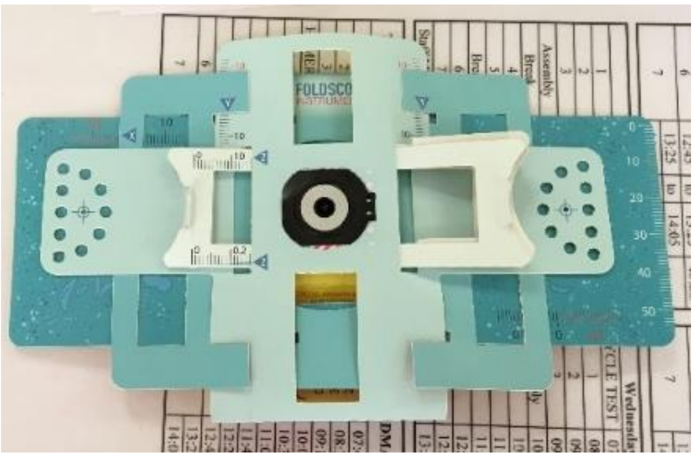


Figure 2-2: Completed Foldscope assembled by one of the learners

2.3 Teacher pedagogical content knowledge (PCK)

Pedagogical Content Knowledge (PCK) stems from the constructivist view point of teaching and learning (Cochran, 1997). Teaching requires a special mixture of both content knowledge and pedagogical knowledge. Shulman (1986) identified that some teachers do not have the know-how to transfer knowledge and skills; therefore the term pedagogical content knowledge (PCK) was introduced. According to Shulman (1987:8) pedagogical content knowledge (PCK) is the "*blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners and presented for instruction*".

Content knowledge is the knowledge of subject matter that is studied by the teachers (cognitive domain) (Mishra & Koehler, 2006), i.e., Natural Sciences and Life Sciences facts and theories. There are two types of knowledge, namely, substantive and syntactic (Van Rooyen & De Beer, 2006). Substantive knowledge comprises scientific theories, concepts and principles; and syntactic knowledge is the 'set of rules' (Shulman, 1986) or the nature of science (NOS) (Cronje, 2015) or how a particular discipline emerged. Therefore, substantive knowledge refers to the 'product' of science and its syntactical nature to the 'processes' of science. Both these constructs underpin PCK.

Pedagogical knowledge is the knowledge about teaching practices and the purpose, aim and value of education (Mishra & Koehler, 2006). This includes lesson plans, classroom management or discipline and personal teacher reflection. According to Mishra & Koehler (2006:1027) *"a teacher with deep pedagogical knowledge, understands how learners construct knowledge, acquire skills, and develop habits of mind and positive depositions toward learning".*

PCK is how the combination of subject matter (content knowledge) and teaching practices (pedagogical knowledge) is represented within aspects of Natural Sciences and Life Sciences subject matter (Mishra & Koehler, 2006). Furthermore, there are three aspects to PCK: specific knowledge of the *content*, the *pedagogy* to follow and the specific *context* in which the content is represented (Grossman, 1990; De Beer & Van Wyk, 2012). PCK is how Natural Sciences and Life Sciences teachers teach by demonstrating and expressing content, thus representing it in different ways to make it comprehensible for others to understand (Shulman, 1986). PCK also includes the understanding of what makes a specific topic easy or difficult to others (Carney & Indrisano, 2013). PCK may also include knowledge of the presumptions and misunderstandings that learners express about a particular topic (Shulman, 1986). In essence, it is about the teachers' levels of expertise in their content knowledge, their teaching practices, and how they teach a specific topic.

Many studies have concluded that teachers do not have sufficient PCK. According to Mothwa (2011) teachers show an absence of indigenous knowledge in all three PCK domains:

1. Teachers have a shortage of content knowledge with regard to indigenous knowledge subject matter;
2. Teachers do not have pedagogical knowledge to demonstrate practical approaches (experiments) when incorporating indigenous knowledge in the classroom; and
3. Teachers have limited contextual knowledge of different South African cultural groups.

Cochran (1997) recommends guidelines for teachers who lack PCK. Firstly, teachers should become reflective practitioners, as an awareness of their own knowledge, skills and teaching strategies will allow them to think critically and to set goals for themselves as self-directed learners (see 2.11). Secondly, teachers should investigate how learners think about specific concepts in the Natural Sciences and Life Sciences curricula and ask questions such as *how* and *what* they understand. Thirdly, discussions could be initiated among teachers about teaching practices, and they could exchange various strategies within a variety of subjects. Lastly, teachers should take part in professional development programmes to enhance their PCK in various aspects of their subject.

2.4 Classroom action research (CAR)

Classroom action research (CAR) is a process whereby teachers research and conduct lessons which work best in their class and in their particular circumstances (Gravett & De Beer, 2015). Classroom action research was one of the outcomes of an indigenous knowledge intervention held by the North-West University, where teachers were taught about CAR and how to improve teaching, and especially learning, within the Natural Sciences and Life Sciences classroom.

Various steps (see Figure 2-3) were required to be followed during the classroom action-research (CAR) cycle:

1. Teachers were to identify a problem in the classroom. In this case, the problem is lack of curiosity and interest amongst learners in some topics in Natural Sciences and Life Sciences, such as botany or ecology (Pretorius *et. al*, 2014); lack of practical resources

in South African schools (Cronje, 2015; Jacobs, 2015; Pretorius, 2015); and trying to inculcate a sense of consideration for the environment (i.e. water quality). Despite this, teachers need to think of alternative ways to teach the content and to create curiosity at minimal cost.

2. Teachers were required to plan their research. It is essential for teachers to write a literature review (including a theoretical and conceptual framework), research approach, methodology, and ethical considerations.
3. Teachers needed to complete the activity and ensure that it was going smoothly, including observations and reflections.
4. Teachers needed to mark or analyse the activity.
5. Teachers were required to evaluate and reflect on their findings.

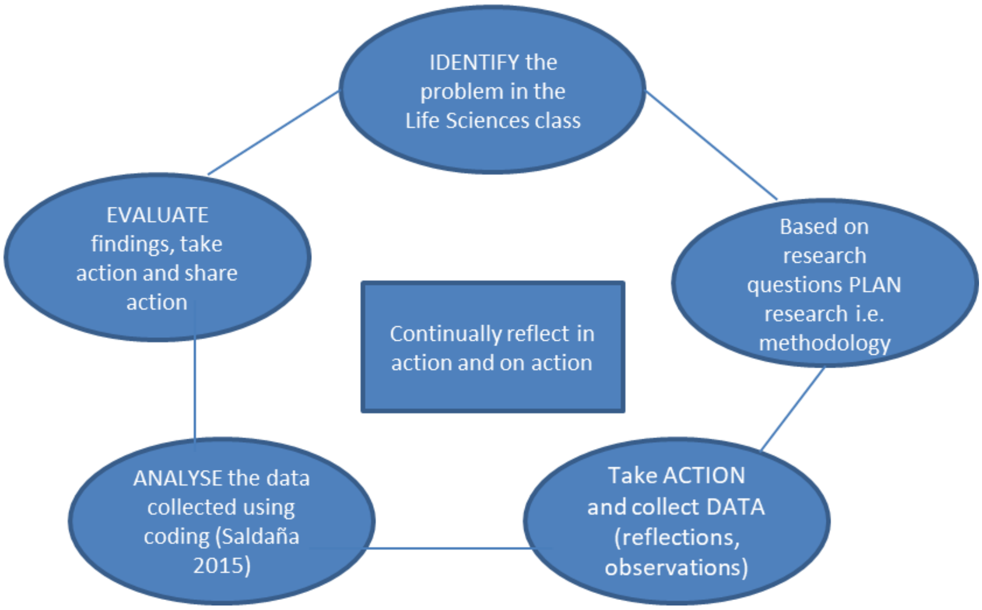


Figure 2-3: CAR cycle adapted from Gravett and De Beer (2015: 347)

Reflection cannot be excluded from CAR. Teachers have to continually reflect during the lesson as well as during the entire CAR. Reflecting and completing the CAR cycle improves teacher pedagogical content knowledge (PCK) (Hoy, 2013; Gravett & De Beer, 2015); gives them a sense of control and judgement over their own teaching (Biesta *et al.*, 2015); and ensures affective learning has taken place (Green & Batool, 2017). This creates teachers who are life-long and self-directed learners (SDL) (Knowles, 1975) and agents of change (Van der Heijden *et al.*, 2015).

2.5 Embodied, situated and distributed cognition

There are many psychological studies on cognition (Piaget, 1964; Vygotsky, 1978; Bandura, 1986; Hill, 2000; Hardy-Vallée & Payette, 2008). An emerging neurological area of cognition is the 'embodied, situated and distributed cognition' (ESDC) which provides a very good point into the abstract world of science (De Beer, 2016). ESDC theory views cognition as a process of neural (neurotransmitter connections between neurons), intellectual (cognitive), and social systems (Agency) (Hill, 2000; Wilson, 2002; Hardy-Vallée & Payette, 2008). Cognitive phenomena require interactions within environmental situations, which allow cognitive processes to evolve and function (Hutchins, 2010).

This research viewed indigenous knowledge learning and affective development from an ESDC viewpoint. In the context of this research, indigenous knowledge systems of various cultures are part of a person's everyday life. It is part of their physical body (their mind) known as 'embodied cognition'; the environment they are exposed to, which is known as 'situated cognition'; social connections with others, which is known as 'distributed cognition' (Wilson, 2002). Embodied cognition also refers to the various synaptic connections for neural function within the brain, for example: awareness, memory, learning, language, movement, emotions, and attention. These neural functions are in different areas within the brain, but cannot be isolated from each other (Holvikivi, 2007). Positive emotions can enhance learning and negative emotions can hinder learning (Cronje, 2015). Natural Sciences and Life Sciences teachers need to identify these feelings and intellectual processes; and recognise the impact they have on their own learning and professional development within their own environmental context.

This research of the affective development of Natural Sciences and Life Sciences teachers during an indigenous knowledge intervention used embodied, situated and distributed cognition. Embodied cognition refers to the intellectual processes profoundly entrenched in a Natural Sciences and Life Sciences teacher's pedagogical content knowledge and experience of indigenous knowledge. 'Situated cognition' indicates their understanding of the context of a real-life environment, such as: the indigenous knowledge intervention; a visit to a cultural museum; and an interaction with authentic artefacts. 'Distributed cognition' denotes the dispersal of their understanding of indigenous knowledge to their learners in the classroom (interactive situation), including mind, body and environment (Wilson, 2002).

2.6 The affective domain and affective development

In Natural Sciences and Life Sciences education, the affective domain has been ignored and devalued in comparison to the other two domains, namely, the cognitive and psychomotor (Pierre & Oughton, 2007; Garritz, 2010). Natural Sciences and Life Sciences teachers need to understand that teaching scientific facts involves more than cognition, as teaching and learning are filled with emotion, values and ideals (Garritz, 2010). Teaching 'hot' topics such as evolution and indigenous knowledge require a positive attitude and a confident teacher (De Beer & Henning, 2010). Mothwa (2011) maintains that teachers do not fully incorporate indigenous knowledge into their teaching practices. They simply mention a few examples (cognitive component) and omit the hands-on (psychomotor) and emotional (affective) components. These components cannot be separated and must be seen holistically (McKeachie, 1976; Wilson, 2002). Similarly, Smith and Ragan (1999) noted that psychomotor and cognitive objectives have affective elements to them.

More emphasis should be placed on the emotional teaching experience of the teachers, which includes their motivations and inner reflective practices. The affective domain includes aims that describe changes in awareness, interest, attitudes and values (Birbeck & Andre, 2009; Neuman & Friedman, 2010). Research alludes to the fact that the affective domain is the 'gateway to learning' (Pierre & Oughton, 2007:1). Pintrich, Marx and Boyle (1993) proposed four motivational concepts for the affective, namely: self-efficacy, values, goals, and beliefs. These were later expanded by Eccles and Wigfield (Pintrich *et al.*, 1993; Eccles & Wigfield, 2002; Garritz, 2010).

Self-efficacy is defined by Bandura (1997) "*as individuals' confidence in their ability to organise and execute a given course of action to solve a problem or accomplish a task"* (Eccles & Wigfield, 2002:110) where tasks or problems may vary in difficulty. Some teachers may have a strong sense of self-efficacy and others don't (Eccles & Wigfield, 2002). Bandura characterised two types of expectancy beliefs, namely, 'outcome expectation' and 'efficacy expectation' (Bandura *et al.*, 2001). Some teachers may present strong self-efficacy toward the indigenous knowledge intervention and infuse some of the indigenous knowledge notions in scientific content and teaching practices. This is the 'outcome expectation' as these teachers believe that specific behaviours may lead to certain outcomes (Bandura, 1997; Eccles & Wigfield, 2002). Teachers who teach with authentic and hands-on indigenous knowledge examples can stimulate learner curiosity, interest and love for the subject. By contrast, teachers who do not believe they can perform this specific behaviour (a negative 'efficacy expectation') won't accomplish their goal (Eccles & Wigfield, 2002).

A value is defined by Neuman (2010:2) as a "*concept or an idea that we feel strongly about, so much so that it influences the way in which we understand other ideas and interpret events*". Values that teachers hold can influence their teaching performance and motivation to teach specific concepts such as indigenous knowledge (Eccles & Wigfield, 2002). Teachers may not see the value in indigenous knowledge games or concepts as they see these games or concepts as difficult tasks; and this may affect their teaching practices. Research refers to people attaching more value to activities in which they do well (Eccles & Wigfield, 2002:121). Motivation is also significant, as teachers specific attitude toward a specific activity is a causative factor to achievement (Edwards & Porter, 1972). Therefore, if teachers affectively embrace indigenous knowledge and take the time to learn the concepts, they can see the value in teaching indigenous knowledge and ultimately in contextualising science.

More studies have confirmed that "*individuals' values influence the attractiveness of different goal objects and, consequently, the motivation to attain these goals*" (Eccles & Wigfield, 2002: 121). Research indicates that if the goals are challenging they can promote self-efficacy, improve teaching performance and motivation. The indigenous knowledge intervention was designed to allow teachers to set personal and professional goals to challenge themselves. When teachers are intrinsically motivated they will take part in an activity because they enjoy it and their interest is captured during the indigenous knowledge intervention (Eccles & Wigfield, 2002). When teachers are extrinsically motivated they will take part in an activity for a reward that is offered (Eccles & Wigfield, 2002). According to the affective stance adopted in this research, teachers need to be intrinsically motivated and have the desire to teach indigenous knowledge in the classroom.

Affective learning can alter values, feelings and attitudes, which in turn may influence thinking and behaviour (Neuman & Friedman, 2010). Affective learning and affective development is apparent in behaviour and involves all learning domains (Neuman & Friedman, 2010). The teacher will indicate awareness and interest, and show specific demonstrations in their actions. Positive attitudes, actions and emotions can improve affective development and affective learning, while negative attitudes, actions and emotions can prevent affective development and affective learning (Holvikivi, 2007). Furthermore Brown, Ferrill, Hinton and Shek (2001:241) explain that "*affective characteristics such as motivation, initiative, compassion, service,* *accountability, empathy, honesty, advocacy, commitment, optimism, respect and self-confidence lead to behaviours that typically produce professional excellence*". If a teacher experiences affective learning, then affective teaching can take place. Thus the values and motivations are transferred to the learners themselves, who then become curious and excited about learning science.

For any authentic learning to occur, whether it be cognitive, behavioural (psychomotor) or affective (emotional), the teacher must firstly be attentive and secondly receptive, i.e., interested and open to the concepts of indigenous knowledge (Neuman & Friedman, 2010). Affective learning and affective development can be measured using Krathwohl's classification system. This addresses various affective concepts such as teacher values, attitudes, beliefs, feelings, motivations, self-efficacy, self-esteem, academic self-concept, and their interests (Krathwohl, 1964; Martin & Briggs, 1986; Pierre & Oughton, 2007; Birbeck & Andre, 2009; Neuman & Friedman, 2010).

2.7 Krathwohl's taxonomy of the affective domain

The taxonomy described here is hierarchical. Each learning level progresses from the previous level (Neuman & Friedman, 2010). Krathwohl (1964) developed a continuum for affective development. The proposed taxonomy is an effective tool for measuring affective learning of Natural Sciences and Life Sciences teachers. As mentioned before, this is a hierarchical system, which focuses on teacher emotions and attitudes towards a particular concept, specifically indigenous knowledge and the value teachers attach to indigenous knowledge. It starts with a teacher becoming aware of a phenomenon (in this case, indigenous knowledge) with teachers reflecting on their initial thoughts and emotions and progressing to more complex emotions and the values they attach to indigenous knowledge. This eventually becomes part of their behaviour; thus affective learning has taken place.

This model by Krathwohl is designed as a principle of internalisation. There are five categories including receiving, responding, valuing, organising, and characterising by a value complex (Krathwohl, 1964; Lynch *et al.*, 2009). Receiving (Krathwohl *et al.*, 1965) refers to a state of being aware or sensitive towards a particular phenomenon. Responding refers to some commitment towards a phenomenon; and valuing is the ability to support or approve of the particular phenomenon. Organising refers to some internalisation of the phenomenon into own philosophy; and characterising by a value complex refers to the phenomenon being fully internalised as a value set (Lynch *et al.*, 2009). Krathwohl's taxonomy focuses on the concept of internalisation, emphasising that values, attitudes and motivation need to be internalised to become part of a person's world view (Krathwohl, 1964). This is a valuable classification system for identifying affective learning and development (see Table 2-2).

Table 2-2: Table showing descriptions for affective learning (Neumann & Friedman, 2010:5)

Krathwohl's (1964) affective hierarchy	Krathwohl's affective hierarchy	Description of the hierarchy	Examples (Jackson *et al.*, 2016)
L0	Not aware	No awareness. Show no interest before, during or after the indigenous knowledge intervention.	Cannot remember or explain pedagogies and link it to the affective domain.
L1	Receiving	Becoming aware.	Awareness of IK and pedagogies during indigenous knowledge professional development intervention.
L2	Responding	Participation in tasks. Discussions.	Teacher reflective practice (VNOIK and affective domain pre- and post-intervention questionnaires) as well as following instructions, participation and motivation to learn.
L3	Valuing	Show value towards IK. Promising attitudes.	Affective development of the teacher (affective domain). Acceptance of IK.
L4	Organising	Accountable for their own behaviour, show planning and solving (CAR).	Examine and discuss indigenous knowledge, integrating (IK) into own value system. Teachers can plan and conduct their own research (CAR).
L5	Characterising by a value set	Consistent behaviour show consistency towards internalised values. Professional commitment.	Influence teacher PCK, values, morals and attitude when teaching indigenous knowledge. The teacher has a more positive outlook and understanding of the nature of IK (working independently and becoming self-directed).

In this research, Level 1 refers to teachers showing awareness of the concept of indigenous knowledge and deciding to learn more about the topic. Teachers (especially the more experienced teachers not previously exposed to the topic of indigenous knowledge in pre-service training) attended the intervention and became aware of the new topic. During the intervention, novice and more experienced teachers showed further interest in the topic, thus showing selected attention and the start of concept acceptance. The first level refers to the *"active attention to stimulus*" (Rovai *et al.*, 2009:8), and the motivation to learn more about indigenous knowledge. In other words, teachers pay active attention and respond willingly to the concept of indigenous knowledge, and perhaps show satisfaction in their responses.

On the second level teachers complied with instructions and fully participated in practical sessions and commented in group discussions. Responding can also refer to teacher reflection, by responding in writing to their experiences during and after the intervention. Teachers who responded to the idea of indigenous knowledge showed some understanding and acceptance of the concept.

Valuing refers to "*valuing a particular idea*" (Rovai *et al.*, 2009:8). This idea could be that teachers start to become aware of the value of indigenous knowledge holistically and to accept the ideas surrounding indigenous knowledge. Teachers may show a sense of commitment to indigenous knowledge by supporting some ideas and sharing these ideas with others.

Organising signifies conceptualisation, internalisation and organisation of values (Rovai *et al.*, 2009) to develop a personal value system. Teachers who conceptualise indigenous knowledge begin to study, theorise and integrate their own ideas on how to infuse indigenous knowledge into the curricula, or into the way they teach. This also refers to the section on self-directed learning.

Characterising by value set is the highest level of internalisation of values, promoting a consistent value system (Rovai *et al.*, 2009) where teachers will act on their own values or beliefs. Teachers will work independently and show professional commitment to the new phenomenon, i.e., indigenous knowledge. Furthermore, teachers will not only integrate some indigenous knowledge topics in one or two sections, but will try to integrate indigenous knowledge in almost every section of Natural Sciences and Life Sciences topics within the curricula. Teacher attitudes and excitement towards what they experience and learn during the indigenous knowledge intervention can, in turn, influence their further studies as self-directed learners, and this could develop their PCK, which they can utilise in the classroom. These theoretical views form part of the study's conceptual framework. The conceptual framework shown in Figure 2-4 below provides a better understanding of Krathwohl's taxonomy and the indigenous knowledge intervention.

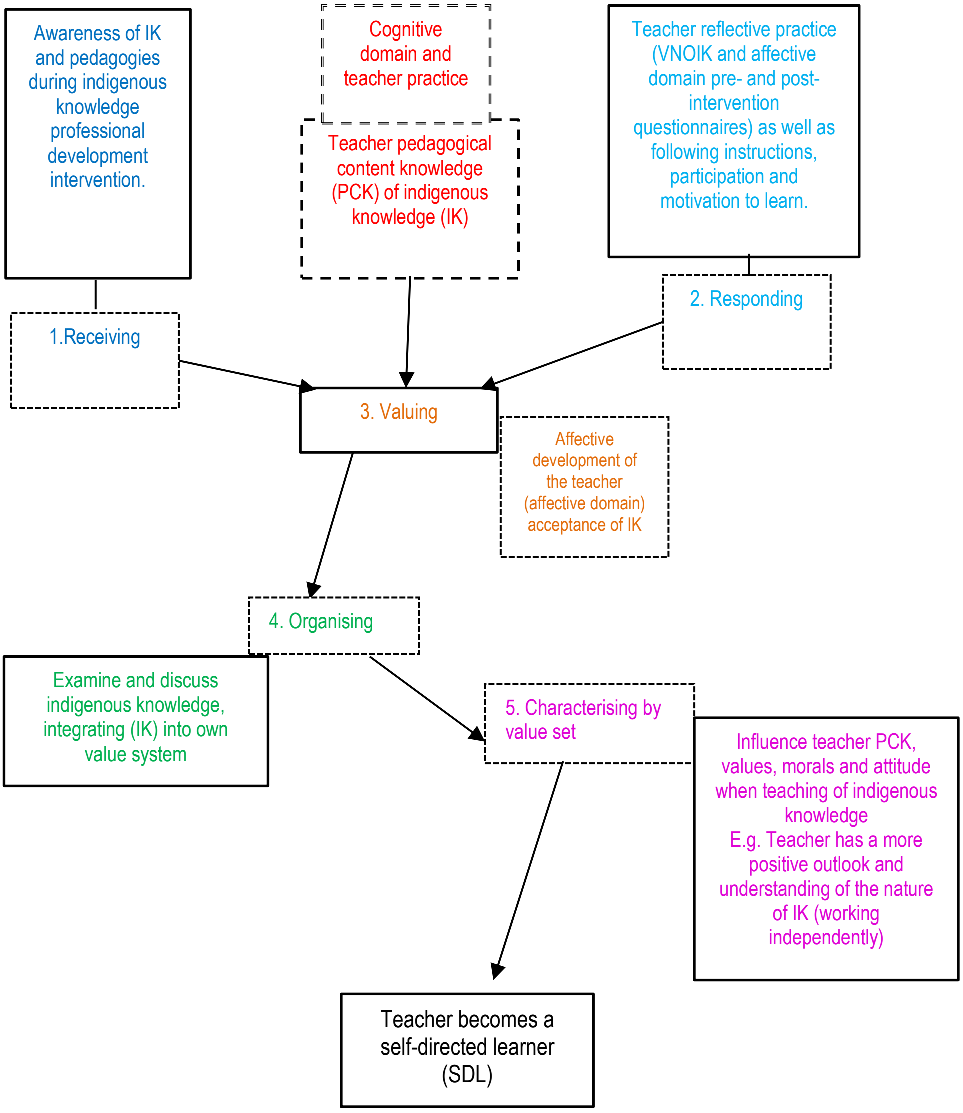


Figure 2-4: Intermediate theory for a framework of the affective development of teachers (Jackson *et al.,* 2016:499) during an indigenous knowledge intervention for self-directedness (adapted from Krathwohl, 1964)

2.8 'Hot' and 'cold' conceptual change, controversial conceptual change, and the affective domain

One of the most fundamental aspects in science education is conceptual change (Duit & Treagust, 2003). Conceptual change refers to the way in which specific scientific concepts, as well as the associations between these concepts, change. In the context of this research, conceptual change will be viewed in terms of the teachers' participation in the short learning programme. There are two notions that apply to conceptual change. Firstly, teachers may have negative or positive views of indigenous knowledge which may change after the indigenous knowledge intervention; this is known as 'status change*'* (Kural & Kocakülah, 2016). During the indigenous knowledge intervention various teachers may exchange their own ideas for alternative ideas, and change their perceptions of indigenous knowledge; this is known as 'conceptual change' (Hewson, 1992). Secondly, teachers, especially the experienced teachers, who did not learn about indigenous knowledge during their pre-service studies, may not have been exposed to the variety of indigenous knowledge (Mothwa, 2011). The experienced teachers go from ignorance of indigenous knowledge to awareness (Hewson, 1992) and this is *also* known as conceptual change.

Conceptual change is similar to 'mindfulness' (Duit & Treagust, 2003), and, according to Salomon and Globerson (1987:623), 'mindfulness' is a "*construct which reflects a voluntary state of mind, and connects amongst motivation, cognition and learning*". 'Mindfulness' is associated with motivation and cognition. Motivation is an aspect of the affective domain (Krathwohl, 1964). Teachers who are motivated to create a contextual learning environment using indigenous knowledge systems can enhance learner curiosity (Cronje, 2015). Cognition is an aspect of the cognitive domain (Crowe *et al.*, 2008) and comprises the facts and theories which form part of the curricula and must be taught. Thus, a combination of the affective and cognitive aspects of 'mindfulness' is required for conceptual change. In order to achieve conceptual change, teachers need to be open to the concepts of indigenous knowledge.

The cognitive domain and the affective domain are dimensions of conceptual change. The cognitive domain is seen as 'cold' and 'isolated' conceptual change (Pintrich *et al.*, 1993; Sinatra, 2005), as this entails the facts and theories surrounding scientific concepts. Teachers often regurgitate and automate cognitive aspects such as scientific facts and theories. This is known as chalk and talk (Riga, Winterbottom, Harris & Newby, 2017). This is not considered proper knowledge transfer for learners to understand concepts (Pintrich *et al.*, 1993; Sinatra, 2005). A cognitive-only approach may limit learner enthusiasm, engagement, willingness, goals, prospects, purposes and needs (Pintrich *et al.*, 1993).

The affective domain is seen as warm conceptual change (De Beer & Henning, 2010; Kural & Kocakülah, 2016) as motivational beliefs, attitudes, values and feelings of teachers and learners are involved. Warm conceptual change can influence teacher PCK (Pintrich *et al.*, 1993). Teachers often only concentrate on the cognitive domain and not on the affective domain which could prevent learners and teachers from learning and understanding new concepts (Kural & Kocakülah, 2016). Therefore, Kural (2016) proposed a model known as the teaching model for hot conceptual change (TMHCC), whereby true conceptual change can only occur if teachers affectively embrace hot topics such as indigenous knowledge.

This research will also look at controversial conceptual change (CCC) where teachers need to combine Western science and indigenous knowledge tenets as well as challenge the religious views they may hold. Religious experiences and behaviours learnt by Natural Sciences and Life Sciences teachers and learners may shape their everyday perceptions and interactions, i.e., their worldview (Hart, 2010) also referred to as 'conceptual ecology' (Hewson, 1992). Worldviews involve philosophical beliefs, religious beliefs and scientific elements (Schilders, Sloep, Peled & Boersma, 2009) which can affect decision-making, problem-solving and assumptions (Hart, 2010), thus creating conflict. Worldview is used as a 'sense language' to ensure learners understand what they have learnt and make sense of a particular phenomenon (Reddy, 2012:12; Schilders *et al*. 2009). However, misconceptions could arise between controversial topics including Western science, indigenous knowledge and religion. The SLP aims to address some of these misconceptions.

Controversial conceptual change (CCC) will occur when Natural Sciences and Life Sciences teachers change the way they observe the 'nature of the conception' (Mills, Tomas & Lewthwaite, 2016). A recent trend in the study of conceptual change refers to affective aspects, such as motivation, positive attitudes and interest which may bring about conceptual change (Mills *et al.*, 2016). If teachers affectively change the nature of their conceptions, this could influence the way in which they teach a variety of scientific topics which could influence learners' understanding, hence the necessity for professional development interventions.

2.9 Professional development of Natural Sciences and Life Sciences teachers

The purpose of teacher professional development is to scaffold teachers' professional learning and competence in pedagogical content knowledge, skills and effectiveness (Fraser, Kennedy, Reid & McKinney, 2007). Support for the notion of the 'teacher as a learner' can create opportunities for teachers to learn more about a specific topic and to continue their professional development (Fraser *et al.*, 2007); consequently one of the design principles included classroom action research (CAR). Teacher professional learning is complex and requires teachers to reflect individually and collaboratively (Avalos, 2011). Teachers can share ideas from CAR with other teachers, thus motivating them in a community of practice (CoP). If teachers become lifelong learners, they will enhance their ongoing professional development.

According to Pretorius (2015:37) *"many teachers lack self-efficacy and are often not motivated at all, which necessitates ways of offering social and emotion support through interventions".* Professional learning through interventions assists in developing teachers' pedagogical abilities and this has an overwhelmingly positive influence on their educational practices (Darling-Hammond *et al.*, 2009). There is a need amongst South African science teachers to improve science education in South Africa. A PhD study conducted by Pretorius (2015), "*learning communities for the professional development of science teachers*", emphasised the need for continual professional development of science teachers to enhance pedagogical content knowledge. The five year longitudinal study of the 'A-team' and the 'hybrid ecology of learning practice' proved that a comprehensive professional development programme produced motivated and enthusiastic science teachers who formed a community of practice which shared resources to aid their own professional growth and the growth of others (Pretorius, 2015).

Studies show that professional development interventions with the infusion of indigenous knowledge are successful and have a positive effect on science education (Darling-Hammond *et al.*, 2009; Cronje, 2015). The indigenous knowledge short learning programme offered by the North-West University aims to have a constructive output with regard to affective development and in turn will develop skills and pedagogies for the Natural Sciences and Life Sciences teachers.

Professional development is not only content driven, but also addresses the affective development of the teacher, thus there is a need for the teacher to be a critical reflective practitioner.

2.10 Critical role of being reflective practitioners

Reflection refers to thinking that is focused, intentional and purposeful, and aims to deepen understanding (Gravett & De Beer, 2016). Reflection and reflexive practices incorporate serious thought or consideration for one's own understanding of self and the experiences one encounters. During reflection teachers think methodically about their practices and learn from their experiences (Rodgers, 2002); and during reflexivity they revert to inward reflection, which is an integral part of the lifelong learning process (Ryan, 2015). It is an important skill for teachers to reflect and understand their own identity, and by the same token teacher identity plays a substantial role in their own professional development (Körkkö *et al.*, 2016). In the context of this research, it is important to distinguish between the different types of reflection. Schön (1983) distinguishes between reflection 'in action' and reflection 'on action'. Teacher identity and reflection influences teacher fulfilment, commitment, motivation and self-efficacy (Körkkö *et al.,* 2016: 199). Being a reflective practitioner, Natural Sciences and Life Sciences teachers perceive and assess their thoughts and these thoughts are linked to their emotions, principles and assumptions (Körkkö *et al.*, 2016). In turn, these emotions, principles and assumptions provide an analytical viewpoint of their teaching practices, thus improving their teaching pedagogy. In essence this is part of professional development and ultimately allows teachers to set their own professional goals and learn to become self-directed learners.

2.11 Self-directed learning (SDL)

Self-directed learning is not a recent concept and there is evidence of this concept being followed by Greek philosophers such as Plato and Aristotle (Knowles, 1975). Knowles (1975:19) describes self-directed learning (SDL) as the *"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 outcomes*". Further to this definition, Knowles (1975:2) stipulated further definitions and assumptions: a) as 'humans grow in capacity', they develop the urge to be self-directing; b) encounters in the world provide learning experiences; c) people focus their learning on their 'evolving life tasks'; d) focus is placed on problem-based learning and e) self-directedness is guided by internal emotions, such as confidence, motivations, inquisitiveness and yearning for success.

Self-directedness is a component of affective learning (McCombs, 1988). Being aware of possible achievements, teachers will want to learn more in order to accomplish and improve their teaching and learning skills and goals. Therefore, teachers utilise learning materials and available resources to guide them towards their learning goals and to help them to achieve them. They will also become actively involved in the discussion and analysis of new content, thus showing characteristics of self-directedness. Teachers show the ability to diagnose challenges (problem-solving skills) (Guglielmino, 1978), become critical thinkers and recognise the importance of taking responsibility for their own learning, i.e., professional development. These teachers are not satisfied with shallow knowledge, but rather want to investigate the deeper significance of this knowledge (Candy, 1991).

2.12 Cultural-Historical Activity Theory (CHAT)

As mentioned earlier, the short learning programme (SLP) on indigenous knowledge was conceptualised from a social constructivist perspective. Social constructivism has its origins in the developmental theory of Vygotsky and Bruner (Bruner, 1973; Vygotsky, 1978; Leont'ev, 1981) as well as Bandura's social cognitive theory (Bandura, 1986). Social constructivism is based on how one interprets one's cultural and social settings in order to create meaning (Kim, 2001). Teachers' learning, according to social constructivism, is scaffolded across the zone of proximal teacher development (ZPTD) (Warford, 2011), a construct based on Vygotsky's original ZPD.

Activity theory stems from the work of psychologist Vygotsky and his collaborators (Vygotsky, 1978; Leont'ev, 1981; Veresov, 2004). Cultural-historical activity theory was used as a research lens in this research to enable the researcher to understand socio-cultural factors that arose as a result of interactions between teachers within the context of the activity (the intervention) as well as the teacher-learner interactions in the classroom (Hardman, 2008). Vygotsky suggested that the "*mind is socially constructed during communicative interactions between culturally knowledgeable adults*" (Hardman, 2008:67). The first-generation activity theory framework has originated from the field of learning psychology and specifically the work of Vygotsky and his renowned concept of the zone of proximal development (ZPD) (Vygotsky, 1978; Levykh, 2008; Davis, 2012; Stetsenko & Arievitch, 2014).

The ZPD is the distance between actual and potential development. The potential development can be achieved through scaffolding activities. Vygotsky believed that *mediation* is crucial to recognising how learning takes place (Hardman, 2008). The second-generation activity theory was developed by Leont'ev (1981) and he suggested that human actions are viewed in the context of the activity, i.e., people take on different responsibilities according to the division of labour which is arbitrated by rules (Leont'ev, 1981; Beatty & Feldman, 2012), The third-generation Cultural-Historical Activity Theory was developed by Yrjö Engeström (Engeström, 2009). Engeström's third-generation Cultural-Historical Activity Theory was utilised in this research.

CHAT offers a variety of observations into any activity system. There are three planes in sociocultural analysis of CHAT, namely, the personal plane, the interpersonal plane and the institutional or community plane (Rogoff, Baker-Sennett, Lacasa & Goldsmith, 1995). This research utilised CHAT in two ways, the personal plane and the interpersonal plane.

Furthermore, the third-generation activity system consists of different nodes: the *subject (S), object (O), tools (T), community (C), rules (R) and division of labour (D)* (Engeström, 2000).

2.12.1 Cultural-Historical Activity Theory (CHAT) - personal plane

This research utilised the CHAT research lens from a personal plane. This is where the *subject* is an individual, namely, the Natural Sciences and Life Sciences teacher; therefore the object is the teachers' affective development within the indigenous knowledge intervention context. Engeström (2009) emphasises that the object should be infused into the activity system. Furthermore there is intricacy of the object called 'contradiction of control' (McNeil, 2013). In the ideal context there should be a shared view to achieve the object, but often this does not occur (Mentz & De Beer, 2017). Natural Sciences and Life Sciences teachers should grow their affective domain (Jackson *et al.,* 2016). These include values, motivations, attitudes, stereotypes and feelings about indigenous knowledge. Teachers should also cultivate their indigenous knowledge to develop their pedagogical content knowledge (PCK) and should also create an awareness and sensitivity amongst their learners and fellow teachers towards the indigenous knowledge of the South African multicultural society.

Engeström's third-generation activity theory provided a valuable lens in this research to place pedagogy in context (Hardman, 2008). Using Engeström's CHAT triangle as a research lens allowed for teacher actions and their affective development to be better understood against the context of the activity system (Leont'ev, 1981).

Engeström's activity system assists the researcher in understanding how the teachers are affected by their socio-cultural context. This research used CHAT in the way described by Mentz and De Beer (2017). These authors refer to Engeström (2009:24) who stated that *"in today's interconnected world, it is often useful to take two interdependent activity systems as the minimal unit of analysis*". This research will therefore be contrasting two activity systems: the affective development of teachers during the SLP, and juxtapose it with the transfer of affective outcomes which take place in the classroom after the SLP. In this research the context of the activity system was the indigenous knowledge intervention, with the primary focus on teachers' development within the affective domain.

The key fundamentals or different nodes of the third generation activity system include the *subject, object, tools, community, rules* and *division of labour* (Engeström, 2000). The nodes depicted below provide an outline of the research lens with regard to the study. The *subject* acts on the *object* to alter it using *mediating tools* to reach a specific outcome. Sequentially, the subject is affected by the *rules* of the system, the subject's *community* and the *division of labour*. The arrows in the triangle are two-way arrows which suggest that the various nodes of the activity system are dynamic (Hardman, 2008).

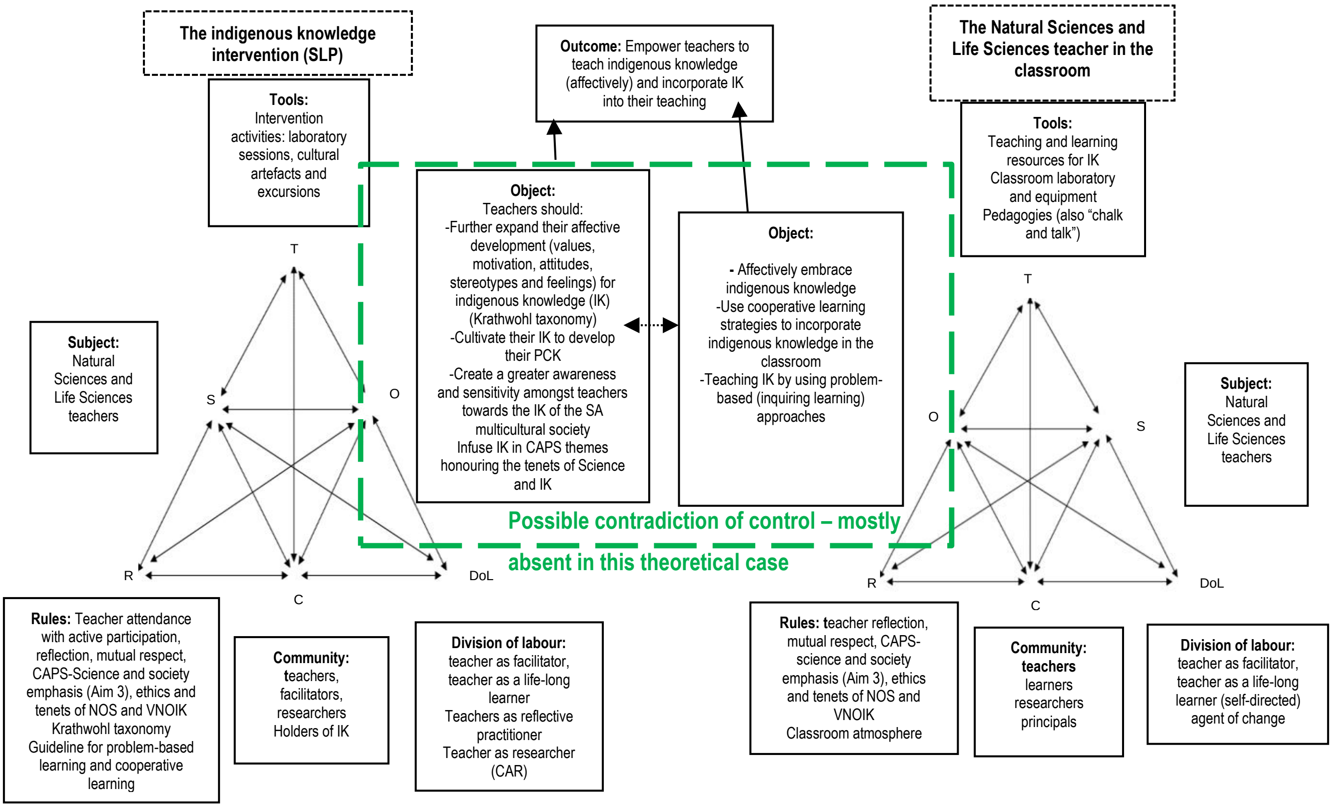


Figure 2-5: Using the third-generation Cultural-Historical Activity Theory (CHAT) the unconventional way: Comparing the SLP and the Natural Sciences and Life Sciences teacher in the Classroom (adapted from Engeström, 1987; and Mentz & De Beer, 2017); and integrating the affective domain (Krathwohl, 2002)

The *subject* is the individuals who participate in the activity at hand. The *object* of the activity system is the goal achieved through the activity. The *tools* (mediating tools) include artefacts and activities which allow the individual's experiences in a social environment. The *community* consists of social members with whom the subject may interact. The *rules* are official or unofficial guidelines that may inhibit or promote the activity and these ultimately guide the *subject* regarding correct actions. The *division of labour* indicates task sharing within the community of the activity system (Yamagata-Lynch, 2010).

The Natural Sciences and Life Sciences teacher is the *subject* who will participate in the indigenous knowledge intervention offered to them by the North-West University. The *object* is to address the affective domain such as their values, attitudes, motivations and their PCK for teaching indigenous knowledge. It was anticipated that this would create greater awareness and sensitivity amongst teachers towards indigenous knowledge. Here the focus points to the fact that conceptual change and PCK development should be seen from a warm lens (Pintrich *et al.*, 1993). The *tools* include the activities of the intervention in which the teachers participate, for example laboratory sessions, cultural artefacts and excursions. These tools will be explained in greater detail later (see Chapter 3). The *rules* in the activity system refer to the CAPS guidelines, the tenets of the nature of science, as well as the tenets of the nature of indigenous knowledge and the taxonomy of the affective domain, as developed by Krathwohl (1964). The community will include the teachers, facilitators and the researchers. The *division of labour* includes the teacher as a facilitator, a lifelong learner, a critically reflective educational practitioner and a researcher, engaging in CAR. The overall outcome of the study was to empower teachers to incorporate indigenous knowledge in their teaching practices and become self-directed.

The second activity system also includes the Natural Sciences and Life Sciences teacher as the *subject*. The *object* refers to the affective development of the teacher developing a more nuanced understanding and appreciation of indigenous knowledge. *Tools* refer to learning materials, artefacts and pedagogies which could assist in the achievement of the *object*. The *rules* in this context refer to the CAPS guidelines, tenets of the nature of science and indigenous knowledge and specifically the taxonomy for the affective domain, as conceptualised by Krathwohl (1964). The community refers to all stakeholders, e.g. all teachers and the SLP facilitators. The *division of labour* refer to the various roles of the teacher (*subject*) e.g. the teacher as a facilitator of learning and a critical reflective practitioner.

CHAT was utilised as a research lens to holistically analyse various roles within an activity system (Koszalka & Wu, 2004) and to identify any tensions or contradictions (Koszalka & Wu, 2004). CHAT as the research lens was a useful tool to identify the outcomes and any contradictions (called 'dramatical collisions') (Veresov, 2010) relating to the study of the affective development of Natural Sciences and Life Sciences teachers.

Various questions arose regarding possible tensions:

- Is there tension between achieving the object of the activity system and the tools used?
- Is there tension between the object and the community?
- Is there tension between the subject and the rules of the activity system, as teachers are restricted by these rules and this may create animosity?

CHAT proved to be a beneficial tool in understanding the Natural Sciences and Life Sciences teacher's abilities, views, attitudes, conflicts, and changes in their conceptualisation (Beatty & Feldman, 2012).

Some tensions may include teachers who struggle with how to infuse indigenous knowledge into scientific content, misconceptions arising from various topics within a variety of African indigenous knowledge, religious beliefs, lack of teaching time, no in-service training in indigenous knowledge and insufficient educational resources for adequate learning. Teachers also fear that they do not have sufficient knowledge about indigenous knowledge and, to avoid being asked difficult questions by the learners, they do not teach this topic. Teachers are unwilling to spend time on self-reflection and critical evaluation, thus leading to more tension within the activity system. Thus, the CHAT lens makes provision for a specific 'gaze' into the activity system and identifies any 'dramatical collisions' (Veresov, 2010).

2.12.2 Cultural-Historical Activity Theory (CHAT) - interpersonal plane

Another aspect of CHAT was applied, namely, the interpersonal plane, which compared two other aspects within an activity system (the Natural Sciences and Life Sciences classroom). Within the classroom two CHAT triangles were compared with one another to see if there were any tensions or contradictions within the activity system. Although the teacher is teaching in a classroom setting, it does not necessarily mean that the learner is learning (Brown, 2003). Therefore the use of CHAT in an unconventional way (Mentz & De Beer, 2017) allowed the researcher to see what transfer of affective outcomes took place in the classroom while teachers engaged in CAR using Foldscopes.

CHAT was a useful lens to analyse data, to provide a 'rich description'. In Figure 2-6 focus is placed on the Natural Sciences and Life Sciences classroom (where Foldscopes were used) by identifying two interdependent activity systems (Mentz & De Beer, 2017). Although the teacher is teaching in a classroom setting, it does not necessarily mean that the learner is learning (Brown, 2003).

The two activity systems in Figure 2-6 were therefore built around the learner as subject, engaging in a learning activity during engagement in CAR (diagram on the right), and the teacher as subject facilitating the Foldscope learning activity (diagram on the left). The use of CHAT in this rather unconventional way (Mentz & De Beer, 2017) allowed the researcher to see what transfer of affective outcomes took place in the classroom when Foldscopes were used. The different nodes in the third generation activity system include the subject (S), object (O), tools (T), community (C), rules (R) and division of labour (D) (Engeström, 2000). The tools that the teacher and learners utilised during the CAR include the Foldscopes, water quality worksheet and laboratory equipment. The activity system was guided by rules, namely, the nature of science (NOS) (the learners completed the practical activity that followed the scientific method), the subject assessment guidelines (SAGS) (IEB, 2018) or curricula assessment policy statement (CAPS) (Department of Basic Education, 2011), as well as the problem-based learning guidelines. The community included the principal, parents, teachers and learners. The division of labour in triangle 1 includes the teacher as a facilitator of learning, critical reflective practitioner, agent of change and a researcher. The division of labour of the learners includes them as 'scientists' conducting fieldwork and the scientific method. The object of this activity system is to enhance affective outcomes from the CAR, namely, inculcate enjoyment, excitement, appreciation and engagement. Engeström (2009) highlights that the object should be permeated into the activity system, furthermore there is complexity of the object called 'contradiction of control' (McNeil, 2013). In the ideal context there should be a shared view to achieve the object (Mentz & De Beer, 2017). In reality there are often 'conflicts' as a result of contradicting (non-aligned) objects in the two activity systems.

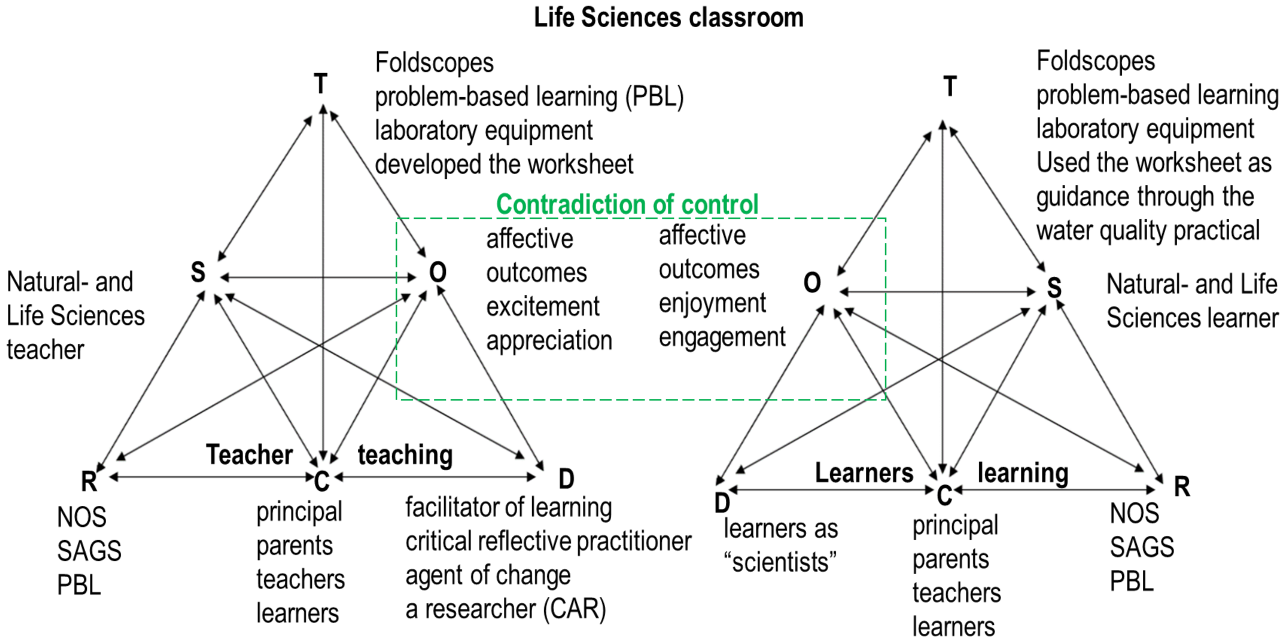


Figure 2-6: Using third-generation Cultural-Historical Activity Theory (CHAT) in an unconventional way: Comparing the Natural Sciences and Life Sciences teacher and the learner (adapted from Engeström, 1987; and De Beer & Mentz, 2017)

2.13 Conclusion

In conclusion, this literature review provided a foundation for Natural Sciences and Life Sciences teachers' affective development regarding an indigenous knowledge professional development intervention. The literature review provided a background to teachers' perceptions about teaching indigenous knowledge, which included a misconception of indigenous knowledge as a 'pseudoscience' or teachers who view it as 'witchcraft'. The literature also covered the value of incorporating indigenous knowledge into the classroom, which is necessary in the context of this research specifically to embrace indigenous knowledge affectively. Various aspects relating to this research were covered and these were used as evidence, along with the data collected, to make the findings more reliable. These included teacher PCK, ESDC, the affective domain, Krathwohl's taxonomy, CCC, professional development, reflective practitioners and SDL. This research viewed indigenous knowledge and affective development from an embodied, situated and distributed cognition. Teacher pedagogical content knowledge (PCK) was relevant in this research because the purpose of the intervention was to address teacher pedagogical content knowledge within the indigenous knowledge sphere. Teachers were given strategies on how to incorporate indigenous knowledge into their teaching pedagogies. Indigenous knowledge is a controversial topic and thus controversial conceptual change was relevant, as teachers need to understand the tenets of Western science as well as indigenous knowledge and the views or opinions they may hold. Professional development was the core of this research as the intervention aimed at improving teacher content knowledge, skills, pedagogies and reflection techniques, thus encouraging self-directed learning. Krathwohl's taxonomy was the tool used to see if any affective development occurred among the teachers, thus was relevant in this research. Social constructivism was utilised as the theoretical framework, which placed emphasis on the zone of proximal teacher development (Warford, 2011). The lens of this research was Engstrom's third generation CHAT theory and provides a much deeper understanding of teacher perceptions, following the intervention and how they incorporate indigenous knowledge in the classroom context to contextualise learning. These aspects provided in the literature were carefully chosen to provide a significant background for the study. These aspects will be used to analyse the qualitative data gathered. The methods used for collecting the qualitative data will be discussed in Chapter 3.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The literature review (Chapter 2) provided a discussion of the key concepts which informed this research of the affective development of Natural Sciences and Life Sciences teachers during an indigenous knowledge intervention. These concepts included teacher perceptions of indigenous knowledge; the value of incorporating indigenous knowledge into the curricula; teacher pedagogical content knowledge (PCK); classroom action research (CAR); conceptual change; controversial conceptual change (CCC); embodied, situated and distributed cognition (ESDC); Cultural-Historical Activity Theory (CHAT); affective development; Krathwohl's taxonomy of the affective domain; teacher reflection; professional development; and the importance of self-directed learning (SDL). Chapter 3 includes the research design and the methodology that was followed.

The research design is a series of phases that a researcher follows to achieve logical and theoretical coherence to ensure the research is validated and of good quality (Creswell, 2013). Specific methods must be followed, which are appropriate for the research at hand, and ultimately answer the primary and secondary research questions.

This research is underpinned by social constructivism which informs the study of cognition, learning and teaching (Piaget, 1964; Vygotsky & Wertsch, 1981). According to Seimears, Graves, Schrover & Staver (2012:267), constructivism is essentially about "*knowing*" and "*the nature of knowledge".* Constructivism allows people to build new ideas from information to create their own understanding that is linked to prior knowledge in their mental models (Seimears *et al.*, 2012; Gentner & Stevens, 2014). Social constructivism in the context of this research focuses on culture and knowledge construction within a group setting (the intervention).

According to the Department of Basic Education, all Natural Sciences and Life Sciences teachers are required to infuse indigenous knowledge into their teaching (Department of Basic Education, 2011). Therefore, this research acknowledges the benefits and challenges of incorporating indigenous knowledge into the Natural Sciences and Life Sciences classroom. Many studies have found that teachers do not have the pedagogical content knowledge to teach indigenous knowledge (Mothwa, 2011; Cronje, 2015), thus creating a need to design and implement an intervention that focuses specifically on indigenous knowledge. This intervention can encourage, motivate and create a positive attitude amongst teachers to teach indigenous knowledge, make them excited about this topic and, in turn, create curiosity among their learners in the classroom. A central premise of this research is that, for a teacher to engage in such epistemological border-crossing in the classroom, the teacher needs to value what is being taught (indigenous knowledge). Therefore, the affective domain is a prerequisite for real conceptual change to occur.

3.2 Research considerations

3.2.1 Aim of this research

The aim of the research was to investigate the affordances of an indigenous knowledge professional development intervention for Natural Sciences and Life Sciences teachers' affective development. Through engagement with the tenets of the nature of both science and indigenous knowledge, teachers were scaffolded in their learning to facilitate epistemological border-crossing in the classroom. The rationale for such border-crossing is to better contextualise science topics, and so appeal to the affective domain. The short learning programme (SLP) presenters realised that a key element in achieving this, is to focus on teachers' reflective practice. For this reason, teachers were introduced to classroom action research (CAR). After the SLP, teachers were asked to conceptualise classroom action research, which could include, among others, the implementation of Foldscopes. These Foldscopes were one of the resources provided to teachers during the interventions. The focus of the CAR (and the Foldscopes) was aligned with the focus of this research, namely, the realisation of affective outcomes in the Natural Sciences and Life Sciences classroom.

3.2.2 Objectives of the study

The objectives of the research were to explore:

- the Natural Sciences and Life Sciences teachers' values, beliefs, perceptions and attitudes during and after the short learning programme regarding the teaching of indigenous knowledge (their affective stance);
- the role of the affective development on Natural Sciences and Life Sciences teachers' perceptions of their own pedagogical content knowledge development;
- why teachers' pedagogical content knowledge and conceptual change cannot be studied only through a cold cognitive lens, but why the focus on the affective domain is so important;
- the affordances of classroom action research (and Foldscope microscopes) on the affective outcomes in the Natural Sciences and Life Sciences classroom;

- Natural Sciences and Life Sciences teachers' engagement in classroom action research (CAR) and their experiences in researching the affective affordances of Foldscopes.

3.2.3 Research questions

The research addressed the following questions:

3.2.3.1 Primary question

What are the affordances of an indigenous knowledge professional development intervention for the affective development of Natural Sciences and Life Sciences teachers?

3.2.3.2 Secondary questions

- How do Natural Sciences and Life Sciences teachers' values, beliefs, perceptions and attitudes change towards the teaching of indigenous knowledge during and after the intervention (their affective stance)?;
- How could the affective development of a Natural Sciences and Life Sciences teacher influence their pedagogical content knowledge (PCK)? (This question further interrogates the role of the affective domain and conceptual change in the PCK development of the teacher.)
- Why can teachers' pedagogical content knowledge and conceptual change not be studied only through a cold cognitive lens, and why is the focus on the affective domain so important?
- What are the affordances of utilising Foldscope microscopes on affective outcomes in the Natural Sciences and Life Sciences classroom?
- What are teachers' experiences of engaging in classroom action research (CAR) on Foldscopes and what are the affective affordances of such CAR?

3.3 Research design

The research design is a very important element of any study, as it allows alignment of all the research aspects. The research design is an integral process and is not only determined by one aspect, but rather by a multidimensional direction that includes the worldview philosophy; the nature of the study, i.e., the aim and the objectives; the theoretical and conceptual framework; and the research questions (Henning *et al.*, 2004; Creswell & Poth, 2017). In the context of this research, the research design followed a generic qualitative approach (Lather, 2006; Creswell, 2013; Merriam & Tisdell, 2015). A rubric (Cronje, 2015) was used to 'quantify' qualitative data in order to determine whether teachers developed more appreciation and if they attached more value to context-specific indigenous knowledge, in other words, to see if there were any changes in their affective experiences (hence affective development). This approach is similar to that of Van der Mark (2011), who used a rubric to quantify teachers' responses, utilising Piagetian levels of conceptual development. This design-based research forms part of the larger NRF-funded project. This research consists of three cycles. Cycle 1 involved two indigenous knowledge interventions held at the University of Limpopo and North-West University (Potchefstroom). Cycle 2 consisted of an improved 'version' of the intervention held in Lenasia, Gauteng. Cycle 3 was the most fruitful intervention. Cycle 3 was built on the previous interventions and was held in Calvinia, Northern Cape.

The decision was made to follow a generic qualitative research approach with elements of design-based research. This decision was motivated by a need for the researcher to gain insight into, and understanding of, various teachers' cultural backgrounds, perceptions, attitudes, and emotions regarding their 'worldview' and affective development. Teachers come from many different cultural backgrounds, such as Afrikaner, Basotho, amaXhosa, amaZulu, etc. Some cultures were marginalised and oppressed in the past, and the knowledge of their culture was not shared (Leibowitz & Bozalek, 2016). Therefore, their lived experiences of incorporating indigenous knowledge into the classroom were essential, necessitating a qualitative research approach.

According to Orb, Eisenhauer and Wynaden (2001:93), "*qualitative researchers focus their research on exploring, examining, and describing people and their natural environment".* The worldview of Natural Sciences and Life Sciences teachers is engrained in their knowledge and experiences. These underpin their social and cultural understandings. Thus, a qualitative research approach was appropriate as it allowed the researcher greater insight into the social and cultural attributes of teachers (Toloie-Eshlaghy, Chitsaz, Karimian & Charkhchi, 2011). The aim of this research was to investigate and interpret the perceptions, opinions, values and attitudes (affective stance) of Natural Sciences and Life Sciences teachers during the intervention, as well as in the classroom with regard to indigenous knowledge. Teachers are regarded as a multi-cultural group, which interacts over a period of time within a school setting (Creswell, 2013). Despite the fact that they hold different cultural backgrounds, indigenous knowledge across the cultural spectrum was marginalised in a previous dispensation (Mothwa, 2011). They are therefore 'united' in an attempt, through such epistemological border-crossing, to give indigenous knowledge its rightful place in the science classroom.

In addition, this generic qualitative research (Creswell, 2013) provides an opportunity for teachers to express their own perceptions within their own contexts. Some teachers may find indigenous knowledge, other than their own, difficult to accept (Mothwa, 2011). The way in which this qualitative research was conducted allowed teachers to express their thoughts and opinions without bias. Furthermore, the research focussed on how teachers' affective development could foster warm conceptual change, as opposed to earlier studies that focused exclusively on cold conceptual change that is fact-based (Pintrich *et al.*, 1993).

Qualitative research is interpreted in a variety of ways. The theoretical framework underpinning this research (refer to Chapter 2) is social constructivism and how teacher professional development could be scaffolded across the zone of proximal (teacher) development (Warford, 2011). Cultural-Historical Activity Theory (CHAT) (Engeström, 2000) is engrained within such a Vygotskian social constructivist viewpoint (Hodson & Hodson, 1998), and is therefore an appropriate research lens for this research. The qualitative data collected (experiences and perceptions of Natural Sciences and Life Sciences teachers teaching indigenous knowledge) will, through triangulation, present rich data that can be analysed further using CHAT as a research lens (see 2.12).

CHAT provided the researcher with the opportunity to identify various benefits or tensions within the activity system and is, therefore, a robust meta-theoretical framework for better understanding of teacher learning and affective development (Mentz & De Beer, 2017). This research concurred with Engeström's (2009:24) view that, *"in today's interconnected world, it is often useful to take two interdependent activity systems as the minimal unit of analysis".* This research, therefore, analysed two such interdependent activity systems, namely, the intervention and the classroom setting. This provided insight into the affective development of the Natural Sciences and Life Sciences teachers before and after the indigenous knowledge intervention.

The various indigenous knowledge interventions in different locations ranged from a two-day to a three-day intervention. The interventions aimed to develop Natural Sciences and Life Sciences teachers' pedagogical content knowledge (PCK) of indigenous knowledge and promote conceptual change surrounding concepts within indigenous knowledge content. The intervention offered a variety of pedagogies for incorporating indigenous knowledge into classwork, including problem-based learning and cooperative learning techniques to enhance self-directed learning. These strategies can be employed in their own classrooms to create a more contextualised learning environment. The focus of this research, within this larger National Research Foundation (NRF) funded study, was to explore the role of the affective domain in conceptual change.

The data collected during the intervention and during classroom visits was of a qualitative nature. The collection methods included personal interviews, focus group interviews, questionnaires (VNOIK and affective), intervention observations, classroom observations, and artefacts such as portfolios. These provided real-life circumstantial perceptions of the Natural Sciences and Life Sciences teachers' worldviews (Henning *et al.*, 2004).

Krathwohl's (2002) taxonomy for the affective domain was utilised as a set of standards which allowed the researcher to simplify the data collected during the intervention, as well as from the classroom visits. Furthermore, this taxonomy was used to develop the affective attributes (Lynch *et al.*, 2009) of Natural Sciences and Life Sciences teachers to encourage, motivate and kindle indigenous knowledge contextualisation in the Natural Sciences and Life Sciences classroom.

This qualitative research also has elements of design-based research, with participating teachers engaging in classroom action research after the intervention. After Cycle 1 of the larger NRF project, the data showed that teachers could benefit from engaging in classroom action research (CAR). Therefore, focus was also given to CAR in later interventions. This research also focused on two teachers' experiences of engaging with such CAR, based on the affordances of the Foldscopes for affective development.

3.4 Indigenous knowledge intervention – methodology

3.4.1 Introduction to the intervention

The indigenous knowledge intervention offered by the North-West University (NWU), focused on scaffolding teacher professional development to allow Natural Sciences and Life Sciences teachers to infuse context-specific indigenous knowledge into their teaching. The focus, therefore, was on providing the teachers with the knowledge and skills to facilitate such epistemological border-crossing in the Natural Sciences and Life Sciences classroom. Interventions also allowed teachers to create networks with other teachers, thus creating a community of practice (Pretorius, 2015). Teachers learnt specific indigenous knowledge examples from various cultures, thus teachers learnt from each other in a social context. During the intervention teachers learnt various pedagogies, such a cooperative-learning strategies and problem-based learning strategies, in the hope of increasing teachers' enthusiasm for teaching in various ways. Hewson (2015:114) proposed some ideas to incorporate indigenous knowledge, as well as Western science, into the Natural Sciences and Life Sciences classroom, namely:

- showing learners various medicinal plants;
- explaining how these medicinal plants are utilised in the pharmaceutical industry;
- allowing learners to conduct research projects; and
- Taking learners on excursions, such as, to nearby botanical gardens, which have an abundant array of medicinal plants.

As part of a larger designed-based research project, the interventions were built on design principles for professional development to improve the interventions. The interventions were designed by a number of co-investigators, together with the Principle Investigator (my supervisor), in this NRF-funded project, designed the intervention. As basis these researchers have used the intervention that was designed by Annelize Cronje at the University of Johannesburg (Cronje, 2015). After each cycle of implementation, design principles were distilled to further improve the intervention. The design of the interventions was based on the zone of proximal teacher development as suggested by Warford (2011), thus closing the gap (ZPD) between their 'actual development' and their 'potential development'. The principles for professional development identified from literature and summarised by De Beer and Kriek (n.d.:4) include:

1. *Focus on specific content*, identify certain pedagogies with specific content in the classroom;
2. *Ensure coherence by aligning curriculum and policies* this is vital to align indigenous knowledge with the current curriculum to ensure indigenous knowledge can be incorporated in the classroom;
3. *Engage in active learning*, hands-on activities done at the intervention;
4. *activities need to be practiced,* cooperative learning activities done by teachers during the intervention;
5. *Intervention must be worthwhile with regard to intensity and contact time*, portfolio as assessment and classroom visits;
6. *Teachers actively involved in their own learning and be reflective practitioners*, evidence of self-directed learning and reflection should be evident in their portfolios;

7. *Teaching resources available for teachers*, current curriculum learning materials developed for the intervention;
8. *Teachers exposed to inquiry-based learning experiences*, problem-based activities designed and completed at the intervention;
9. *Teachers' needs must be well-thought-out when designing the intervention;*
10. *Transfer must be researched after the intervention*, improvement follows from each intervention conducted in each cycle;
11. *Collaboration with the Department of Basic Education;* and
12. *Theoretical framework should be followed,* in this case social-constructivist perspective.

Content validity of the intervention was difficult, as the panel did not want to portray the more metaphysical component of indigenous knowledge systems, but decided to focus mostly on those tenets shared by both western science and indigenous knowledge. (Some scholars might therefore criticise the intervention of not providing a more multi-dimensional perspective of indigenous knowledge systems). If one looks at the definition of content validity being the extent to which a measure represents all facets of a given construct, the intervention would not meet the grade. However, in terms of the research instruments, content validity was ensured by using a panel of experts, in ensuring that the instruments used fairly represented the entire domain covered by the intervention (Zamanzadeh, Ghahramanian, Rassouli, Abbaszadeh, Alavi-Majd & Nikanfar, 2015).

3.4.2 Resources used for the intervention

Prior research from other studies indicates value in incorporating indigenous knowledge into the Natural Sciences and Life Sciences classroom (see 2.2.2). Indigenous knowledge infusion into the curriculum can create a more contextualised learning environment and, with hindsight, creates more curiosity amongst the learners. According to Avalos (2010:10) "*professional development is about teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students' growth*". The interventions offered by NWU are funded by the National Research Foundation, thereby allowing the researcher to provide additional resources for the teachers to take back to their classrooms. The additional resources included books, namely, *Medicinal Plants of the World* written by Ben-Erik van Wyk and Michael Wink; as well as *People's Plants* (a guide to useful plants of Southern Africa) written by Ben-Erik van Wyk and Nigel Gericke; HIV simulation kit and a Foldscope ($1 light microscope that can magnify up to 2000X, that was developed by Stanford University). The Natural Sciences and Life Sciences teachers were not remunerated for attending the course, but if the course was completed, the teachers receive 16 credits (NQF level 6) as well as SACE professional development points.

3.4.3 Risks associated with the intervention and this research

The risks associated with this research and intervention were minimal. Natural Sciences and Life Sciences teachers engaged in practical activities in a laboratory setting where they conducted anti-microbial testing (using a simplified Kirby Bauer technique) on medical plants (see 2.2.3 for more detail). The safety measures required to use the equipment, material and microbes were communicated to the teachers in a professional and safe manner and the university's safety measures were strictly enforced. The bacteria that were used were non-pathogenic thus, if teachers did not follow the laboratory safety measures, they were not exposed to harmful microbes and there was no health risk. Full ethical clearance was obtained for this research to ensure all parties were protected.

3.4.4 Intervention programme

Teachers were notified of the intervention through the Department of Basic Education, their school principals or on a social platform. Natural Sciences and Life Sciences teachers attended one of the interventions depending on where they were located. As part of a larger NRF study, many interventions were on offer in various provinces; however the researcher attended only 2 of the 4 interventions, specifically the three-day North-West University (Potchefstroom) intervention and the two-day Lenasia (Gauteng) intervention. The data from the Limpopo intervention and Calvinia intervention was also used in this research. The two-day and three-day interventions were carefully designed, using design principles to enhance professional development and infuse indigenous knowledge into the curricula (Cronje, 2015). The two-day intervention excluded a visit to a museum and the three-day intervention included a visit to a museum. The intervention exposed teachers to as many of the artefacts, indigenous examples and teaching pedagogies. The four interventions were adapted to the number of participants (see Appendix C and Appendix D).

Teachers were asked to fill in the pre-intervention VNOIK (views on the nature of indigenous knowledge) questionnaire (Cronje *et al.*, 2015) and the pre-intervention affective questionnaire designed by the researcher. These instruments are further explained under paragraph 3.5.3. The first of the three-day interventions included a visit to the Mphebatho Museum in Moruleng, Rustenburg, South Africa. Here teachers were taken on a tour and exposed to various cultural artefacts, medicinal plants and activities. The cultural artefacts ranged from spears, pottery and tools to pounded maize. Figure 3-1 shows the artefacts of the Bakgatla-Ba-Kgafela culture. Medicinal plants were displayed in the museum and the uses of a variety of plants where explained to the teachers. The activities included indigenous games ‘Morabaraba’ (Jagals & Van der Walt, 2016) and drumming (Jautse *et al.*, 2016). The photographs in Figures 3-2 and 3-3 show teachers enjoying the activities offered by the museum. Teachers were also exposed to other aspects of Bakgatla-Ba-Kgafela culture including how to prepare leather to make belts or shoes, as well as the indigenous use of cow dung. As seen in Figure 3-4, the cow dung is smeared on the floors of the huts and then decorated with various patterns which symbolise an occurrence, such as death or birth. The cow dung also serves as a mosquito repellent. Teachers also ate traditional food while engaging with indigenous knowledge holders.

Figure 3-1: Bakgatla-Ba-Kgafela cultural artefacts.

Figure 3-2: Natural Sciences and Life Sciences teachers playing 'Morabaraba' at the Mphebatho Cultural Heritage Museum.

Figure 3-3: Natural Sciences and Life Sciences teachers playing with drums at the Mphebatho Cultural Heritage Museum.

Figure 3-4: Cow dung smearing.

The last two days of each intervention were similar in terms of the activities planned for the NWU and Lenasia SLPs which were held at the North-West University (North-West teachers), and Lenasia High School (Gauteng teachers) respectively. On the second and the third day of the interventions, teachers engaged in various activities. These included problem-based learning, medicinal plants were tested for their anti-microbial properties using the Kirby-Bauer method; and cooperative learning activities such as the jigsaw method and De Bono's hats. The second intervention (Lenasia) also included a component on Ayurveda (Indian indigenous knowledge) and puppetry as a pedagogy *Homo ludens* (pedagogy of play) (Huizinga, 1955 as cited in Jautse, Thambe & De Beer, 2016). *Homo ludens* is a fairly new trend in STEM education. When the 'arts' are infused into STEM education, it is known as STEAM (Science, Technology, Engineering, the Arts and Mathematics Education). Natural Sciences and Life Sciences teachers were presented with the affordances of indigenous knowledge for self-directed learning in Natural Sciences and Life Sciences. These activities were discussed in Chapter 2. After the intervention, teachers were asked to complete the post-intervention VNOIK questionnaire (Cronje *et al.*, 2015) and the post-intervention affective questionnaire.

3.4.5 Consent requirements for the intervention

It is important to be aware of various elements regarding consent and ethics when working with adults. These elements include (Creswell, 2007:123):

- teachers may *withdraw* from the study at any time;
- teachers should know the *purpose* of the study as well as how the data will be collected;
- ensure the teachers know their information will be *confidential* at all times;
- teachers should be made aware of the *risks* involved (minimal in this research) and
- teachers should also be made aware of the *benefits* of this short learning programme.

These elements were adhered to in this research study. Teachers who attended the intervention were asked to participate in the research and were given a full outline and explanation of its purpose. The letter and consent form they received explained the nature of the research, with the assurance that their contributions would be voluntary. Teachers were asked to sign a consent form, after being informed of the nature of the research. More details of the ethics procedure will be explained later in this chapter.

3.5 Data collection strategy

Creswell (2007:118) refers to the data gathering strategy as the "*data collection circle*" which comprises a series of steps to be taken for successful data collection. The steps have been adjusted slightly to suit the nature of this research. Figure 3-5 below illustrates the steps followed in this research.

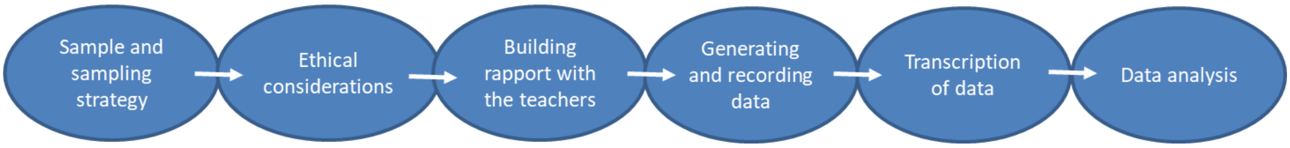


Figure 3-5: Altered 'data collection circle' Creswell (2007:118).

This process will be discussed in the following paragraphs.

3.5.1 Sample and sampling strategy

The purpose of the study was to investigate the affordances of an indigenous knowledge professional development intervention in the Natural Sciences and Life Sciences classroom on the affective development of Natural Sciences and Life Sciences teachers. Therefore, it was important to select key individuals for this research. As participant selection is vital, the researcher relied on the participants' subjective opinions within their environments (Creswell, 2013) as it relates to the social constructivist perspective. A purposeful sampling strategy (Creswell, 2007) was used in this context; Natural Sciences and Life Sciences teachers employed at secondary schools were chosen as they are experts in this field and could thus provide the necessary data required for this research. The Department of Basic Education (after obtaining permission from the Department) was informed about the short learning programmes for teachers. Various schools around the North West University and the University of Johannesburg were notified of the intervention. Social media was a great platform to advertise the intervention and invite teachers to attend.

The 32 Natural Sciences and Life Sciences teachers who attended the first intervention (18 to 20 July 2016) were predominantly from the North-West area. Of the 32 teachers, 6 teachers teach Natural Sciences and 26 teachers teach Life Sciences. The ethnicity of the teachers was 95% Black African, 5% were of White ethnicity. The second intervention (2 to 3 July 2017) involved 23 Natural Sciences and Life Sciences teachers from the Gauteng area. Of the 23 teachers, 5 teach Natural Sciences and 18 teach Life Sciences. The ethnicity of the teachers was 85% were Black African, 10% were White and the other 5% were Coloured. This intervention was held at the Nirvana Secondary School, Lenasia, Gauteng. The teachers who voluntarily took part in both interventions were from a variety of ethnic backgrounds and teaching experiences (from novice to very experienced). Once all the participants had been identified, it was important to obtain consent from parties involved, namely, the principals and teachers.

These short learning programmes were advertised, and any teacher who met the entrance requirements could register for the SLP's. The teachers who participated work in diverse schools, in townships and in more affluent areas.

Table 3-1: Table showing an overview of the sampling strategy and data collection.

Cycle of DBR	Intervention	Dates	Number of Natural Sciences and Life Sciences teachers (n) attended the course	Affective questionnaires completed	VNOIK questionnaires completed	Interviews	Classroom visits	Researcher attended
1	Limpopo intervention (Polokwane)	27 - 29 June 2016	62		Pre = 32 Post = 32			No
	NWU intervention (Potchefstroom)	18 to 20 July 2016	32	Pre = 6 Post = 8	Pre = 21 Post =21	5 personal interviews		Yes
2	Lenasia intervention (Gauteng)	2 to 3 July 2017	23	Pre = 13 Post =13	Pre= 15 Post= 18	2 focus group interviews	2 – IK integration in classroom	Yes
3	Calvinia intervention (Northern Cape)	28-29 July 2017	95		Pre = 36 Post = 36			No
							1 – CAR integration	Yes

3.5.2 Building rapport

It was vital to build rapport with the teachers during the intervention, as this promoted good communication and ensured the teachers were comfortable during the programme and classroom visits. Developing rapport was important to maintain receptive and non-judgemental attitudes throughout the research process. During the personal interviews it was important to ensure that the teachers understood the questions and were comfortable with the interaction. The focus group interviews were conducted during lunch to avoid participants being excluded from the activities of the intervention itself.

3.5.3 Generating and recording data

Qualitative data instruments (questionnaires, portfolios, personal interviews, focus group interviews, observations (during the intervention and classroom visits), reflections and artefacts) allowed the researcher to successfully collect and interpret data.

3.5.3.1 Views on the nature of indigenous knowledge (VNOIK) questionnaires (pre and post)

The VNOIK questionnaire was designed by Cronje (2014). The questionnaire was piloted among many teachers at previous interventions on indigenous knowledge. This instrument was validated, according to Cronje (2015:325) *"by a panel of experts consisting of two science educators, two indigenous knowledge specialists, a language expert and two science education specialists examined the initial questionnaire to ensure content and face validity".* The VNOIK questionnaire allowed teachers to respond honestly to a specific subject. Indigenous knowledge is a controversial topic and teachers have their own views, the views on the nature of indigenous knowledge (VNOIK) questionnaire has open-ended questions which allow honest input based on individual experiences (Cronje *et al.*, 2014) and was the first questionnaire introduced to participants. Teachers were asked to complete this questionnaire at the beginning of the intervention (pre-intervention VNOIK questionnaire). At the end of the intervention, teachers were asked to complete the post-intervention VNOIK questionnaire (Cronje *et al.*, 2015). Asking the teachers to fill in the questionnaire both before and after the intervention allowed the researcher to see if there was any benefit from the intervention. The researcher wanted specifically to observe if any affective development or affective learning took place (see Appendix E).

3.5.3.2 Affective domain (development) questionnaires (pre and post)

When designing a questionnaire, the aim and objectives of the research must be kept in mind. In this research it was important to have open-ended questions to ensure that the participants (teachers) could express themselves freely. This is also useful to the researcher, as it allowed the researcher to obtain valuable insights into the teachers' thoughts, feelings, perceptions and experiences about indigenous knowledge. The purpose of the affective questionnaire was to collect information to see if there was any affective development among the teachers with regard to indigenous knowledge. Therefore, a pre- and post-intervention questionnaire was developed, so answers could be compared, while analysing the data. It was important to ensure that the questionnaire was short, questions were easy to understand and that the purpose of the study was explained.

A panel of experts was asked to check the questionnaire for construct validity (i.e. that it measures what it is intended to measure). On the questionnaire, teachers were assured that their details and answers would be kept confidential at all times. The teachers were asked to complete the pre-intervention affective questionnaire at the beginning of the intervention and the post-intervention affective questionnaire at the end of the intervention (see Appendix F).

3.5.3.3 Portfolios and reflection

Portfolios are collections of work pieces (artefacts) that have been developed over a period of time (Johnson, Mims-Cox & Doyle-Nichols, 2009) and provide evidence for authentic teacher assessment (Attinello, Lare & Waters, 2006). These portfolios were an important part of the intervention and were aimed at teachers' professional development. The portfolios were designed to ensure structured and meaningful short learning programme for teachers who attended the two-day and three-day course. The portfolios also provided the researcher with feedback regarding the SLP; teachers' lived experiences and teacher professional development.

Teachers completed a variety of activities, such as the cooperation activities (De Bono's Hats) and the Kirby-Bauer method (problem-based learning). The portfolio designed was a combination of a growth portfolio, a showcase portfolio and an evaluation portfolio. In this portfolio teachers were expected to provide evidence of the following:

- laboratory report from the Kirby-Bauer method;
- three lesson plans, paying attention to problem-based learning, cooperative learning and indigenous knowledge;
- reflection on a lesson presented with indigenous knowledge infusion;
- a narrative or teaching philosophy, including their own PCK and professional development goals and
- reflections on certain experiences such as CAR and the intervention.

Resources were provided to enable the teachers to fulfil all the instructions related to the portfolios. Teachers also received a resource CD that contained various articles and more electronic resources that could be used in the classroom.

Teachers were encouraged to become critical reflective practitioners. Throughout the portfolio teachers were required to constantly reflect using the DATA (Describe, Analyse, Theorise and Act) method (Gravett, De Beer & Du Plessis, 2015). The DATA method streamlines the reflective write up. The questions teachers needed to answer while reflecting included the following (Gravett, De Beer & Du Plessis, 2015:13-132,139):

- Step 1 Describe what happened.
- Step 2 Analyse why it happened.
- Step 3 Theorise to improve your practice.
- Step 4 Act to test your theory in practice.

Teachers were requested to complete the portfolio within a three-month period. After completion, submission and assessment of the portfolios, teachers would receive 16 credits, NQF level 6 (National Qualifications Framework). These portfolios were used as a data generating tool, to see if any affective development had taken place.

The portfolio outline, outcomes, assessment criteria and contents can be seen on the zipped files accompanying this research (extra resources / documents).

3.5.3.4 Personal interviews

The personal interviews assisted the researcher to understand teachers' responses to specific phenomena and thus ensure the quality of the data gathered and that it related to the study (Niewenhuis & Maree, 2007). Since this research is a generic qualitative approach it was necessary to get an insight into teachers' affective experiences during the indigenous knowledge intervention. Therefore face-to-face (one-on-one) standardised open-ended interviews (Creswell, 2013) were completed with Natural Sciences and Life Sciences teachers. Five randomly selected teachers from the group were asked to be interviewed. The semi-structured interviews were conducted during the intervention depending on the intervention schedule. A variety of open-ended questions relating to the affective domain, affective development and affective learning were asked (see Appendix G). Construct validity was ensured by involving a panel of experts, who studied the designed questions, and provided suggestions for its improvement.

It was important not to make the teachers feel intimidated, but rather comfortable, thus ensuring the openness and honesty of their responses. To ensure confidentiality, teachers were interviewed in a quiet space where there were no other teachers.

3.5.3.5 Focus group interviews

The aim of the focus group interview was to get different views and experiences from several people in the group (Creswell, 2013). Focus group interviews are group interviews that consist of six to eight interviewees (Creswell, 2013). It is essential that the group is not too big or too small, as it is important to ensure that a wide range of views and experiences are captured. The interviewees in this research consisted of 10 Natural Sciences and Life Sciences teachers, divided into two groups of five. The Natural Sciences and Life Sciences teachers were from different ethnic backgrounds and their expertise ranged from novice to experienced. This allowed the researchers to simultaneously gather a large amount of data regarding indigenous knowledge and the affective domain.

Open-ended questions were also asked during the focus group interviews, thus allowing a variety of specific opinions (see Appendix I). Teachers were encouraged to articulate their own opinions and feelings during the interview. Teachers involved in the focus group interview bounced different ideas off each other, thus creating rich data.

The advantage of a focus group allowed the researcher to maintain control over the line of answering and questioning during the interview and ensure that the teachers did not deviate from the topic at hand (Creswell, 2013).

In this research, two focus group interviews were conducted during the indigenous knowledge intervention held in Lenasia, Gauteng. The interviews were recorded and later transcribed for analysis.

3.5.3.6 Observations during the intervention

The researcher's role during the interventions was 'observer as participant' (Creswell, 2013). This allowed for information to be gathered or recorded as it occurred. The researcher was actively involved in the intervention, while also observing teacher participation. The purpose of observation during research was to gather information from the Natural Sciences and Life Sciences teachers without communicating with them (Niewenhuis & Maree, 2007). The researcher used senses and intuition, while remaining objective (Cronje, 2015). Observations were conducted during the indigenous knowledge intervention. For the researcher it was important to see how the teachers interacted with each other as well as with the activities that they completed. Field notes were taken during the intervention as part of recording observations. The data gathered was used as part of the triangulation analysis.

3.5.3.7 Classroom observations

Classroom visits are a vital part of any educational research (UNICEF, 2000), because this is where the teaching and learning takes place. The classroom visits in this research was purely to study the Natural Sciences and Life Sciences teachers in their teaching environment to see whether they included indigenous knowledge in their teaching.

The researcher conducted the classroom observations as ‘complete observer’. This means that the researcher observed without participating (Creswell, 2013). To remain objective, the reformed teaching observation protocol (RTOP) instrument was used (see Appendix M) (Piburn & Sawada, 2000; Sawada *et al.*, 2000), which was designed by the Evaluation Facilitation Group of the Arizona Observation for Excellence (Sawada, Piburn & Judson, 2002). The RTOP instrument was used to measure the extent to which the Natural Sciences and Life Sciences teachers affectively embraced the incorporation of indigenous knowledge into their teaching practices.

Each classroom visit was at a different school. Furthermore, classroom visits to view the classroom action research (CAR) with the Foldscopes were conducted, this will be further discussed in 3.5.3.8. Before the classroom visits could occur, permission from various stakeholders was required. The principal and the School Governing Body (SGB) were notified of the classroom visit (see Appendix K). All the learners were notified of the classroom visit and were asked to obtain permission from their parents. A permission letter was sent home (see Appendix L) and signed by all the parents to ensure permission was obtained (ethical requirement). This was done out of courtesy, as the object of the study was the Natural Sciences and Life Sciences teachers, not the learners.

3.5.3.8 Classroom action research observations

Gravett and De Beer (2015:344) explain classroom action research as "*more data-based and systematic than reflection, but less formal and controlled than traditional educational research*". It is vital that practicing teachers becomes researchers as this allows them to learn a variety of ways to incorporate more problem-based approaches in the classroom, possibly creating curiosity amongst the Natural Sciences and Life Sciences learners.

One of the outcomes of the intervention (indigenous knowledge intervention held by the North-West University), was not only to encourage teachers to participate in more inquiry approaches, but also to engage in classroom action research (CAR). Gravett and De Beer (2015:344) define classroom action research as *"a midpoint between teacher reflection at one end, and traditional educational research at the other".* One of the design principles that were distilled during the intervention, was that teachers should be encouraged (and empowered) to engage in CAR, this is an aspect under the affective domain (Krathwohl, 1964). Therefore two teachers, after the intervention, engaged in Foldscope research. Furthermore, two willing participants were selected to observe their classroom action research (CAR) task with regard to Foldscopes and water quality in the Natural Sciences and Life Sciences classroom. Thus, the link between the Foldscopes and the affective domain was investigated.

The Foldscope activity (see Appendix R) was designed by one of the teachers to streamline the use of the Foldscopes in the classroom. The problem that the teacher identified for their CAR was how to address the affective domain, and spark learners' interest specifically in the topic of ecology and especially with regard to current issues concerning the quality of water in South Africa. The teacher investigated two problems during the CAR:

1. learner motivation and interest,
2. how to contextualise the Foldscope learning task with reference to water quality.

The Foldscope activity included two parts, activity 1 and activity 2. During activity 1 the learners were required to collect a water sample from a nearby water source. While collecting the sample they had to practice their observation skill, i.e., look at the colour of the water and identify any organisms in the water. Learners also had to show practical skills, i.e., take the pH and the temperature of the water. Activity 2 was during class time, in this time learners were required to fold the Foldscope and test the water's pH and temperature. After folding the Foldscope learners were required to make prepared slides from their water to view with their Foldscope.

The Foldscope is a $1 foldable microscope, developed by Stanford University, which can be used to observe unicellular organisms. Learners were asked to complete a water quality project and write reflections on their overall experiences using and folding the Foldscope. This reflective data was collected from the learners as artefacts. No videos were taken, to ensure confidentiality at all times. The data was transcribed and coded by the researcher for evaluation from the CAR and the use of Foldscopes.

Ethical considerations were vital: parental permission for each learner was obtained by the teacher. As a researcher, special permission forms were required for classroom observations, so once again, consent from parents was mandatory.

3.5.3.9 Artefacts

Artefacts are authentic evidence of the research; this evidence was collected during the entire research process. The artefacts collected in this research included the following (Creswell, 2013):

- photographs (qualitative audio-visual material);
- audio recordings;
- personal documents (portfolios);
- teacher reflections;
- learner reflections from the Foldscope activity and
- video clips from the intervention.

Photographs were taken during the intervention and classroom visits. These photographs can be seen throughout the research and on the zipped files (extra resources) provided. The photographs show only the teachers at the intervention, as we had been granted permission to work with teachers only. The classroom photographs are only of the classroom, with no learners' present.

The audio recordings include the personal, one-on-one interviews and the focus group interviews. This was necessary as the information was transcribed and analysed to obtain results.

Personal documents (portfolios) were assessed and used as a data gathering tool. The teachers included reflections in their portfolios and this data was also captured and analysed.

The learner reflections were transcribed to see if the Foldscope is a valuable tool to use in the Natural Sciences and Life Sciences classroom, and to determine whether it enhances affective learning in the Natural Sciences and Life Sciences classroom for both the learners and the teachers.

The video clips were used as part of the data. The video clips were based on the intervention activities and were produced by an external videographer. These videos were uploaded onto YouTube. The video clips are a valuable resource to show other teachers the benefit of including indigenous knowledge into the classroom as well as encouraging others to attend the interventions offered. The videos have been downloaded and added to the zipped files (extra resources). Particularly important to this research is teachers' enthusiastic participation in the activities and their body language (for example); a lot can be learnt from such observations about their affective experiences.

All the artefacts were handled with confidentiality, and permission was granted to work with the artefacts mentioned.

3.5.4 Transcription of the data gathered

Transcription of data is a vital part of research. Before the data can be made sense of, the data must be typed out. All the data, including the personal interviews, focus group interviews, VNOIK questionnaires, affective questionnaires, and teacher and learner reflections, was transcribed. The audio recordings of the personal interviews and the focus group interviews were carefully listened to and every word was typed onto paper. The answers to the questionnaires and the reflections were transcribed verbatim, as it was important to get the full experiences and feelings of the Natural Sciences and Life Sciences teachers with regard to indigenous knowledge.

3.5.5 Data analysis

Once the data was transcribed, the next stage was to analyse the data, i.e., content analysis (Neuendorf, 2016), keeping in mind the research questions, aim and objectives. Amos-Hatch (2002:148) describes data analysis as "*a systematic search for meaning, a means of processing qualitative data so that what has been learned can be communicated to others".* Data analysis allows for arrangement of data to make sense of it. In making sense of the data, themes emerge and this should link to the research question. All the data that had been transcribed was analysed to make sense of complex phenomena. Three methods were used in this research, namely, Saldaña's (2015) code-to-theory, Cronje's (2015) rubric and Krathwohl's (1964) levels for the affective domain.

3.5.5.1 Saldaña's (2015) code-to-theory

Saldaña's (2015) code-to-theory was used to form themes that intertwined with the literature review. Figure 3-6 illustrates how data is analysed using Saldaña's code-to-theory method. Saldaña (2015:3) describes a code as "*a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-base or visual data"*. The transcribed data was read and descriptors (codes) were extracted from the data. Descriptors were used and the frequency of the number of times that the descriptors were found in the data was also shown in the tables created. Codes were collated to form categories and from the categories, sub-themes emerged and from the sub-themes, major themes were developed.

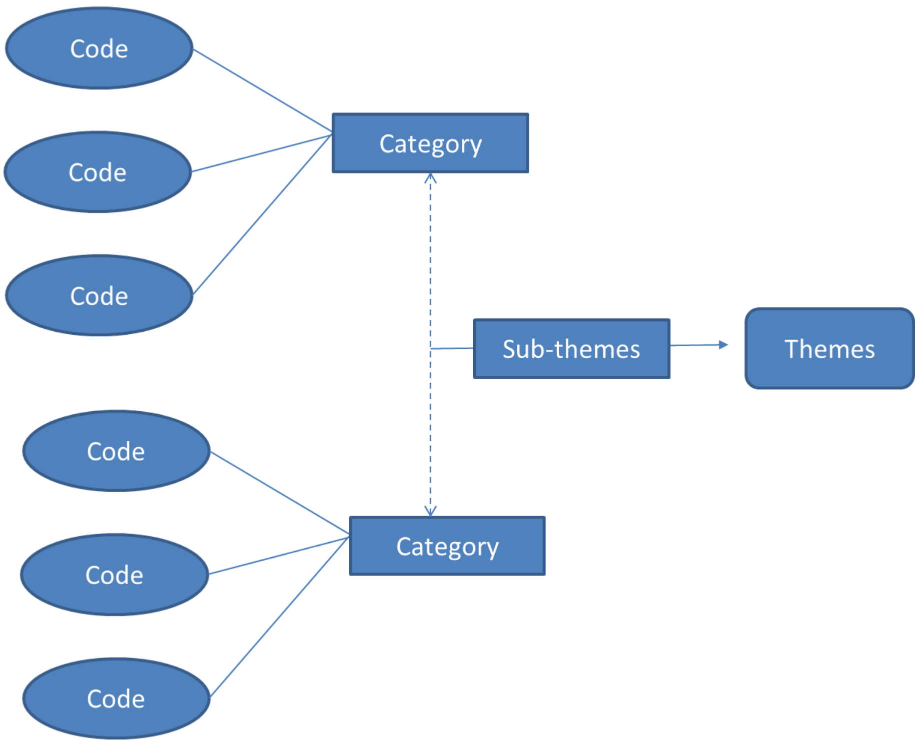


Figure 3-6: Figure illustrating code-to-theory model (Saldaña, 2015).

Saldaña (2015) differentiates between various coding filter methods. The types of coding that were infused in this research include the following:

- in-vivo coding;
- emotion coding;
- values coding;
- descriptive coding; and
- simultaneous coding.

In-vivo coding is when the 'direct speech' of the Natural Sciences and Life Sciences responses is used, rather than the codes selected by the researcher (Saldaña, 2015). Qualitative research is of a descriptive nature and prefers natural responses from the teachers. Emotion coding was a vital part of this research as it investigated the affective development of teachers. Emotions are part of the teachers' worldview and provide a variety of perspectives (Saldaña, 2015) regarding indigenous knowledge. Values coding identified teacher values, attitudes and beliefs (Saldaña, 2015). This is a generic qualitative study, which revealed teachers' cultural beliefs. Descriptive coding was appropriate to use as teachers' responses were long. Descriptive coding condenses the long phrases to a word (noun) or a short phrase (Saldaña, 2015). Simultaneous coding was evident as coexisting with emotion and value coding (Saldaña, 2015).

3.5.5.2 The Cronje (2015) rubric for analysing the VNOIK data

The VNOIK questionnaires were transcribed and analysed using the technique described by Cronje *et al.,* (2015:329). A rubric (see Appendix S) was used to code teachers' responses to the questions. The codes used were (see Table 3-2 below):

- an informed view;
- a partially informed view; or
- an uninformed view.

Each participant was allocated a weighting for their responses, namely, 0 for an uninformed view, 1 for a partially informed view, and 2 for an informed view. To obtain the predominant category for each teacher, an average was calculated and rounded off (Cronje *et al.*, 2015:329).

Table 3-2: Example of the table to code teacher responses to the VNOIK questions (Cronje *et al.*, 2015:329)

Participant	Qu 1	Qu 2	Qu 3	Qu 4	Qu 5	Qu 6	Qu 7	Qu 8	Qu 9	Qu 10	Score
Example	UI	UI	PI	PI	I	I	I	I	PI	I	13

Note: Qu = Question; N/A = not answered; UI = uninformed view (0); PI = partially informed view (1); I = informed view (2)

3.5.5.3 Krathwohl's (1964) levels for the affective domain

The affective questionnaires were analysed using Krathwohl's levels for the affective domain. A table was used (see Table 3-3) to see if any affective development took place or if there was a shift between levels. The aim of this research was to see if any affective development had taken place before, during or after the indigenous knowledge intervention.

Table 3-3: Table showing the affective shift, using Krathwohl's levels for the affective domain (Neumann & Friedman, 2010:5).

Affective level of each Natural Sciences and Life Sciences teachers Affective pre- and post-intervention questionnaire Key: Level 0- Not aware Level 1- Receiving (aware) Level 2- Responding Level 3- Valuing Level 4- Organising Level 5- Characterising by value set													
	Pre-questionnaire						**Post-questionnaire**						
Affective levels	L0	L1	L2	L3	L4	L5	L0	L1	L2	L3	L4	L5	Level shift
Participants													

Table 3-4 below was formulated by the researcher in order to identify any codes that appeared in the data.

Table 3-4: Table showing descriptions for affective learning (Neumann & Friedman, 2010:5).

Codes	Krathwohl's affective hierarchy (1964)	Description of the hierarchy	Examples (Jackson *et al.*, 2016)
L0	Not aware	No awareness. Showed no interest before, during or after the indigenous knowledge intervention.	Cannot remember or explain pedagogies and link them to the affective domain.
L1	Receiving	Becoming aware.	Awareness of IK and pedagogies during indigenous knowledge professional development intervention.
L2	Responding	Participation in tasks. Discussions.	Teacher reflective practice (VNOIK and affective domain pre- and post-intervention questionnaires) as well as following instructions, participation and motivation to learn.
L3	Valuing	IK is valued. Promising attitudes.	Affective development of the teacher (affective domain). Acceptance of IK.
L4	Organising	Accountable for their own behaviour, showed planning (CAR).	Examine and discuss indigenous knowledge, integrating (IK) into own value system.
L5	Characterising by a value set	Consistent behaviour, show consistency towards internalised values. Professional commitment.	Influence teacher PCK, values, morals and attitude when teaching of indigenous knowledge. The teacher has a more positive outlook and understanding of the nature of IK (working independently and becoming self-directed).

Table 3-5 shows each item as presented on question 8 on the affective questionnaire. These items aimed to get an understanding which domain teachers' value most.

Table 3-5: Table showing outcomes per item as illustrated on the affective questionnaire.

Outcome (Item)	Domain illustrated in the outcome
1. Learners should have a sound knowledge of Natural Sciences and Life Sciences	Cognitive domain
2. My biggest role as a teacher is to ensure that most learners pass the exam	Cognitive domain
3. Learners should be able to think critically and substantiate opinion with relevant data	Cognitive domain
4. Learners should be able to plan and execute an experiment	Cognitive domain
5. Learners should appreciate value of Natural Sciences and Life Sciences in everyday life	Affective domain
6. Learners should be able to analyse and synthesise when studying Natural Sciences and Life Sciences	Cognitive domain
7. I am motivated and positive to teach indigenous knowledge in my classroom	Affective domain
8. My role as a teacher encompasses cultivating an interest in Natural Sciences and Life Sciences in the learners	Affective domain
9. Learners should be biologically literate citizens that value the contribution of Natural Sciences and Life Sciences in modern society	Affective domain
10. Learners should be scientifically literate citizens who can compete in a global society	Cognitive domain
11. Learners should appreciate the science underpinning many indigenous knowledge practices	Affective domain

3.5.5.4 Triangulation

Triangulation was utilised to obtain a 'rich description' from the captured data. Furthermore, triangulation compares different data sources, in order to get to a richer description in the findings. Using three different methods of data analysis was part of triangulation and ensured the validity and reliability of this research study. Three classroom visits were attended by the researcher accompanied by a research colleague; this also assisted with ensuring triangulation. Discussions of the classroom visit, and portfolio assessment with the research colleague improved the validity of this research.

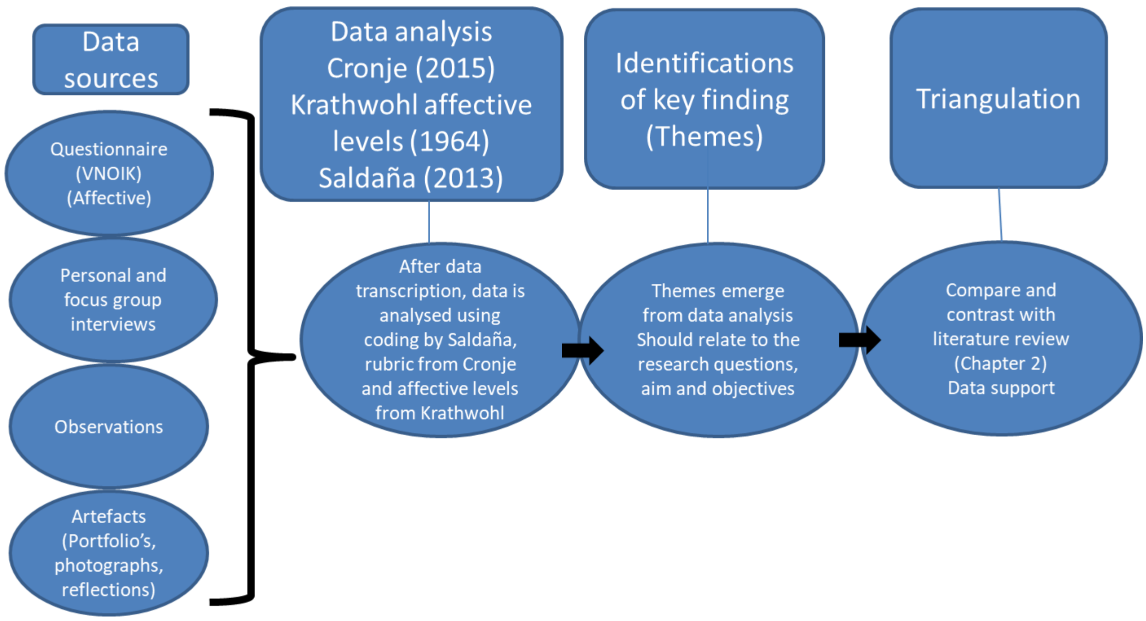


Figure 3-7: Overview of the data analysis procedure used in this research.

3.5.6 Gaining access, permission procurement and ethical considerations

Ethics are a necessity in any research study (Orb *et al.*, 2001), and permission to work with the participants should be obtained (Natural Sciences and Life Sciences teachers). Ethics protect the participants and ensure confidentiality. In qualitative research, the researcher will need teachers to share their experiences of a particular phenomenon freely and autonomously, whilst observing them as part of their ordinary setting, this is known as emic perspective (Orb *et al.*, 2001). Before teachers expressed their experiences, permission was granted by the ethics committee to ensure that there were no issues that could arise. The ethics committee ensured that all ethical principles were adhered to in order to protect the participants.

To gain access, permission should be granted, and the risks should be evaluated (see 3.4.3). Firstly, it is important to get permission from the institution where the study is being undertaken, in this case the North-West University (NWU). The NWU has several research ethics committees (RECs), and the Faculty of Education's REC considered the generic ethical clearance for this NRF-funded project. This generic ethical clearance was granted for the greater project (certificate reference: NWU-00271-16-A2). Individual ethical clearance is required as there were affective questionnaires handed out to the teachers as well as an individualised interview protocol (certificate reference: NWU-00357-18-A2) (see appendix T). Permission from the Department of Basic Education (North-West province) was also obtained as well as the school principals and the teachers who took part in the short learning programme.

Orb *et al.* (2001) describe three principles regarding ethics in qualitative research; these include autonomy, beneficence and justice. The first principle, autonomy, suggests teachers should have a good understanding of the research. Teachers should be briefed on the aim and objectives. In this research, teachers were informed and were provided with a letter describing the nature of this research to ensure that they were willing to participate in this research and that they were aware they could withdraw at any stage (see Appendix A). The second principle, beneficence, is to ensure "*doing good for others and preventing harm*" (Orb *et al*., 2001: 95). Teachers were not harmed during the short learning programme. Teachers worked with laboratory equipment and safety procedures were followed at all times. Pseudonyms have been used, rather than the teachers' names. The third principle, namely, justice, refers to "*equal share and fairness*" (Orb *et al*., 2001:95). Teachers were a major part of this research and their contributions were essential. Teachers were provided with many resources (see 3.4.2). It was kept fair as all teachers received the same resources whether they contributed to the study or not.

Confidentiality was a vital aspect to ensure that teachers were treated fairly. During data transcription and data analysis the teachers' answers and feedback were treated fairly, and discretion was used at all times. The potential benefits outweighed the risks and allowed Natural Sciences and Life Sciences teachers to enhance their PCK, indigenous knowledge understanding as well as boost their affective professional development.

3.6 Data validity, reliability and trustworthiness

Validity, reliability and trustworthiness are important facets in qualitative research to ensure that all aspects of the research conform to quality measures. Validity is a facet in qualitative research that ensures that the researcher is actually measuring what was intended to be measured (Thyer, 2001). In this research it is important not to deviate from the aim of the research and remain focused on the affective development of the teachers (and, to a limited extent, of the learners in the CAR research on the Foldscopes) during and after the indigenous knowledge intervention. The open-ended questions for the interviews and questionnaires were designed with this aim in mind and ensured the validity of the research. Therefore, validity is vital for 'the accuracy of the findings' (Thyer, 2001).

Internal validity refers to the research results, the results should be presented in the same framework that the researcher investigated (Niewenhuis & Maree, 2007). Because data triangulation was used, the various data collection methods, such as questionnaires, observations and interviews enhanced the validity of the data (Huberman & Miles, 2002; Meijer & Hartell, 2009; Creswell, 2013). Data was linked and compared from the different data collection methods and literature using data triangulation (Denzin & Lincoln, 2008; Abowitz & Toole, 2010). To support the validity and trustworthiness in this research and to avoid bias, the different types of data, such as teacher reflections and data from questionnaires, were compared to existing literature (Golafshani, 2003). Therefore, construct validity was ensured by asking experts to peruse the affective questionnaire, the generic questionnaire and the interview protocol. Furthermore, data validity was confirmed by continued engagement in the field; this research was conducted over a three-year period. Continuous discussions regarding findings with fellow students, the supervisor and the co-supervisor ensured validity (Henning *et al.*, 2004). The findings were also presented at the ISTE conference. Trustworthiness of qualitative data can be guaranteed through credibility, transferability, dependability and confirmability (Babbie & Moutin, 2002). Trustworthiness should ensure the results obtained are credible in adherence to the literature, the context of the study.

According to Thyer (2001) reliability is the replicability and consistency of findings. Various details about sample selection, methodology and data analysis must be provided and explained to ensure the reliability of the findings. In this research the data was reliable and the collection methods, namely, the interview and the questionnaires' questions (VNOIK and affective) remained the same. The same questions were asked of all interviewees. The same RTOP (reformed teaching observation protocol) instrument was utilised for the classroom visits. The classroom visits were made by two researchers, verifying the infusion of indigenous knowledge into the Natural Sciences and Life Sciences classroom.

3.7 Conclusion

Chapter 3 provided an overview of the research design and the research methodology. This research followed a generic qualitative approach, with design-based research elements. The research lens utilised was the third-generation Cultural-Historical Activity Theory (CHAT), to identify any benefits of or contradictions in the activity systems. The activity systems considered in this research were the intervention and the classroom (teaching environment) as well as the teacher teaching (using CAR) in the classroom and the learner learning in the classroom (using Foldscopes). Krathwohl's taxonomy for the affective domain was utilised to see if any affective development occurred from the indigenous knowledge intervention. A variety of data methods were used to ensure validity and reliability, namely VNOIK questionnaire, pre- and post-intervention affective questionnaires, personal teacher interviews, focus group interviews, observations, classroom visits (RTOP), artefacts, reflection and portfolios. The variety of sources were necessary as this provided a better understanding of the affective development of the teachers as a whole, with regards to indigenous knowledge. Triangulation was utilised to match data (through cross verification from a variety of sources) with the findings to ensure that the research findings were sound. The methodology included a two-day and three-day indigenous knowledge professional development for Natural Sciences and Life Sciences teachers. Teachers were exposed to a variety of pedagogies, and hopefully, from an affective stance, teachers will incorporate this into their teaching. Data was analysed using coding (Saldaña, 2015), rubric designed by Cronje (2005) and Krathwohl's taxonomy for the affective domain.

CHAPTER 4: DATA ANALYSIS AND SYNTHESIS

4.1 Introduction

Chapter 3 provided an overview of the research process, research design and methodology of this design-based qualitative research study. Chapter 4 focuses on how the data collected was analysed and synthesised, and the emerging themes from this data are discussed. Data was collected from four different indigenous knowledge interventions. Interventions consisted of two-day and three-day interventions (short learning programmes), and the outline of the interventions can be seen in Appendices C and D. (With the three-day interventions, participating teachers had the opportunity to engage with the holders of indigenous knowledge, at a suitable museum. This aspect was not included in the two-day interventions). Although the researcher attended only two of the four interventions, data was used from all the interventions. (This research is part of a larger NRF-funded project). The data collected in this research included teachers' responses to the VNOIK questionnaire, responses to questionnaires with items related to the affective domain, personal (individual) teacher interviews, focus group interviews, classroom visits (utilising the RTOP instrument), teacher portfolios, artefacts, teacher and learner reflections. The data was then transcribed and analysed using various data analysis techniques. These techniques included Saldaña's (2015) code-categories-themes technique, Cronje's (2015) rubric technique for analysing VNOIK data, and Krathwohl's (1964) affective domain taxonomy technique. These coding techniques provided a variety of meaningful themes that were identified from the research conducted. Ultimately, the goal is to find out if any affective development or learning took place during and after the indigenous knowledge intervention, and if teachers affectively embraced classroom action research (CAR) in their teaching practices. The data that was collected was analysed only from an affective standpoint using *in vivo coding*, *emotion coding* and *value coding* as part of descriptive codes. The data analysed answered the primary and secondary research questions and allowed the researcher to draw comparisons, note contrasts and evaluate the degree of affective development of Natural Sciences and Life Sciences teachers and their classroom action research (CAR) experiences. The analysis provided various recommendations for further research and studies in this field of affective development and indigenous knowledge – which will be discussed in Chapter 5.

4.2 Summary of qualitative data analysis methods used in this research

4.2.1 Using Cronje rubric method for data analysis

The VNOIK rubric was designed by Cronje (2015), guided by research done by De Beer & Van Wyk (2011); while conceptualising a matrix method for ethnobotanical research. The rubric was utilised to 'quantify' qualitative data. Part of the rubric used a weighting or scoring system for the Natural Sciences and Life Sciences teachers' responses. This rubric was used to analyse the VNOIK questionnaire filled in by the Natural Sciences and Life Sciences teachers (see Appendix E). The VNOIK questions are listed in Table 4-1 for easy reference. This rubric allowed for consistency in coding as well as assessing the Natural Sciences and Life Sciences teachers' answers. The rubric has generic responses as codes, namely, informed view (I) which was allocated two points, partially informed view which received one point and uninformed view which was zero points (see 3.5.5.2).

Cronje (2015:130) streamlined the assessment criteria in terms of specific responses from the teachers. Each question had certain requirements to obtain these points see Table 4-2. In terms of question 1 Natural Sciences and Life Sciences teachers had to mention the tenets of indigenous knowledge to score points. For classification as an informed view in question 1, teachers had to refer to at least four tenets, for a partially informed view in question 1, teachers had to refer to at least two tenets and lastly, for an uninformed view in question 1, teachers need only provide one or not provide any tenets of indigenous knowledge. The tenets of indigenous knowledge can be referred to in Table 2-1. An average was calculated and rounded off (Cronje, 2015). These averages provided a more nuanced description of teachers' views about incorporating indigenous knowledge affectively into their teaching pedagogies.

Table 4-1: Views-on-the-nature-of-indigenous-knowledge questionnaire (VNOIK) (Cronje, 2015: 326).

	Questions from VNOIK
1.	In your view what is indigenous (or traditional) knowledge? What makes indigenous knowledge different from other types of knowledge systems (such as Western knowledge)?
2.	Practitioners of indigenous knowledge (e.g., elders, herbalists, traditional healers) observe nature to generate knowledge. Do they do experiments and tests to verify or validate this knowledge? • If yes, explain how they test or validate their knowledge • If no, explain why not
3.	Practitioners of indigenous knowledge observe nature and give explanations about their observations. Elders in a community can, for example, explain where lightning comes from. Do the elders always use natural causes to explain their observations such as lightning, or do they sometimes include supernatural causes in their explanations? • If they only use natural causes, explain why and give examples of some of the causes. • If they sometimes use supernatural causes, explain why and give examples of some of the causes.

4.	Indigenous knowledge is transferred from one generation to the next over many decades and centuries. Does this knowledge stay the same or does it change over time? • If yes, explain why it stays the same • If no, explain the causes of such changes
5.	*Hoodia gordonii* is a plant that was used by Khoi-San hunters to suppress their hunger and thirst when they went on hunting expeditions. How do you think the Khoi-San people come to know that this particular plant has these properties?
6.	Sustainable development is an emerging concept that includes topics such as hunger, poverty and underdevelopment. Globally governments and organisations struggle to find solutions for these important issues. Do you think indigenous knowledge can be used to alleviate some of these problems? • If you say yes, please explain why and how indigenous knowledge can be used. • If you say no, please explain why it cannot be used to solve these problems.
7.	An athlete regularly competing in marathons struggles with pain in his legs during the last part of a marathon and can sometimes not complete a marathon due to this. The athlete decides to consult a traditional healer to determine why his legs pain during the last part of a marathon. • What methods do you think the traditional healer will apply to diagnose the problem when consulting with the athlete? • What possible treatment or advice do you think he will give the athlete?
8.	Myths are stories that are told in different cultures by elders from one generation to the other. Do you think myths and rituals play any important role in indigenous knowledge systems? • If yes, explain why and provide examples. • If no, explain why and provide examples.
9.	Some claim that indigenous knowledge is infused with social and cultural values. That is, indigenous knowledge reflects the social and political values, philosophical assumptions, and intellectual norms of the specific culture in which it is practiced. Indigenous knowledge is thus generated locally and can only be used in a specific area. It cannot be used universally in other contexts or globally to solve different problems. • Do you believe that indigenous knowledge reflects the social and cultural values of a specific community? Explain with the use of examples how indigenous knowledge reflects the social and cultural values of a local community. • Do you believe that indigenous knowledge can only be used in a specific area or do you believe it can be used in other areas or globally to solve problems? Explain your answer with examples.
10.	Indigenous knowledge is passed from one generation to the other by elders. The elders are deemed very important and some people believe their ways of knowing knowledge is truth and cannot be challenged. Does this mean that current practitioners of indigenous knowledge must use this knowledge exactly as it was passed on to them, or can they use their creativity and imagination to modify the indigenous knowledge to solve current problems? • If you say yes and believe that indigenous knowledge practitioners cannot change this knowledge, explain why. Use examples if possible. • If you say no and believe that indigenous knowledge practitioners can change and modify their knowledge, explain why. Use examples if possible.

Table 4-2: Table showing suggested responses on the VNOIK questionnaire (Cronje, 2015:130).

Question from VNOIK	**Informed view (I)** Natural Sciences and Life Sciences teachers refer to or answers:	**Partially informed view (PI)** Natural Sciences and Life Sciences teachers refer to or answers:	**Uninformed view (UI)** Natural Sciences and Life Sciences teachers refer to or answers:
1	Four or more tenets of indigenous knowledge mentioned.	Two tenets of indigenous knowledge mentioned.	One or no tenets of indigenous knowledge mentioned.
2	Yes, with correct explanation.	Yes, with no explanation.	No.
3	Include supernatural to explain cause, with examples of unnatural causes.	Include supernatural to explain cause, without examples of unnatural causes.	No.
4	Yes and no or yes, but explain resilience of indigenous knowledge, but knowledge can be adapted as society changes.	Only yes with correct explanation or no with correct explanation of why it changes.	Not sure, with no explanation.
5	Suitable answer with explanation and mentioning 2 aspects NOS.	Suitable answer with explanation and mentioning 1 aspects NOS.	Not sure or no explanation.
6	Yes, with good explanation using examples.	Yes, explanation unsuitable.	Not sure or no explanation.
7	Provides good explanation on advice and mention herbal treatment from a holistic viewpoint.	Provides minimal explanation on advice and mention herbal treatment from a holistic viewpoint.	Not sure or no explanation.
8	Yes, with examples or explanation.	Yes, with no examples or explanation.	Not sure or no explanation.
9	Yes, agree that IK reflects social and cultural values as well as a good explanation. Teacher believes it is universal/transferrable with relevant explanation.	Yes, agree that IK reflects social and cultural values as well as an explanation. Teacher believes it is universal/transferrable with no explanation.	No to both questions posed; or not a suitable explanation.
10	Yes, it can change with explanation and example.	Yes, explanation not appropriate.	Not sure or no explanation.

4.2.2 Using Krathwohl's (1964) taxonomy for the affective domain analysis

The affective domain includes teacher and learner interests, attitudes, values and emotions (Birbeck & Andre, 2009; Clark & Price, 2002). Krathwohl's taxonomy (1964) for the affective domain was utilised as an intermediary theory to distil the data collected. It was important to see if affective shifts occurred during and after the intervention or during the class visits. This assisted the researcher to identify if any affective development took place during the indigenous knowledge intervention as well as in the classroom afterwards. There are five affective hierarchal levels including receiving, responding, valuing, organising and characterising by a value complex (Krathwohl, 1964; Lynch *et al.*, 2009). The focus of this research was to investigate if any affective gains took place among the teachers who engaged in the intervention as well as in CAR. A table was therefore designed to show if any affective shifts occurred (see 3.5.5.3).

4.2.3 Using Saldaña's (2015) code-to-theory analysis method

This qualitative research explored teachers lived experiences of the indigenous knowledge intervention and of incorporating it into the classroom. In so doing it also addressed the affective domain, as well as the CAR investigation. Saldaña's (2015) code-to-theory was the main method used to analyse the data that was collected in this research. Descriptors were identified (see Table 4-3), and codes were applied to words or phrases in the answers given by the Natural Sciences and Life Sciences teachers, these were then used to create categories and these categories were grouped together to obtain sub-themes and then specific affective themes (see 3.5.5.1). Saldaña (2015) discusses a variety of coding filter methods, some of these methods are utilised. This provided an in-depth understanding of the data collected. The following coding filters that were used include *in-vivo coding, emotion coding, values coding, descriptive coding* and *simultaneous coding.* These are described in detail in 3.5.5.1.

Table 4-3: List of descriptor codes used for some of the data collected Saldaña (2015).

Descriptors	Code	Keywords identified from teacher responses	Explanation of descriptor linking to the research question
Indigenous plants/medicinal plants.	P	Medicinal, plants, aloe, any reference to medicinal or indigenous plants.	Indigenous plants or medicinal plants are important when teaching Botany, good way to infuse IK into the curriculum, this can also encourage learner curiosity.
Resources and materials for IK not available.	RM^0	Lack of context-specific IK resources such as textbooks, worksheets, assessments, etc.	No resources or materials available. Lack of support. No expert knowledge (no elders to share knowledge, i.e., knowledge lost).
Time in the classroom.	T^-	No time, pace setter and full curriculum.	Teachers struggle to manage their time with regard to getting through the content of the curriculum. Many factors contribute to this, including full curriculum, too many learners in the class (time used for classroom management), pace setter,

			overassessment, no time to do cooperative learning strategies or problem-based strategies, etc.
Teaching strategies such as problem-based learning and cooperative learning.	TS^{+}	De Bono's hats, jigsaw, Kirby-Bauer method, problem-based learning, (inquiry-based learning, i.e., heuristic methods).	Positive influence on learners learning in the classroom with regard to teaching using these teaching strategies to enhance the affective domain (create excitement).
Teaching strategies such as problem-based learning and cooperative learning.	TS^{-}		Teachers do not incorporate these strategies. Negative outcome with regard to the affective domain.
Reference to indigenous knowledge or indigenous knowledge systems.	IK^{+}	Forefathers, knowledge transfer from generation to generation Includes NOIK.	Acceptance, reference and understanding of indigenous knowledge, including integration of IK in the classroom. Positive outlook of IK and NOIK.
Misconception of IK.	IK^{0}		Do not know what IK is or how to incorporate it into the curricula or use it as part of pedagogies.
Reference to Western knowledge or Western knowledge systems.	WK	Testing, practicals with reference to scientific experiments.	Reference scientific explanations are based upon hypothesis, theories and laws only. Teachers prefer Western views only.
Nature of Science.	NOS		Any reference to NOS (see table 2-1), i.e., scientific theory and scientific method.
Indigenous knowledge intervention / short learning programme.	IKI^{+}	Learnt a lot from SLP.	Positive feedback with regards to IK intervention.
Affective domain.	A^{+}	Hearts-on, general feelings, motivations, attitudes and values.	Reference and understanding to the affective domain mentioned by teachers or learners. Full understanding of the affective domain evident.
Affective domain.	A^{-}	Lack of understanding of the affective domain.	Teachers do not know how to teach within the affective domain.
Conflict of IK / affective.	C^{+}	Witchcraft, religious conflict, does not believe in IK.	Find out if there is conflict regarding worldviews, IK and the affective domain.
Pedagogical content knowledge.	PCK	Cognitive domain, content knowledge, pedagogical knowledge.	Required skills for being a Natural Sciences and Life Sciences teacher.
Lack of knowledge.	PCK^{0}	Lack of knowledge of content,	Lack of pedagogical

		context and pedagogies.	content knowledge, including lack of knowledge of the affective domain.
Curriculum (CAPS and SAGS).	$CAPS^{+}$	Good to integrate more IK into the curriculum.	Positive outcomes in learner's worldview because content becomes relevant and exciting to learners.
Curriculum (CAPS and SAGS).	$CAPS^{0}$	Cannot integrate IK into every topic.	Teachers are not sure how to integrate IK and cannot see where IK can be integrated to ensure affective outcomes.
Self-directed learning.	SDL	Reflection, professional development, research, self-directed learning.	Evidence of Self-directed learning, reflective practitioner. Show interest in professional development and fostering own professional development.
Learners will learn more if they can relate to what the teacher is talking about.	L^{R}	Any reference to using IK to relate to content better. Meaningful in real life/worldview.	R^{L} = Learners relate to content being learnt. Contextualisation of learning.
Learner activities (e.g. practicals).	LA^{+}	Learners engage are stimulated by a hands-on or collaborative activity.	Activity is fun, exciting and stimulating.
Learner activities (e.g. practical is difficult).	LA^{-}	Learners find the hands-on or collaborative activity very challenging or frustrating.	Activity is difficult to complete.
Teachers relate to IK.	T^{R}	Meaningful in real life/worldview.	Contextualisation of content. Relevance of IK to Natural Sciences and Life Sciences.
Classroom action research.	CAR^{+}	A teacher an affectively embracing CAR cycle.	Teacher shows an appreciation of CAR.
Learner interest.	LI^{+}		Learners show interest in IK.
Learners not interested in IK or Natural Sciences and Life Sciences as a subject	LI^{-}		Learners show no interest in the Natural and Life Science content.
Krathwohl's level-Not aware.	L^{0}	No recall or participation, etc.	No awareness, affective domain not addressed and no commitment to IK.
Krathwohl's level-Receiving.	AL^{1}	Inquirers, chooses, describes, asks and follows.	Becoming aware, note taking and attendance.
Krathwohl's level-Responding.	RL^{2}	Answers, assists, show interest, active participation and respond.	Participation in tasks. Active and critical discussions with colleagues.
Krathwohl's level-Value/Valuing.	VL^{3}	Values, completes the task, demonstrates, differentiate, excited and passionate.	Show value towards indigenous knowledge, promising attitudes.

			Refer to the importance, worth or usefulness of teaching IK in the classroom or use of inquiry, cooperative or problem-based strategies.
Krathwohl's level-Organising.	OL[4]	Alters, arrangement, planning, collaborate, prioritise, integrate and develop.	Accountable for their own behaviour, show planning and solving (CAR).
Krathwohl's level-Characterising by a value set.	CL[5]	Acts, influence, solve, embody, conclude, internalise and display.	Consistent behaviour - show consistency towards internalised values. Professional commitment.

The descriptors were identified from an affective standpoint. These descriptors or codes assisted the data analysis process. Each time the descriptor appeared in the data, a note was made, and the frequency of the descriptor was noted.

4.3 Intervention programme

Relevant data for this research (for the affective domain) was obtained from 4 interventions. The interventions were carefully planned and improved in each DBR cycle. In Cycle 3, professional development principles (De Beer & Kriek, n.d.) were used to improve the Calvinia intervention and the data showed that this intervention was the most successful of all four (De Beer & Kriek, n.d.). These principles can be viewed in 3.4.1.

The intervention programmes layout is described in Appendices C and D. The intervention was attended by the Natural Sciences and Life Sciences teachers. These interventions included a variety of pedagogies, such as cooperative learning techniques (including the jigsaw method and De Bono's Thinking Hats), Kirby-Bauer method and problem-based learning activities. More detail of the intervention activities can be seen in 2.2.3 and 3.4.4.

4.4 Analysis of the data collected in this research

From the data collected, only data relevant to this research was selected (i.e. for the affective domain and affective development of Natural Sciences and Life Sciences teachers).

Cultural-historical activity theory (CHAT) (Figure 4-1) was used as a research lens to analyse the data that follows, except for the data regarding the Foldscopes and CAR. The CHAT diagram assisted the researcher to determine what the affordances of the intervention were, and to determine if there were any negative or positive tensions from the indigenous knowledge intervention and in the Natural Sciences and Life Sciences classroom, as well as how it influenced teachers' affective development.

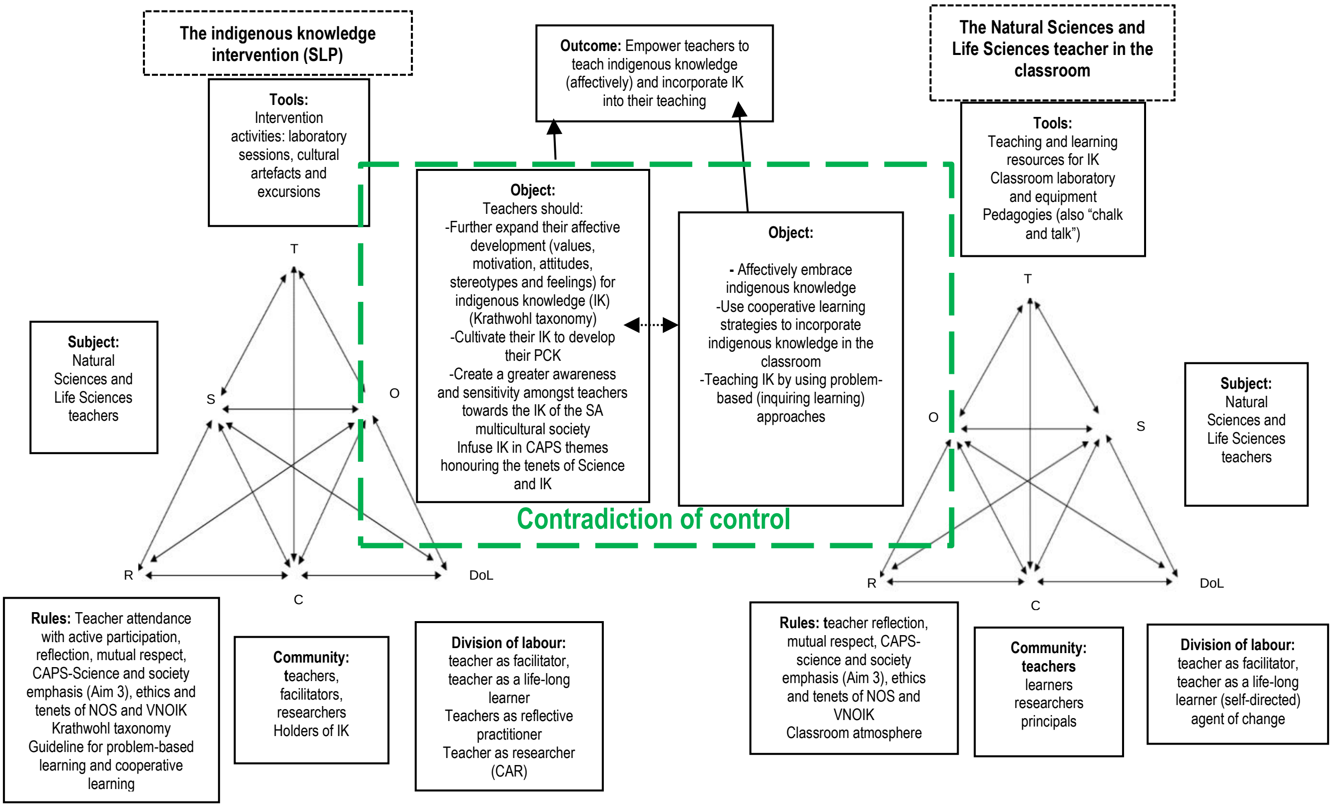


Figure 4-1: Using the third-generation Cultural-Historical Activity Theory (CHAT) the unconventional way: Comparing the SLP and the Natural Sciences and Life Sciences teacher in the classroom, adapted from Engeström (1987) and Mentz & De Beer (2017), integrating the affective domain (Krathwohl, 2002).

4.4.1 Analysis and discussion of the observations during the NWU intervention (Potchefstroom) and Lenasia intervention (Gauteng)

During the two interventions, the researcher observed and participated in the intervention as 'observer as participant' (Creswell, 2013). During this time photographs were taken and field notes were made to capture the lived experiences of the Natural Sciences and Life Sciences teachers during the indigenous knowledge intervention. The general feeling at the interventions, from the researchers' point of view, was the excitement shared among the teachers when learning new concepts. Teachers had the opportunity to engage with indigenous knowledge holders during the visit to the Mphebatho Cultural Heritage Museum. Teachers really appreciated and enjoyed the involvement with the holders of indigenous knowledge. Many of them savoured the moment, engaging in traditional games such as ‘Morabaraba’ and traditional practices such as drumming, cow dung smearing/painting and the winnowing of grain. Teachers also had the opportunity to eat traditional food, learn about the medicinal plants used and feel part of the Bakgatla-Ba-Kgafela culture. A teacher mentioned in their reflection, *“the museum visit and the course allowed me to learn new things that will help me be a better science teacher. It is never enough with learning; you will always discover new things”.* Another teacher said, *“it was very interesting and fruitful to me”.*

Figure 4-2: Natural Sciences and Life Sciences teachers enjoying a drumming activity held at the museum.

Figure 4-3: Natural Sciences and Life Sciences teacher learning how to winnow grain, a traditional practice by the Bakgatla-Ba-Kgafela culture.

Teachers were exposed to many different pedagogies, which they may not have known about before. These included testing for indigenous plants' anti-microbial properties and how to incorporate this into their classroom activities. Teachers were taught how to implement an adapted Kirby-Bauer method (see Figure 4-4) and, as seen in this figure, teachers were mesmerised by the practical element during the intervention. Many teachers refreshed their laboratory skills and practised safety procedures. From the researcher's observations, teachers could not wait for the results of their experiments. The Natural Sciences and Life Sciences teachers looked at their petri dishes the next day to see if the medicinal plants used in this experiment had had any anti-microbial action.

Figure 4-4: Natural Sciences and Life Sciences teachers implementing the Kirby-Bauer method in the NWU laboratory.

During the intervention the teachers engaged in critical discussions and discussed various cooperative strategies that they could utilise in their own classrooms. During the intervention all teachers were engaging with each other, but the researcher noticed that the interest faded if the activity carried on too long. This might be a good learning opportunity for teachers, as learners might also get bored and lose interest if an activity takes too long. Teachers will need to reflect and investigate ways to ensure that learners are engaged and stimulated during the lesson, thus enhancing the affective domain.

Figure 4-5: Natural Sciences and Life Sciences teachers engaging in critical discussions during the indigenous knowledge intervention.

The competitive spirit of the teachers was also evident. Teachers had to create a problem-based learning activity with elements of the NOS and present it on a poster. Teachers were very pleased with their achievement and affectively embraced the activity. A teacher responded to this activity in the portfolio and said *"I enjoyed the presentation of the poster and the responses we got from other groups. It was also good to see the other groups presenting their ideas, as all of us had completely different approaches to the same problem".*

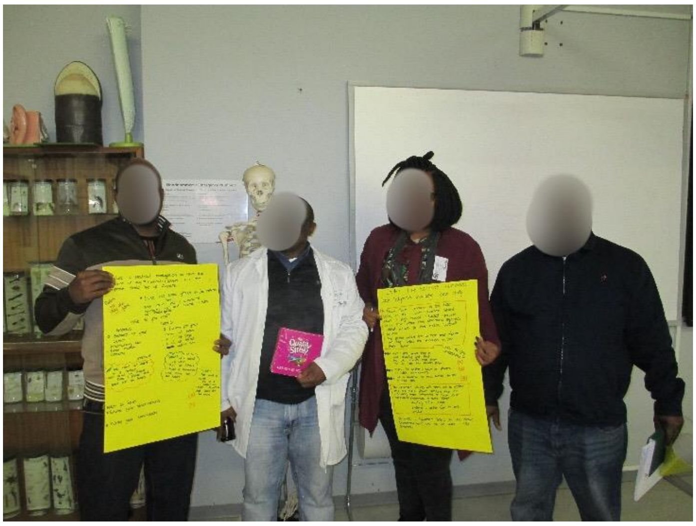


Figure 4-6: Excited Natural Sciences and Life Sciences teachers presenting their posters to colleagues.

More pictures of cultural practices teachers engaged in at the museum as well as activities completed at the interventions can be seen in the zipped files (extra resources) provided.

4.4.2 Analysis and discussion of questionnaire data from the Limpopo intervention

The Limpopo intervention was held on the 27th - 29th of June 2016. This was the first intervention of the larger NRF-funded project (Cycle 1). This intervention was similar to the intervention held at NWU (Potchefstroom); the only difference being the museum excursion. Teachers visited the Bakone Malapa Museum in Polokwane, whereas teachers in the North-West province visited the Mphebatho Cultural Heritage Museum in Moruleng. 62 Natural Sciences and Life Sciences teachers attended the intervention, of which 32 Natural Sciences and Life Sciences teachers completed the ‘adapted’ pre- and post-intervention VNOIK questionnaire. Relevant data for the affective domain was selected and utilised from the Limpopo intervention even though, due to work commitments, the researcher did not attend this intervention. Tables 4-4 and 4-5 show a summary of the data analysis from this intervention using both Cronje’s (2015) rubric and Saldaña's (2015) code-to-theory. Questions posed to Natural Sciences and Life Sciences teachers have elements from the VNOIK questionnaire and only relevant questions and data for the affective domain was selected for this research.

Question 1 (pre) was analysed using Cronje’s (2015) rubric to examine what views teachers had regarding indigenous knowledge: How would you describe indigenous knowledge?

Table 4-4: Table showing analysis of question 1 (pre) from the Limpopo intervention using Cronje’s (2015) rubric: How would you describe indigenous knowledge?

***Key:** **Score:**

UI – uninformed view (0)
PI – partially informed view (1)
I – informed view (2)

**See table 4-2 for teacher response requirements*

Participant	Question 1 (Pre)	Score
1.	I	2
2.	UI	0
3.	UI	0
4.	I	2
5.	PI	1
6.	PI	1
7.	I	2
8.	PI	1
9.	PI	1
10.	UI	0
11.	UI	0
12.	UI	0
13.	PI	1

14.	PI	1
15.	PI	1
16.	UI	0
17.	UI	0
18.	PI	1
19.	UI	0
20.	PI	1
21.	PI	1
22.	UI	0
23.	PI	1
24.	PI	1
25.	UI	0
26.	PI	1
27.	UI	0
28.	I	2
29.	PI	1
30.	PI	1
31.	UI	0
32.	PI	1
Total score (All participants)		**24/64**
Average	**0.6875 round off to 1**	

Natural Sciences and Life Sciences teachers mostly did not have very informed views of indigenous knowledge and struggled to understand the true nature of what indigenous knowledge is. One teacher said that IK is a "*traditional way of getting knowledge*" and another explained that IK is *"a knowledge that is used in a particular community or internationally. It can be localised or also nationalised"*. These are vague statements not explaining the core of what IK entails. Another teacher commented that IK *"is a way of knowing things by not using scientific methods, but beliefs, supernatural powers and being gifted from their ancestors"*. Table 4-4 shows the score the teachers achieved collectively; the score was 24 out of 64 and worked out to an average of 0.6875 (rounded off to 1). This indicates a partially informed view of indigenous knowledge. Mostly teachers identified only two tenets of indigenous knowledge as seen in Table 4-4 (Cronje, 2015). Most teachers mentioned that the NOIK is empirical and metaphysical as well as resilient yet tentative but did not make the connection that NOIK can be inferential, subjective or holistic. These tenets were addressed during the intervention, thus showing there is a correlation between the NOS and NOIK (Abd-El-Khalick *et al.*, 1998; Schwartz *et al.*, 2004).

The following questions 2, 3, 4, 5 ,6 and 7 was analysed using Saldaña's (2015) code-to-theory method to examine what affective outcomes, learning or development took place during and after the indigenous knowledge intervention.

Questions posed to the teachers:

2. Would you say there is a place for teaching IK in the Natural Sciences and Life Sciences classroom? Motivate your answer.
3. What are the difficulties that you anticipate in teaching indigenous knowledge in your lessons?
4. Did this short learning programme change your views on the use of cooperative learning methods in the Natural Sciences and Life Sciences classroom? Motivate your answer.
5. Did this short learning programme change your views on the use of problem-based learning methods in the Natural Sciences and Life Sciences classroom? Motivate your answer.
6. How could the incorporation of knowledge in the classroom better prepare learners for future careers, or in developmental entrepreneurial skills? Is this the responsibility of the subject teacher?

After the intervention:

7. Based on your experiences these three days, is it necessary for you to formulate any professional developmental goals for yourself?

Table 4-5: Analysis of Natural Sciences and Life Sciences teachers responses from the Limpopo (Polokwane) intervention (Questions 1–7) including some extracts of raw data to substantiate findings.

Codes[7]	Frequency of occurrence	Raw data	Categories	Sub-theme/s	Theme
NOS	4	*"Knowledge about different plants, materials, methods and rituals of different cultures and what qualities they have that can be helpful in modern society."* *"Knowledge through which learners learn by acquiring what is important from elders that was learnt through discoveries, viewing."*	1. Teachers do see the positive link between NOIK and NOS.	The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude	
IK	10				
WK	1				

[7] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

		"Very useful knowledge that one needs to bridge between mortal science and Western science." *"IK will help out learners to know that there is nothing different between what they are doing at home to cure diseases and what is done in the laboratory."*		(affective stance) towards indigenous knowledge and an improved skill set (including becoming reflective practitioners and setting professional goals) to incorporate IK into the classroom. (Jackson *et al.,* 2016)	
IKI$^+$ TS$^+$	14 5	*"I learnt new strategies that I saw are effective and I will use* *It will help learners participate in class."* *"There are things I never thought of, but as from now on I will definitely use IK in my classroom."* *"Help learners' different abilities to understand all levels of topics in the classroom."* *"Cooperative strategies and discussions motivate learners to acquire knowledge."* *"These strategies are beneficial, it encourages socialisation, self-research and ideas are combined."* *"When working towards answering a question, it is motivating."*	2. Positive response from IK intervention, including showing teachers a variety of cooperative learning strategies and problem-based learning approaches. 3. Teachers learnt new strategies. Excited to incorporate them into their teaching pedagogies. These strategies can motivate learners to acquire knowledge.		
IK^0 C$^+$ (CHAT tension - negative)	1 16	*"When elderly people may not be willing to share. Conflict in religion, as some things are confidential when one researches".* *"The other information is contrary to the rules and regulations of God our Creator, our father, for example Jesus Christ heals. Other people use anti-Christ beliefs, so it*	4. Negative attitudes towards IK. Misconceptions about IK. Not documented properly. Some teachers have never taught IK.		Many teachers had negative attitudes themselves about indigenous knowledge believing it to be 'myth' or 'witchcraft'. (Jackson *et al.,* 2016)

		does not fit into Christianity." *"It is not everything that can be introduced in class, e.g. some plants are not found in other areas."* *"Some believe it is witchcraft and do not believe in it."* *"It has myths and unpredictable, science is pure."* *"Learners being not interested with the topic, some feel out of space as it will sometimes talk about witchcraft. Some feeling shame because their parents or grandfathers are practicing it."*			
PCK^0 (CHAT tension - negative)	10	*"I don't believe one should incorporate IK."* *"I was lost during the Kirby-Bauer lab activity, as I was not trained in facilitating laboratory work."* *"I struggle to guide learners in formulating hypotheses or developing a lab protocol."* *"I lack confidence in performing laboratory experiments."* After the intervention teachers said they learnt: laboratory skills; observation skills; how to handle equipment; formulate hypotheses; and safety measures in a laboratory.	5. Anxiety and negative attitudes are created as the teachers are not equipped to answer questions regarding IK. 6. Teachers are not comfortable to perform laboratory experiments as they lack the skill set but did mention that they improved and revised those skills – the intervention assisted them.	Lack of pedagogical content knowledge regarding indigenous knowledge practices and laboratory skills and knowledge. Laboratory experiments require PCK.	
LI^-	2	*"Learners may not be interested in IK".* *"Learners do not have*	7. According to teachers, learners are not involved in IK practices as		

		knowledge of IK from their community." *"The kind of assessment used is common this doesn't include IK. It doesn't allow learners to apply what they have learned in the classroom then the approach become meaningless."*	they do not have much knowledge from the community.		
RM^0 (CHAT tension - negative)	10	*"I don't know how to incorporate IK in the classroom to add meaning to the lesson."* *"I really need to do some research on IK and learn a lot, as I am not familiar with all cultures."* *"I firstly need to understand and do more research on it and also prepare myself or know the content deeply by reading further."* *"I need assistance going forward."* *"Lots of resources is still lacking to teach learners on this indigenous".* *"There are learners from various cultures in our school. I think it will be difficult to find a common ground in incorporating IK."* *"It is because of a lack of resources."* *"Reference is difficult, something we have been told and have never experienced or seen before."* *"It is not documented properly and thoroughly researched".*	8. Teachers are not sure how to teach IK or incorporate it into their teaching strategies. Teachers are unsure about the various IKS in South Africa. Plants are not accessible to teachers. Teachers indicated some anxiety about how to incorporate it into their multicultural classroom. Teachers are not sure about how to assess IK.	IK content and resources not readily available to teachers – cannot affectively embrace or incorporate IK in the curricula or their teaching practices. Teachers indicate that there is a lack of resources to effectively infuse indigenous knowledge in their teaching of CAPS themes.	
T^- (CHAT tension -	1	*"Not enough time allocated for a period in*	No time in the classroom		

negative)		*school to now teach IK as well".*	therefore affective domain is neglected; teaching becomes chalk and talk (content driven).		

According to the data, Natural Sciences and Life Sciences teachers do see the positive link between NOIK and NOS. The frequency of a positive outlook on IK and the NOIK appeared 10 times in the data collected from the Limpopo intervention. Teacher 31 said *"IK will help out learners to know that there is nothing different between what they are doing at home to cure diseases and what is done in the laboratory".* Teachers also provided positive feedback with regard to the indigenous knowledge intervention. After the intervention teachers showed a better understanding of IK and moved from a partially informed view to a more informed view of IK.

Teachers also realised that professional development is important and should improve how they teach, including using cooperative strategies to bring excitement into the classroom (affective domain). The data indicated (TS^{+} code appeared 5 times) that teachers are enthusiastic to incorporate teaching strategies they had not used before into the classroom, including De Bono's Hats, the jigsaw method and problem-based learning activities. A sub-theme emerged from this data - the intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude towards indigenous knowledge.

The evidence also showed that IK still has negative connotations for some teachers. One teacher said *"The other information (IK) is contrary to the rules and regulations of God our Creator, our father, for example Jesus Christ heals. Other people use anti-Christ beliefs, so it does not fit into Christianity".* This is considered a CHAT tension (negative) as it may restrict many teachers from incorporating IK in the classroom. Many teachers still have misconceptions about IK therefore creating a negative attitude towards infusing it into the classroom. For example some teachers referred to IK as 'witchcraft'. The code used for 'conflict towards IK' (C^{+}) appeared 16 times in the data, suggesting that many teachers are still resistant towards IK. This is a 'dramatical collision' (Veresov, 2010) identified through the CHAT lens.

Reasons for this resistance to incorporating IK into the classroom could be that some teachers have not taught IK before or do not have the content knowledge therefore creating tension in the activity system. Many teachers do not have the necessary PCK or PK to affectively introduce and facilitate IK in the classroom (Mothwa, 2011). A major theme that emerged from the data is that some teachers view indigenous knowledge as pseudo-science. Some teachers believe that IK is related to 'witchcraft' or is a 'myth'. This is illustrated in the following response *"it has myths and unpredictable, science is pure".* IK is also seen as opposing many religions, therefore creating another tension in the activity system, resulting in teachers avoiding incorporating IK into the classroom. One example stems from the holistic nature of indigenous knowledge, and the traditional healers' practice of making contact with the ancestors. This is frowned upon by many Christian teachers, as can be seen from some responses *"different belief systems might bring a lot of misconceptions when dealing with this topic"* and *"confusion is created among teachers and learners as the indoctrination of IK entails witchcraft and myths".* The theme that emerged from this data is that many teachers had negative attitudes themselves about indigenous knowledge believing it to be 'myth' and 'witchcraft'.

Many teachers indicated that IK is not well documented in the available teaching resources provided by the Department of Basic Education. Teachers do not have a sound knowledge of IK. Teachers are also not familiar with the variety of IK that South Africa holds. Because they have multicultural learners, one teacher mentioned that *"we are a diverse nation and you find that different places differ, so it makes it difficult to teach".* Teachers are also not confident about their knowledge of medicinal plants and, even if some teachers are aware of some medicinal plants, the plants are not readily available for them to use in the classroom. Teachers are under pressure to complete the curriculum, and do not have enough time, therefore they neglect the affective domain and teaching becomes content or chalk and talk driven. This is another CHAT tension which essentially prevents teachers from incorporating IK in the classroom, thus creating a demotivated Natural Sciences and Life Sciences teacher. One teacher expressed concern about her knowledge of IK, *"when teaching IK one needs to have a sound knowledge of culture and traditions of people's IK for the practical implication thereof, of which I am not sure of all".*

The intervention played a vital role in reducing these negative tensions as teachers were provided with many resources and ideas that they could use in the classroom. Another sub-theme that emerged from the data includes the teachers' lack of knowledge of context-specific indigenous knowledge and their consequent lack of motivation (cannot affectively embrace) to teach indigenous knowledge. This should also be viewed in terms of available resources and in-service programmes for professional development.

4.4.3 Analysis and discussion of questionnaire data from the NWU (Potchefstroom) intervention

The NWU intervention was held at the North-West University's Potchefstroom campus from the 18th to the 20th of July 2016. After the welcome address, the consent letter and the pre-intervention VNOIK questionnaire were handed out to the Natural Sciences and Life Sciences teachers. 32 Natural Sciences and Life Sciences teachers attended the North-West University indigenous knowledge intervention, and 21 completed the pre-VNOIK questionnaire. The VNOIK questionnaires were completed within an hour. This hour was set aside for administration. The post-intervention questionnaire was handed out to the teachers after the intervention. At the NWU intervention 21 post-intervention questionnaires were completed and handed in. Below are the questions posed to the Natural Sciences and Life Sciences teachers.

Please note data was extracted from the pre- and post-intervention VNOIK questionnaires and only relevant data was selected in this research (i.e. for the affective domain and affective development of Natural Sciences and Life Sciences teachers).

Questions posed to the teachers:

1. How would you describe indigenous knowledge?
2. Would you say there is a place for teaching IK in the Natural Sciences and Life Sciences classroom? Motivate your answer.
3. What are the difficulties that you anticipate in teaching indigenous knowledge in your lessons?
4. Did this short learning programme change your views on the use of cooperative learning methods in the Natural Sciences and Life Sciences classroom? Motivate your answer.
5. Did this short learning programme change your views on the use of problem-based learning methods in the Natural Sciences and Life Sciences classroom? Motivate your answer.
6. How could the incorporation of knowledge in the classroom better prepare learners for future careers, or in developmental entrepreneurial skills? Is this the responsibility of the subject teacher?

After the intervention:

7. Based on your experiences these three days, is it necessary for you to formulate any professional developmental goals for yourself?

Table 4-6: Analysis of Natural Sciences and Life Sciences teachers' responses to Questions 1–7, including extracts from the raw data to support the findings. The responses are from the NWU (Potchefstroom) intervention.

Codes[8]	**Frequency of occurrence**	**Raw Data**	**Categories**	**Sub-theme/s**	
P	5	*"Begin knowledge about different plants, materials, methods and rituals of different cultures and what qualities they have that can be helpful to modern society."* *"We can bring herbs, like garlic, turmeric for learners to see, and let them experiment and research the plants and figure out the purpose of these plants and how to grow them."* *"Without it (IK), no knowledge of medicinal plants and their uses would be available."* *"They will appreciate science better, because we are teaching them home grown education, and plants that can be used for medicine, that are endemic to their areas."* *"It is an important role because IKS teaches learners that medicine come from everyday plants. It brings home the knowledge to learners. IKS*	Reference to medicinal plants.	The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude (affective stance) towards indigenous knowledge and an improved skill set (including becoming reflective practitioners and setting professional goals) to incorporate IK into the classroom. (Jackson *et al.*, 2016)	

[8] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

		provides a platform for learners to look at things with new perspective and knowledge."			
R&M^0 (CHAT tension - negative)	3	*"Biggest challenge is not having the information available."* *"I do not know where to go for information on certain plants and medicines."*	Lack of IK resources.		
C$^+$ (CHAT tension - negative)	3	*"Sangomas are witchcraft - dirty, bad, hurts people."* *"That herbs 'muthi' are used for witchcraft."*	Clash with religious practices. Teachers believe it is supernatural, 'myth' and 'witchcraft'.		Many teachers had negative attitudes about indigenous knowledge believing it to be 'myth' or 'witchcraft'. (Jackson *et al.*, 2016)

L^R	19	*"Most learners can relate to the IK."* *"Learners relate more to things they know and will definitely learn more if they can relate to the things the teacher is talking about other than talking more about things they don't know and have never seen."* *"I think this would help in general knowledge and understanding culture. But most to see the plants in your "back yard" is not just there. The plants have a meaning in life."* *"Yes, learners relate better to what is being taught, because of these IKS systems, so integrating it with Life Sciences make it more interesting."*	IK introduced in the Natural Sciences and Life Sciences classroom can be relevant because it is what many learners know, thus creating interest in the Natural Sciences and Life Sciences classroom. Learners connect to the real world - relevance. Make science more interesting. Indigenous garden. Fusion of content and relevance in society (CAPS AIM 3).		Teachers acknowledge that teaching for the affective domain with regard to indigenous knowledge (IK) can stimulate learners' interest and motivation to learn Natural and Life Sciences by contextualising the learning. (Jackson *et al.*, 2016)
T^R	4	*"It could make them relate to the content and see the value of it in their own lives."* *"It adds an interest factor to learning. It also allows learners to relate to aspects of their lives that may be similar to examples given."* *"IKS can influence learners in a positive way: Learners will look at Life Sciences in a different perspective. (As I have today). Learner will relate to*			

		the content therefore enjoy and see the relevance of what they do (IKS) at home."			
CAPS+	7	*"During experiments, it stimulates their interest and some would be keen to try some of herbs especially if it relates to health issues."* *"Part of the aims CAPS (A3) is that IKS should be linked to content. A teacher should create opportunities in class to link IKS to content in their lessons (Not all lessons, only the ones where the links could be made)."*	Good to integrate IK into the curriculum.		
SDL	12	Teachers were asked to mention some goals after the intervention: *"We must also research not only content, but also how to teach every topic."* *"I will use the reflection protocol to reflect. Keep a reflective journal."* *"To always reflect on lessons in order to improve the effectiveness of lessons."* *"Pre-reflect and post-reflect is important."* *"Make strategies*	Teachers motivated to reflect and learn. Teachers improved their laboratory skills and reflect on their teaching pedagogies.	Teacher as a reflective practitioner, researcher and self-directed learner.	The intervention played a role in making teachers more reflective practitioners, setting professional development goals for themselves to become self-directed learners. (Jackson *et al.*, 2016)

		that will be used in terms of weaknesses that might be identified."			
CAPS⁰ (CHAT tension - negative)	4	*"The CAPS document allows a very short time in the pacesetter; therefore, indigenous knowledge requires literature research and there is no time for that. In grade 12, there is literally no concepts covering this section."* *"Time constraints, willingness of other colleagues, types of classes."*	Not all Natural Sciences and Life Sciences content can be infused with IK (maybe teachers not sure how to integrate IK). Not in line with CAPS policy document. Little time available during class time.		

This intervention was still part of Cycle 1 of the larger NRF funded project. Once again, data showed a number of negative tensions with regard to incorporating IK into the classroom. These tensions include 'myths', 'witchcraft', limited resources, time constraints, lack of PCK and the lack of various skill sets as seen in Table 4-6. These trends are confirmed in Mothwa (2011) and Cronje's (2015) research.

Teachers, however, do make the connection that IK can contextualise the learning in the classroom. A teacher said *"learners relate more to things they know and will definitely learn more if they can relate to things the teacher is talking about other than talking more about things they don't know and have never seen".* Teacher 21 said *"learners mostly do not relate with scientific knowledge, so IK will contribute to their learning process".* Many teachers expressed a positive attitude towards IK which outweighed the negative connotations associated with IK. Teacher 32 said "*yes, IK can be integrated into the curriculum because there are indigenous trees in the garden where learners can experience this*". Teachers can create their own indigenous gardens to expose learners to indigenous plants and learn more about their value, therefore making the learning more relevant. Teachers realised the value of IK (Krathwohl's taxonomy level 3) as teacher 15 said *"when learners learn from their environment, learning becomes meaningful".* This also relates to Aim 3 of the CAPS, where teachers become aware of the fact that learners should show appreciation for Natural Sciences and Life Sciences in society. The data showed that teachers acknowledged teaching for the affective domain with regard to IK. Indigenous knowledge can stimulate learners' interest and motivation to learn Natural Sciences and Life Sciences (Jackson *et al.,* 2016). Data also revealed that teachers are mindful of the fact that not all content in the curriculum can be infused with IK.

IK is used in the classroom to allow learners to relate to the real world and to create connections thus making meaning. A teacher says *"If you teach them in a practical manner, show real examples of indigenous plants, do experiments with them, show them videos. Make it interesting to learners, allows to do research on these plants, will create relevance to their understanding of Life Sciences".* Teachers realise that if the content they teach is relevant to the learners then they are, within their own contexts, affectively learning about Natural Sciences and Life Sciences. In turn, if teachers realise the purpose and the importance of incorporating IK into the classroom, they will be motivated to reflect on, learn about and research IK. Teachers thus become self-directed learners. Therefore the data highlighted another theme, namely, the teacher as a reflective practitioner, researcher and self-directed learner.

4.4.4 Analysis and discussion of questionnaire data from the Lenasia intervention

The Lenasia (Gauteng) intervention was held on the 2nd and 3rd of July 2017. After the welcome address, the consent letter and the adapted pre-intervention VNOIK questionnaire were handed out to the Natural Sciences and Life Sciences teachers. 23 Natural Sciences and Life Sciences teachers attended the Lenasia intervention, and 15 completed the adapted pre-intervention VNOIK questionnaire. The adapted VNOIK questionnaires were completed within an hour. This hour was set aside for administration. The post-intervention questionnaire was handed out to the teachers after the intervention. At the Lenasia intervention 18 post-intervention questionnaires were completed and handed in. Below are the questions posed to Natural Sciences and Life Sciences teachers. These questions have elements from the previous VNOIK questionnaire and only relevant questions and data for the affective domain were selected for this research.

Table 4-7: Table showing analysis of question 5 (pre) and question 6 (post) from the Lenasia intervention using Cronje rubric (2015). (In your view what is indigenous knowledge (or traditional) knowledge? What makes indigenous knowledge different from other types of knowledge systems (such as Western knowledge)?)

Participant	**Question 5 (pre)**	**Score**	**Question 6 (post)**	**Score**
1.	UI	0	PI	1
2.	PI	1	I	2
3.	PI	1	I	2
4.	PI	1	PI	1
5.	PI	1	I	2
6.	UI	0	PI	1
7.	PI	1	I	2
8.	UI	0	PI	1
9.	PI	1	I	2
10.	UI	0	I	2
11.	PI	1	PI	1
12.	PI	1	I	2
13.	UI	0	PI	1
14.	I	2	I	2
15.	PI	1	I	2
Total score (All participants)	**11/30**		**24/30**	
Average	**0.66667 Round off to 1**		**1.6 Round off to 2**	

***Key:** **Score:**

UI – uninformed view (0)
PI – partially informed view (1)
I – informed view (2)

**See table 4-2 for teacher response requirements*

Professional learning through interventions assists in evolving teachers' pedagogical abilities and this has a positive influence on their teaching skills (Darling-Hammond *et al.*, 2009). Interventions can allow exposure to concepts (indigenous knowledge) that are relevant to Natural Sciences and Life Sciences. Data in Table 4-7 shows that the majority of the teachers moved from a partially informed view of indigenous knowledge (pre-intervention) to an informed view of indigenous knowledge after the intervention (post-intervention). Therefore the role of the indigenous knowledge intervention provided a better understanding of the concept of indigenous knowledge. This also indicates that teachers understand the difference between the traditional aspects of indigenous knowledge and Western knowledge.

Selected data from pre- and post-intervention VNOIK questionnaires is distilled in Table 4-8.

Table 4-8: Analysis of Natural Sciences and Life Sciences teachers' responses from Lenasia (Gauteng) intervention.

Codes[9]	Frequency of occurrence	Raw Data	Categories	Sub-theme/s	Theme
IKI+	16	*"IK empowers students and facilitates comprehension. It does also helps them appreciate their environment."* *"Appreciation of different cultures and their beliefs."*	Teachers indicate that the intervention was fantastic and they learnt a lot. They can't wait to implement what they have learnt.	The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude (affective stance) towards indigenous knowledge and an improved skill set (including becoming reflective practitioners and setting professional goals) to incorporate IK into the classroom. (Jackson *et al.,* 2016)	
NOS	4	*"Science is accurate, reliable and ethical, it is ever-changing and can be tested."*	Traditional medicine must be tested. Not enough clinical trials, more tests should be done.		
CAPS+	1	*"Yes, there is a place for IKS in the classroom because this knowledge is unique to a culture or society but formal education systems have disrupted the life aspects of IKS."* *"Learners always practice this at home. Some, it will be easy to apply this in class."*	Decolonisation of the curriculum.		

[9] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

CAPS^0 (CHAT tension - negative)	4	*"No, I don't integrate IK."* *"No. some time we were not aware of this IK."* *"limited resources in CAPS and learner material currently on IK"*	Some teachers do not teach or integrate IK. Never taught IK. Teachers not aware of IK before this SLP - L^0		
C^+ (CHAT tension - negative)	3	*"Religious barriers. Some of the IK information is linked to certain religions. I would not want to teach about a 'muthi' that chases 'tokoloshes' away."* *"Racial, cultural, religious segregation, lack of trust, parental interference."*	Negative connotations associated with IK.	Many teachers had negative attitudes themselves about indigenous knowledge. (Jackson *et al.*, 2016)	
L^R	2	*"Generation of learners have moved away from pure theory and require a broader perspective of practical knowledge to add relevance to the theory."* *"To clear misconceptions about the use of herbs which is associated with witchcraft for conservation purposes."* *"adds to a more inclusive and meaningful learning environment"* *"Because it can be able to bring different cultures together."* *"The process of having to learn and understand my learners background in order to accommodate them in*	Contextualise learning. Relevant to learners. Add relevance to theory. Clear any misconceptions.	Incorporating indigenous knowledge in the Natural Sciences and Life Sciences curriculum and teaching it in the classroom allows for contextualisation of learning. (Jackson *et al.,* 2016)	Teachers acknowledge that teaching for the affective domain with regard to indigenous knowledge (IK) can stimulate learners' interest and motivation to learn Natural and Life Sciences by contextualising the learning. (Jackson *et al.,* 2016)

		my lesson by making content relevant. It might come across as time consuming."			
AL[1]	3	*"IK is a natural theoretical perspective found within everyday life and in the classroom of various cultures. This knowledge can be medicinal, spiritual or used in other ways. Often it is passed down through the generations."*	Recognise that all learners have their own IK.	Affective domain evident in the data. Teachers affectively embrace IK and incorporate it in their value set.	Teachers show an affective shift during the intervention regarding their values, beliefs perceptions and attitudes of IK and their responsibility toward incorporating indigenous knowledge in the Natural Sciences and Life Sciences classroom. (Jackson *et al*., 2016)
RL[2]	9	*"Yes, I have been teaching IK in cancer treatment, the use of African medicine, i.e., African potato, etc. I have used it in the teaching of health medicine especially in grade 10 and 11."* *"I have mentioned IK in Biodiversity in grade 11 – spoke about Hoodia and Pfizer developing it into a tablet and not paying the Khoi San people enough for their knowledge."*	Teachers have taught some IK before. Teachers already 'respond' by teaching IK.		
VL[3]	19	*"I have an appreciation of different cultures and their beliefs."* *"Science is not theoretically based, but also requires a practical and emotional factor to understanding."* *"Through IK people expose their cultures and value IK through sharing."*	Appreciation of different cultures and their beliefs.		
OL[4]	11	*"IK does reflect social and cultural values of a certain people. Mopane worm is food, a good protein source – people get food and employment."*	Organise their ideas for example which topics they can incorporate IK, such as environmental studies, botany,		

		"IK can be used globally to solve problems because many problems are generic such as diabetes. Active ingredients in plants don't choose how and when they will work."	cells and anatomy. Teachers indicate that IK can be used to solve variety of human and environmental issues.		

Data from this intervention (Cycle 2) showed more evidence that teachers want to affectively incorporate IK into the curriculum. Teacher 6 said *"IK empowers students and facilitates comprehension. It does also help them to appreciate their environment"*.

In the post-intervention questionnaire teachers were asked how they experienced the short learning programme and 88% (16 out of the 18) of the teachers from the Lenasia intervention said it was fantastic and that they had learnt a lot. The teachers could not wait to implement what they had learnt. This is a positive outlook towards IK and incorporating IK in the Natural Sciences and Life Sciences classroom. The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude towards IK (Jackson *et al.,* 2016:501). This is essential with regard to the affective domain as the development of teachers' own understanding of their motivations, attitudes and behaviour influence their professional drive and citizenship (Birbeck & Andre, 2009).

One teacher indicated that the teaching of indigenous knowledge in the Life Sciences classroom can be used to deal with conflict or misconceptions. Teacher 3 said *"to clear misconceptions about the use of herbs which is associated with witchcraft".* Teachers are showing organisation (level 4) from Krathwohl's taxonomy, as they realise that they need to prioritise the fact that IK is not witchcraft.

4.4.5 Analysis and discussion of the questionnaire data from the Calvinia intervention

Relevant data was also selected and utilised from the Calvinia intervention held 28th - 29th of July 2017. 95 Natural Sciences and Life Sciences teachers attended the Calvinia intervention, and 36 pre- and post-intervention VNOIK questionnaires were handed in. Tables 4-9, 4-10, 4-11 and 4-12 below show a summary of the data analysis from this intervention.

Table 4-9: Summary of responses from pre-intervention VNOIK questions (Qu) posed to Natural Sciences and Life Sciences teachers at the Calvinia (Northern Cape) intervention.

Key: UI – uninformed view Score: (0)				PI – partially informed view (1)				I – informed view (2)			
Participant	Qu 1	Qu 2	Qu 3	Qu 4	Qu 5	Qu 6	Qu 7	Qu 8	Qu 9	Qu 10	Total Score	
1.	1	0	0	1	0	1	2	1	2	1	0.9	PI
2.	1	0	2	1	1	1	0	1	2	1	1.0	PI
3.	1	1	0	2	0	1	1	2	0	0	0.8	PI
4.	1	0	2	2	0	0	1	0	0	0	0.6	PI
5.	0	1	1	1	0	2	2	1	0	2	1.0	PI
6.	0	1	1	0	0	2	0	1	2	2	0.9	PI
7.	1	1	1	0	2	2	2	2	2	2	1.5	I
8.	0	0	0	1	0	2	0	1	1	0	0.5	PI
9.	1	0	2	2	1	0	0	1	1	1	0.9	PI
10.	1	0	1	2	2	0	0	2	1	0	0.9	PI
11.	1	0	0	2	1	0	0	1	0	0	0.5	PI
12.	1	0	0	2	1	0	0	0	0	0	0.4	UI
13.	1	2	0	1	0	1	0	0	0	0	0.5	PI
14.	1	1	1	1	0	1	0	1	0	2	0.8	PI
15.	0	0	0	1	0	1	0	1	0	0	0.3	UI
16.	1	0	1	1	1	2	2	2	2	1	1.3	PI
17.	1	1	1	1	1	2	1	0	2	1	1.1	PI
18.	2	2	0	2	1	1	0	1	1	0	1.0	PI
19.	1	0	0	0	1	2	1	0	2	2	0.9	PI
20.	1	0	0	0	0	1	0	1	1	0	0.4	UI
21.	1	1	0	1	1	1	0	1	0	0	0.6	PI
22.	1	0	0	0	1	2	1	1	1	1	0.8	PI
23.	1	0	0	0	0	0	0	1	1	0	0.3	UI
24.	1	0	2	2	2	1	0	1	0	0	0.9	PI
25.	1	0	1	1	0	1	1	0	0	1	0.6	PI
26.	1	1	1	0	1	2	0	1	0	0	0.7	PI
27.	0	1	0	0	1	1	0	1	0	0	0.4	PI
28.	1	1	0	1	1	2	0	1	0	0	0.7	PI
29.	1	1	0	0	2	1	1	0	0	0	0.6	PI
30.	0	0	1	0	1	1	0	1	2	2	0.8	PI
31.	0	1	1	2	1	2	0	1	1	1	1.0	PI
32.	0	1	0	0	0	1	0	1	0	1	0.4	UI
33.	1	0	0	0	1	0	0	1	2	0	0.5	PI
34.	1	1	0	2	1	1	0	1	1	2	1.0	PI
35.	1	1	0	2	1	2	0	1	1	1	1.0	PI
36.	1	1	0	1	1	1	0	1	2	1	0.9	PI
Average:	0.81	0.56	0.53	0.97	0.75	1.14	0.42	0.92	0.83	0.69	0.8	PI

Table 4-10: Summary of responses from post-intervention VNOIK questions (Qu) posed to Natural Sciences and Life Sciences teachers at the Calvinia (Northern Cape) intervention.

Key: UI – uninformed view Score: (0)				**PI – partially informed view (1)**				**I – informed view (2)**			
Participant	**Qu 1**	**Qu 2**	**Qu 3**	**Qu 4**	**Qu 5**	**Qu 6**	**Qu 7**	**Qu 8**	**Qu 9**	**Qu 10**	**Total Score**	
1.	2	1	1	1	1	2	2	1	2	2	1.5	I
2.	1	2	2	2	1	2	1	1	2	1	1.5	I
3.	2	2	0	2	1	2	1	2	2	1	1.5	I
4.	2	1	2	2	2	2	2	1	1	1	1.6	I
5.	2	2	2	1	1	2	2	1	0	2	1.5	I
6.	0	2	2	2	1	2	2	2	2	2	1.7	I
7.	2	2	2	1	2	2	2	2	2	2	1.9	I
8.	0	2	0	2	0	2	0	1	1	0	0.8	I
9.	1	2	2	2	2	1	1	1	1	1	1.4	PI
10.	2	2	1	2	2	1	1	2	1	1	1.5	I
11.	1	1	2	2	1	1	1	1	1	1	1.2	PI
12.	2	2	1	2	2	1	1	1	1	1	1.4	PI
13.	1	2	1	1	0	2	1	1	1	1	1.1	PI
14.	2	2	2	1	1	1	1	1	1	2	1.4	PI
15.	1	1	1	1	0	1	1	1	1	1	0.9	PI
16.	2	1	2	2	2	2	2	2	2	1	1.8	I
17.	2	2	1	1	1	2	2	1	2	1	1.5	I
18.	2	2	2	2	1	1	1	1	1	1	1.4	PI
19.	1	1	1	1	2	2	1	1	2	2	1.4	PI
20.	1	1	1	1	2	1	0	1	1	0	0.9	PI
21.	1	1	1	1	1	1	1	1	1	1	1	PI
22.	1	1	1	1	1	2	1	2	2	2	1.4	PI
23.	1	1	1	1	0	1	0	2	1	1	0.9	PI
24.	1	1	2	2	2	1	2	1	2	1	1.5	I
25.	1	1	1	1	2	1	1	1	1	2	1.2	PI
26.	1	1	1	1	1	2	1	2	1	1	1.2	PI
27.	0	1	1	1	1	1	1	1	0	0	0.7	PI
28.	1	1	1	1	1	2	1	1	1	1	1.1	PI
29.	1	1	0	1	2	1	2	1	1	1	1.1	PI
30.	1	1	1	1	1	1	2	1	2	2	1.3	PI
31.	1	2	2	2	1	2	1	1	1	1	1.4	PI
32.	1	2	1	1	0	1	1	1	1	2	1.1	PI
33.	2	1	1	1	1	1	1	1	2	1	1.2	PI
34.	2	1	1	2	2	2	1	1	1	2	1.5	I
35.	1	1	1	2	1	2	1	1	1	2	1.3	PI
36.	1	1	1	1	2	1	2	1	2	2	1.4	PI
Average:	1.2	1.4	1.3	1.4	1.2	1.5	1.2	1.2	1.3	1.2	1.3	PI

Table 4-9 shows averages from the pre-intervention VNOIK questions posed to teachers. The teachers' overall average showed a partially informed view (average 0.8) of indigenous knowledge. Table 4-10 shows averages from the post-intervention VNOIK questions posed to teachers. The teachers' overall average still showed a partially informed view of indigenous knowledge, but the average increased to 1.3. Most teachers shifted from an uninformed view to a partially informed view and others moved from a partially informed view to an informed view of indigenous knowledge. The data also shows that teachers affectively embraced this knowledge and incorporated it into their classroom practices. Research done by De Beer and Kriek (n.d:14) show that there was less of a contradiction of control (CHAT) in Cycle 3 (Calvinia intervention) than the Limpopo, NWU (Potchefstroom) and Lenasia interventions. The Calvinia teachers incorporated more of what they had learnt from the intervention in their classrooms than teachers from Cycles 1 and 2. This results in fewer tensions in the activity system.

Table 4-11: Analysis of Natural Sciences and Life Sciences teacher responses (pre-intervention questionnaire) from Calvinia (Northern Cape) intervention.

Codes[10]	Frequency of occurrence	Raw Data	Categories	Sub-theme/s	Theme
L^0	10	-	Some teachers are not familiar with IK and do not teach IK in the classroom. This is evident as many teachers left the question out that asks 'would you say there is a place for teaching IK in the LS classroom?'		
AL^1	6	*"IK can be applied as a basis; can show better understanding for change."* *"To be able to show in nature to learners how natural science works will give them a much better understanding.*"	Some awareness and mention of IK.		
C^+ (CHAT	5	*"Too much negativity around IKS e.g. muti-*	Conflict evident surrounding IKS		Many teachers had negative

[10] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

tension - negative)		*murders."*	such as muti-murders[11] mentioned by a teacher.		attitudes themselves about indigenous knowledge related to 'myth' or 'witchcraft', but the short learning programme does play a role in changing this. (Jackson *et al.,* 2016)
RM^0	7	*"Resources are too limited."*	Limited resources pertaining to IK available to teachers.	Teachers' lack of knowledge of context-specific indigenous knowledge and demotivation to teach indigenous knowledge should also be viewed in terms of available resources and in-service programmes for professional development. (Jackson *et al.,* 2016)	

Teachers were asked in the pre-intervention questionnaire what their expectations for the short learning programme were and many teachers fell into the L^0 category (level 0 of Krathwohl's taxonomy (1964)). Most teachers did not mention learning more about indigenous knowledge (see Table 4-11). The data in Tables 4-9 and 4-11 correlate, as teachers did not show a full understanding of indigenous knowledge before the intervention. Many of them wanted to improve their teaching strategies or to incorporate practical lessons more often. However, data in Table 4-12 of the post-intervention questions (after the short learning programme) highlighted

[11] Muti-murders: human beings are murdered for body parts which are then used as medicine or for magic..

the fact that they had learnt a lot about indigenous knowledge and how they could utilise and incorporate IK into their teaching.

Table 4-12: Analysis of Natural Sciences and Life Sciences teacher responses (post questions) from Calvinia (Northern Cape) intervention

Codes[12]	Frequency of occurrence	Raw Data	Categories	Sub-theme/s	Theme
IK	4	*"Knowledge and practices maintained by communities - the knowledge about experiences / practices that developed over a long period of time."* *"I am excited to build the ethnobotany project at school and trusting learners will be just as excited."* *"With so many different cultures in one class, it is good for each learner to understand each other's backgrounds."*	Show understanding and appreciation for IK.	Teachers understand the importance of better contextualising CAPS themes, through the infusion of indigenous knowledge. (Jackson *et al*., 2016)	Teachers showed appreciation for the fact that, through the creation of contextualised learning opportunities, affective outcomes such as learner interest and motivation could be better achieved. (Jackson *et al.,* 2016)
L^R	10	*"Contextual science - stimulates interest in nature and lets it filter in syllabus learning."* *"Definitely. Indigenous knowledge can make life learning much more meaningful."* *"Pupils more interested. Can go out see, feel, study plant, etc."* *"I realised that the learner would be most likely to learn and*	Real life experiences and circumstances. Learner interest. Personalised learning. Improve learners' learning.		

[12] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

		remember better in this way." *"Learners learn best when school work is based on real life experiences/real life circumstances."*			
SDL	13	*"The course 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".* *"Reflected regularly, but it helps to participate in the process most productively and motivate it to capture your progress."* *"It is important to evaluate yourself and take into account all possible teaching methods and the possible outcomes that it may have on learners."* *"By reflecting on what you have done is a good way of knowing what you still need to give attention and you will also be loveable to keep tract or made to ascertain whether you are achieving your goals teaching and learning."*	Teachers are encouraged to incorporate what they have learnt during the intervention.	The intervention played a role in making teachers more reflective practitioners, setting professional development goals for themselves to become self-directed learners. (Jackson *et al.*, 2016)	

The Calvinia intervention was part of Cycle 3 of the larger NRF project. Data presented from the larger NRF project showed that teachers had a partially informed view (overall score 0.7) of IK and IKS before the intervention took place. However, after the intervention the data showed that there was positive change; the teachers from Calvinia showed more understanding and sensitivity towards incorporating IK in their lessons; some teachers shifted from an uninformed view of indigenous knowledge to a partially informed view and other teachers moved from a partially informed view to an informed view (see Tables 4-9 and 4-10). A theme that emerged from the findings in an article written by De Beer and Kriek (n.d.) is that the *"Northern Cape teachers generally incorporated indigenous knowledge effectively in their lessons, adhering to the tenets of Science".* Teachers from Calvinia were exposed to CAR during the intervention and therefore the data showed that the intervention had played a role in making teachers more reflective practitioners, setting professional development goals for themselves to become self-directed learners (sub-theme).

Teachers from the Calvinia intervention understood and valued the importance of incorporating IK and affectively embraced the necessity that learners should know about each other's cultural backgrounds. One teacher stated that *"with so many different cultures in one class, it is good for each learner to understand each other's backgrounds".* Another teacher said "*learners learn best when school work is based on real-life experiences and real-life circumstances*". A third teacher said *"it is more personal to them, because they experience these things on a daily basis"*.

Ultimately, the teachers from Calvinia embraced indigenous knowledge, as they realised that indigenous knowledge that is relevant to the learners will have a positive (affective) outcome on the learners' learning experiences, thus a major theme emerged (which correlates to data from the Limpopo and North-West as well as the Lenasia interventions). If a teacher creates a more contextualised learning opportunity, there is a bigger chance of achieving affective outcomes, such as learner interest and motivation.

4.4.6 Analysis and discussion of affective domain questionnaires using Krathwohl's taxonomy

32 participants attended the NWU intervention but only 6 completed the pre-intervention affective questionnaire and 8 completed the post-intervention affective questionnaire. Twenty-three (23) participants attended the Lenasia intervention and 13 completed the pre- and the post-intervention affective questionnaires. Teachers' answers are marked with an 'X' on the table below depending on which level of the hierarchy they fall under. The purpose of this was to see if affective development has occurred after the indigenous knowledge intervention. See Appendix F for the pre- and post-intervention affective questionnaires.

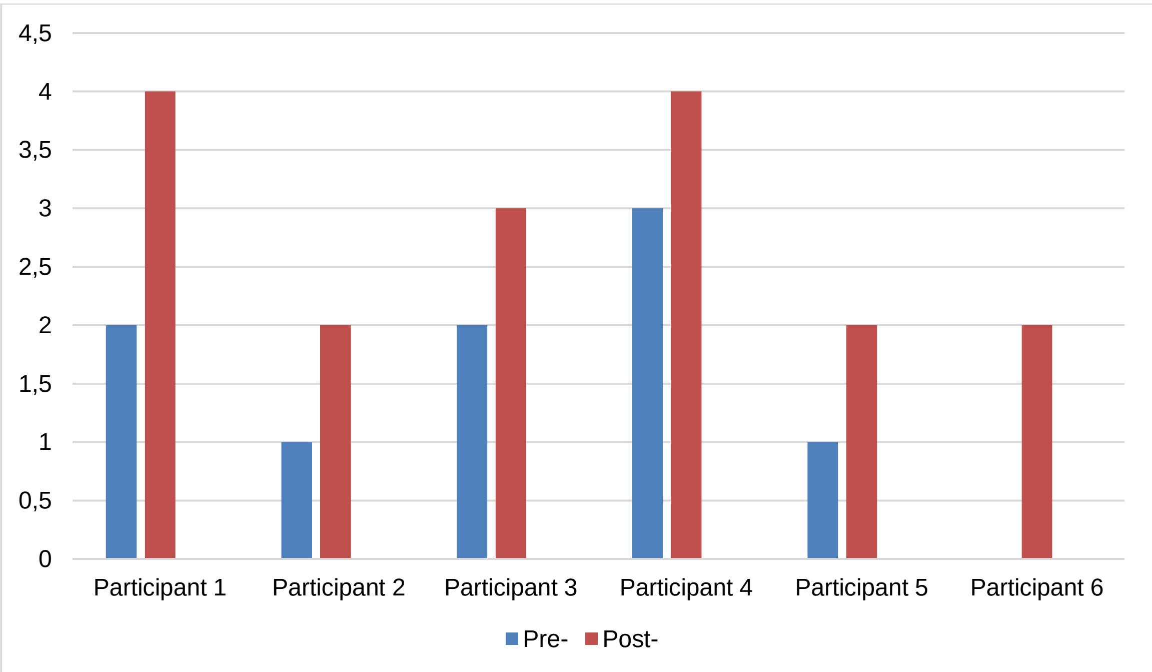
Table 4-13: Table showing the affective shift, using Krathwohl's levels for the affective domain (Neumann & Friedman, 2010:5) – NWU (Potchefstroom) intervention

Affective level of each Natural Sciences and Life Sciences teachers pre- and post-intervention affective questionnaires

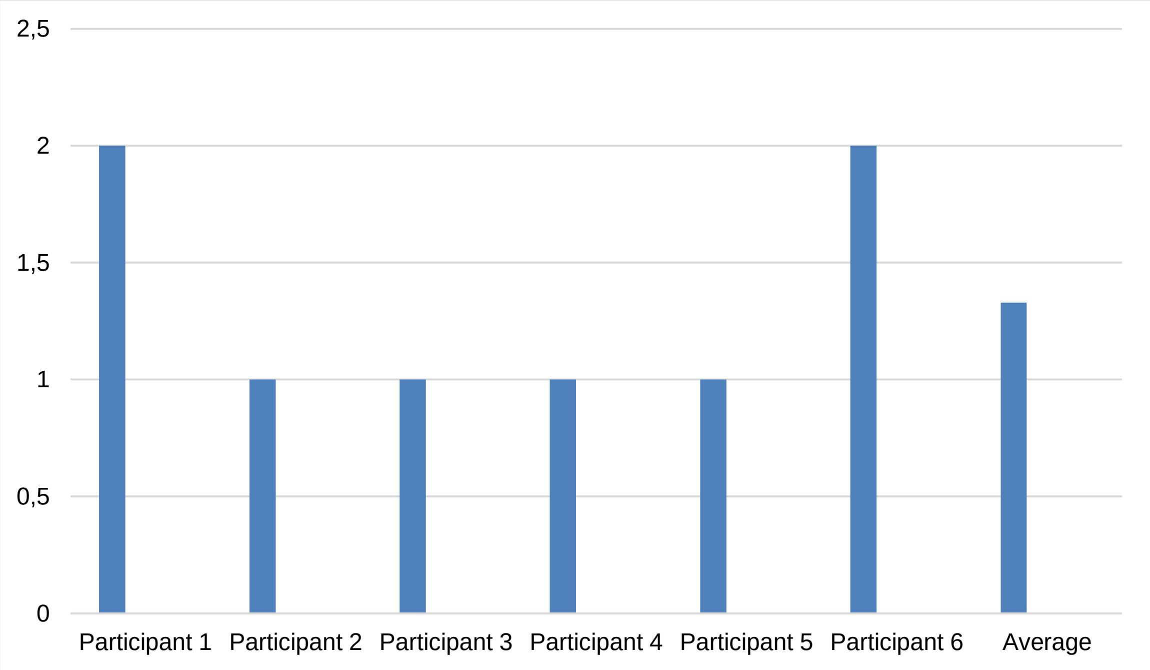
Key:
Level 0- Not aware
Level 1- Receiving (aware)
Level 2- Responding
Level 3- Valuing
Level 4- Organising
Level 5- Characterisation by value set

	Pre-questionnaire						Post-questionnaire						
Affective levels	L0	L1	L2	L3	L4	L5	L0	L1	L2	L3	L4	L5	Level shift
Participants													
1			x								X		2
2		x							x				1
3			x							x			1
4				x							X		1
5		x							x				1
6	x								x				2
Average													1.33

Graph 4-1: Graph showing the affective levels (pre- and post-intervention questionnaire) of participants, using Krathwohl's levels for the affective domain (Neumann & Friedman, 2010:5) – NWU (Potchefstroom) intervention.



Graph 4-2: Graph showing the affective shift of participants, using Krathwohl's levels for the affective domain (Neumann & Friedman, 2010:5) – NWU (Potchefstroom) intervention.



Overall, as seen in Graph 4-1, affective development has improved, based on the data, most teachers have shifted up Krathwohl's (1964) hierarchy for the affective domain. Most participants shifted one level up after the intervention, whereas others shifted up two positions. This shift indicates that Natural Sciences and Life Sciences teachers affectively embraced indigenous knowledge after the intervention. This includes understanding what indigenous knowledge is and how to incorporate it into the Natural Sciences and Life Sciences classroom to contextualising learning from an affective perspective.

The data illustrated in Graph 4-2 shows the affective shift of Natural Sciences and Life Sciences teachers. The data indicates a positive affective shift after the intervention.

Question 8 (see Appendix F) on the affective questionnaire, asked the Natural Sciences and Life Sciences teachers to rate outcomes in terms of importance, these outcomes encompass the affective domain and cognitive domain. The teachers' responses (rating scale) indicate which domain is valued more, the cognitive domain or the affective domain.

Table 4-14: Table showing the rating scale for various outcomes posed to the teachers on the affective questionnaires – NWU (Potchefstroom) intervention.

Outcomes (item) as shown on the affective questionnaire
1. Learners should have a sound knowledge of Natural Sciences and Life Sciences
2. My biggest role as a teacher is to ensure that most learners pass the exam
3. Learners should be able to think critically and substantiate opinion with relevant data
4. Learners should be able to plan and execute an experiment
5. Learners should appreciate value of Natural Sciences and Life Sciences in everyday life
6. Learners should be able to analyse and synthesise when studying Natural Sciences and Life Sciences
7. I am motivated and positive to teach indigenous knowledge in my classroom
8. My role as a teacher encompasses cultivating an interest in Natural Sciences and Life Sciences in the learners
9. Learners should be biologically literate citizens that value the contribution of Natural Sciences and Life Sciences in modern society
10. Learners should be scientifically literate citizens who can compete in a global society
11. Learners should appreciate the science underpinning many indigenous knowledge practices
Summary of responses from question 8 (Qu) posed to Natural Sciences and Life Sciences teachers Key: Rating scale 1 – least important 6 – most important

Participant	Pre- Post-	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11
1	Pre-	6	6	6	6	6	6	6	6	6	6	6
	Post-	6	6	6	6	6	6	6	6	6	6	6
2	Pre-	6	6	6	6	6	5	5	6	6	6	5
	Post-	4	4	4	6	6	6	6	6	6	6	6
3	Pre-	6	4	6	3	6	5	6	6	4	6	3
	Post-	5	4	5	6	5	3	6	6	6	5	5
4	Pre-	4	4	5	5	6	6	6	5	6	5	6
	Post-	5	5	5	6	6	6	6	6	6	5	6
5	Pre-	6	3	6	5	6	6	6	5	6	5	5
	Post-	6	3	5	5	6	5	6	6	3	6	6
6	Pre-	5	5	6	0	6	6	6	6	6	6	5
	Post-	6	6	6	5	6	6	6	6	6	6	6
Average	Pre-	5.5	4.67	5.83	4.17	6	5.67	5.83	5.67	5.67	5.67	5
Average	Post-	5.33	4.67	5.17	5.67	5.83	5.33	6	6	5.5	5.67	5.83
Domain[13]		C	C	C	C	A	C	A	A	A	C	A

[13] C – Cognitive domain
A – Affective domain

Graph 4-3: Graph showing the averages of the pre- and post-intervention rating scale for various outcomes posed to the teachers on the affective questionnaires – NWU (Potchefstroom) intervention

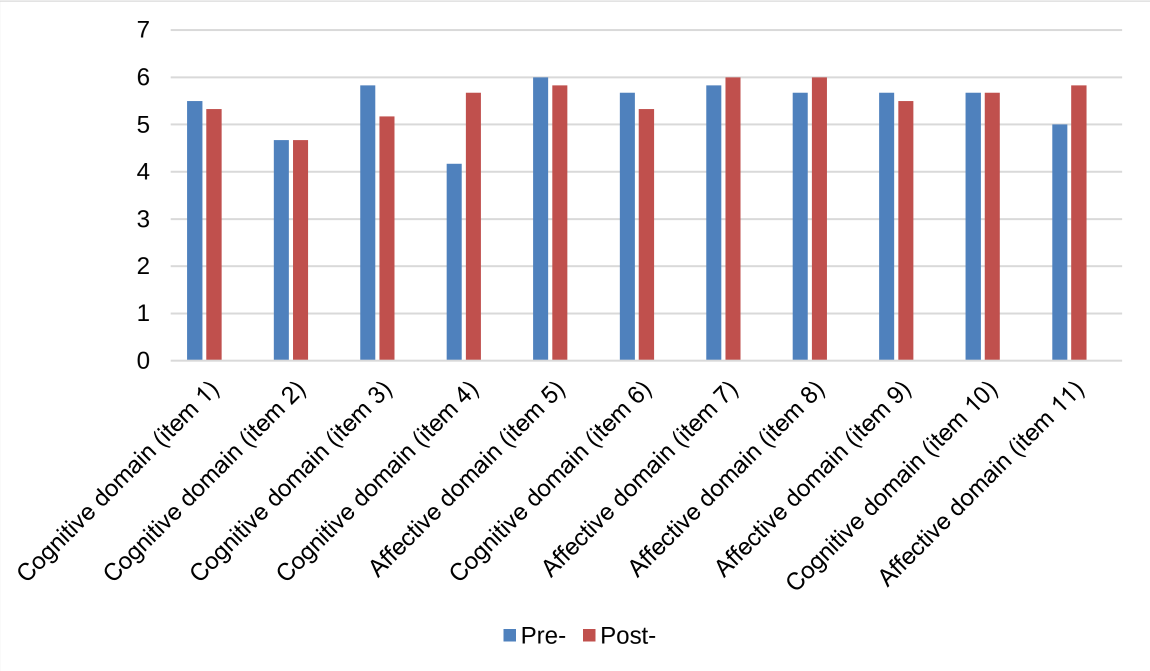


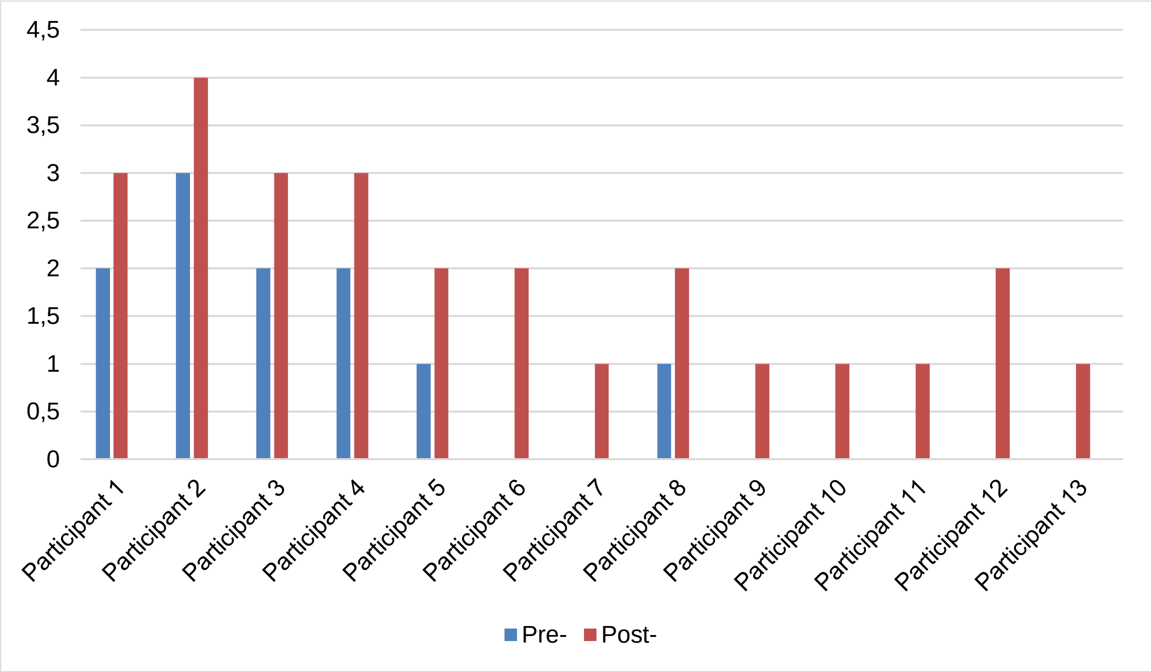
Table 4-15: Table showing the affective shift, using Krathwohl's levels for the affective domain (Neumann & Friedman, 2010:5) – Lenasia intervention.

Affective level of each Natural Sciences and Life Sciences teacher pre- and post-intervention affective questionnaire

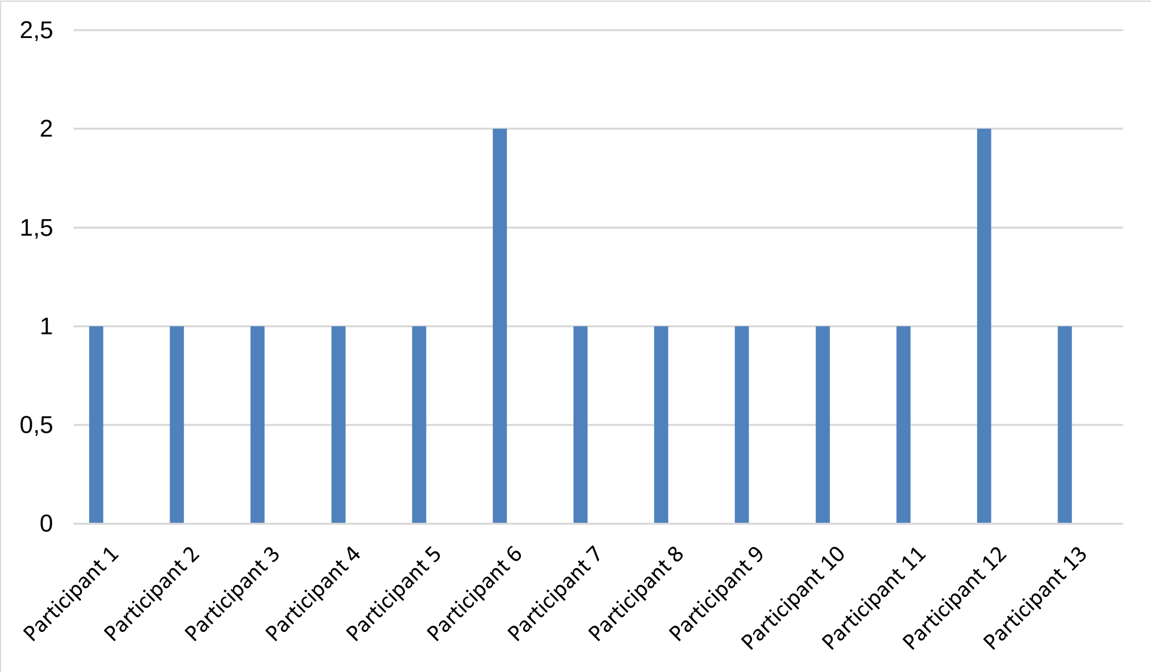
Key:
Level 0- Not aware
Level 1- Receiving (aware)
Level 2- Responding
Level 3- Valuing
Level 4- Organising
Level 5- Characterisation by value set

	Pre-questionnaire						**Post-questionnaire**						
Affective levels	L0	L1	L2	L3	L4	L5	L0	L1	L2	L3	L4	L5	Level shift
Participants													
1			x							x			1
2				x							x		1
3			x							x			1
4			x							x			1
5		x							x				1
6	x								x				2
7	x							x					1
8		x							x				1
9	x							x					1
10	x							x					1
11	x							x					1
12	x								x				2
13	x							x					1
Average													1.15

Graph 4-4: Graph showing the affective levels (pre- and post-intervention) of participants, using Krathwohl's levels for the affective domain (Neumann & Friedman, 2010:5) – Lenasia intervention.



Graph 4-5: Graph showing the affective shift of participants, using Krathwohl's levels for the affective domain (Neumann & Friedman, 2010:5) – Lenasia intervention.



Data from the Lenasia intervention shows that teachers had a much better view of indigenous knowledge than those from the previous three cycles before they completed the intervention but lacked an understanding of the affective domain. More emphasis must be placed on the affective domain during the intervention.

Table 4-16: Table showing the rating scale for various outcomes posed to the teachers on the affective questionnaires – Lenasia intervention

Outcome (item) as shown on the affective questionnaire
1. Learners should have a sound knowledge of Natural Sciences and Life Sciences
2. My biggest role as a teacher is to ensure that most learners pass the exam
3. Learners should be able to think critically and substantiate opinion with relevant data
4. Learners should be able to plan and execute an experiment
5. Learners should appreciate value of Natural Sciences and Life Sciences in everyday life
6. Learners should be able to analyse and synthesise when studying Natural Sciences and Life Sciences
7. I am motivated and positive to teach indigenous knowledge in my classroom
8. My role as a teacher encompasses cultivating an interest in Natural Sciences and Life Sciences in the learners
9. Learners should be biologically literate citizens that value the contribution of Natural Sciences and Life Sciences in modern society
10. Learners should be scientifically literate citizens who can compete in a global society
11. Learners should appreciate the science underpinning many indigenous knowledge practices

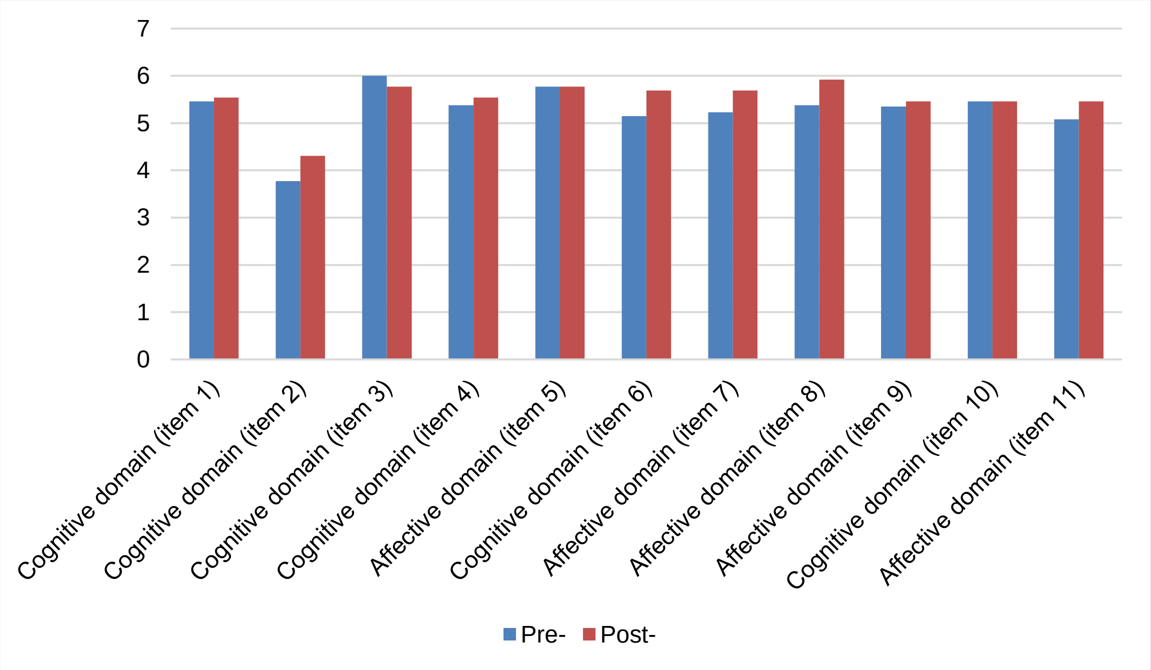
Summary of responses from question 8 (Qu) posed to Natural Sciences and Life Sciences teachers

Key: Rating scale
1 – least important
6 – most important

Participant	Pre- Post-	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11
1	Pre-	6	2	6	6	6	6	6	6	6	6	6
	Post-	6	4	6	6	6	6	6	6	6	6	6
2	Pre-	4	4	6	6	6	6	3	6	6	6	3
	Post-	6	6	6	6	6	6	6	6	6	6	6
3	Pre-	6	4	6	5	6	6	5	6	6	6	5
	Post-	6	4	6	6	6	6	6	6	6	6	6
4	Pre-	6	2	6	6	6	6	6	6	6	6	6
	Post-	6	3	6	6	6	6	6	6	6	6	6
5	Pre-	6	4	6	6	5	5	6	5	5	5	6
	Post-	6	4	6	6	6	5	5	6	3	4	4
6	Pre-	6	2	6	6	6	6	5	0	5	5	5
	Post-	6	4	6	6	6	6	6	6	6	6	6
7	Pre-	5	4	6	5	6	5	5	6	3	3	3
	Post-	4	4	5	5	4	5	6	6	4	4	4
8	Pre-	6	5	6	5	6	5	5	6	6	6	6
	Post-	6	5	6	5	6	5	6	6	6	5	6
9	Pre-	6	6	6	6	6	6	6	6	6	6	6
	Post-	6	6	6	6	6	6	6	6	6	6	6
10	Pre-	4	2	6	4	4	5	3	5	5	5	4
	Post-	4	3	5	4	5	5	4	5	5	5	4
11	Pre-	4	5	6	5	6	0	6	6	5	5	5
	Post-	4	3	6	5	6	6	5	6	5	5	5

12	Pre-	6	6	6	6	6	6	6	6	6	6	6
	Post-	6	6	6	6	6	6	6	6	6	6	6
13	Pre-	6	3	6	4	6	5	6	6	5	6	5
	Post-	6	4	5	5	6	6	6	6	6	6	6
Average	Pre-	5.46	3.77	6	5.38	5.77	5.15	5.23	5.38	5.35	5.46	5.08
Average	Post-	5.54	4.31	5.77	5.54	5.77	5.69	5.69	5.92	5.46	5.46	5.46
Domain[14]		C	C	C	C	A	C	A	A	A	C	A

Graph 4-6: Graph showing the averages of the pre- and post-intervention rating scale for various outcomes posed to the teachers on the affective questionnaires – Lenasia intervention



Graph 4-3 and Graph 4-6 show an even distribution of the affective and the cognitive domains.

The affective domain as a learning domain has been neglected by the educational community (Garritz, 2010). The cognitive domain is centralised in education, yet the affective domain (values and attitudes, such as perseverance, tolerance, etc.) is a driver for cognitive development. Research in neuroscience (Dubinsky, Roehrig, & Varma, 2013) shows that experiences with an emotional flavour are more likely to be committed to memory. Literature supports the findings in this research. Conceptual change is similar to '*mindfulness*' (Duit & Treagust, 2003). 'Mindfulness' is associated with motivation and cognition. Motivation is part of the affective domain (Krathwohl, 1964). Cognition is an aspect of the cognitive domain (Crowe

[14] C – Cognitive domain
A – Affective domain

et al., 2008) and includes the facts and theories of Natural Sciences and Life Sciences as a subject. In order to achieve positive conceptual change to indigenous knowledge, teachers will need to have an open mind and combine both the affective and cognitive aspects of 'mindfulness' to teaching.

The data shows that the affective domain and cognitive domain go hand-in-hand in teacher professional development and teaching to create a contextualised learning environment.

Descriptions, as illustrated in Table 4-17, were used while analysing the affective questionnaires. The researcher read the teachers' overall pre- and post-intervention questionnaire responses and matched them to the descriptions in order to determine if any affective development had taken place.

Table 4-17: Table showing data analysis for the affective questionnaires using Saldaña's code-to-theory method (2015) – NWU (Potchefstroom) intervention and Lenasia (Gauteng) intervention.

Codes[15]	Frequency of occurrence	Raw Data	Categories	Sub-theme/s	Theme
IK	10	*"There is not only one type of IKS, there are many. Some of them link (honey, etc.). You could teach these topics in a very interesting way. Some of it really works (turmeric - Zulu (evil spirit chaser)."* *"Contextualising Western knowledge for my learners, in that way they would be confident enough because they would see and understand that these (IKS) are the things they actually know and surrounded by."*	Acceptance, reference and understanding of indigenous knowledge systems.	The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude (affective stance) towards indigenous knowledge and an improved skill set (including becoming reflective practitioners and setting professional goals) to incorporate IK into the classroom. (Jackson *et al.*, 2016)	

[15] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

		"Without it (IK), no knowledge of medicinal plants and uses would be available."			
L[R]	25	*"They will appreciate science better, because we are teaching them home grown education, and plants that can be used for medicine that are endemic to their areas."* *"As soon as learners know, they can get remedies to health problems, right at their doorstep (yard, garden). Learners will be eager to try some of these natural remedies for their sick brother, sisters, etc."* *"My role: to make Western knowledge relevant to my learners by having to contextualise this new knowledge. My responsibility: first understand it myself then explain it to my learners in a best way possible. (mediated learning experience)."* *"What I have noticed to that, the learners enjoy something they see every day that something they can imagine for*	Using IK to contextualise learning. Learners relate to content better. Learner enjoyment of Natural Sciences and Life Sciences as a subject.		Teachers acknowledge that teaching for the affective domain with regard to indigenous knowledge (IK) can stimulate learners' interest and motivation to learn Natural Sciences and Life Sciences. (Jackson *et al.,* 2016)

		instance the use of (Umqombothi) Zulu traditional beer, in so doing learners will be able to understand it better than learning something they are not familiar with." *"To bring the content to learners that is insightful, meaningful, understandable, growth inducing and enjoyable."*			
C+ (CHAT tension - negative)	15	*"People belief that you practise witchcraft if you are using indigenous medicine."* *"There is a stereotype with IK is that many people think it's a 'black peoples' thing not realising that there are many indigenous knowledge even in the Western culture."* *"Traditional healer are the only people who understand and have access to indigenous knowledge."* *"That the herbs do not help, they cannot cure or provide sufficient nutrients in our bodies. In today's life there is no time to develop your own garden."* *"It is a*	Many stereotypes identified leading to misconceptions of IK. Seen as 'witchcraft' Medicinal practices based on IK do not work.		Many teachers had negative attitudes themselves about indigenous knowledge seeing it as 'myth' or 'witchcraft', but the short learning programme can play a role in changing this. (Jackson *et al*., 2016)

		pseudoscience and hence ineffective." *"We just think that applying indigenous knowledge could have a negative feeling about it especially in terms of muthi."* *"Can cure AIDS, cure infertility. Rhino horn for sexual performance."* *"IK is perceived as black magic and voodoo with my Christian learners, they start talking about witch doctors and completely exclude themselves."*			

Again, there is a correlation with other data collected in this research; again, teachers mention the contextualisation of learning using IK in an affective manner. Learners can relate to IK as this is what they know and grew up with. Teacher 2 said "*affective has to do with learners' belief, feelings, culture. Hence, when you teach you need to contextualise lessons, by bringing learner's context into the lesson, linking the content with their context"*. Therefore teachers acknowledge that teaching for the affective domain with regard to indigenous knowledge (IK) can stimulate learners' interest and motivation to learn Natural Sciences and Life Sciences.

Question 7 (post-intervention questionnaire) asked the teachers to describe a stereotype associated with IK and whether or not the short learning programme changed their perception of the stereotype. As can be seen in the table above many teachers mentioned a variety of stereotypes associated with IKS; including *"IK is perceived as black magic and voodoo with my Christian learners, they start talking about witch doctors and completely exclude themselves"*, *and "there is a stereotype with IK is that many people think it's a 'black peoples' thing not realising that there are many indigenous knowledge even in the Western culture"*. Teachers do still hold negative connotations regarding IK, but 10 out of 13 teachers said yes, the short learning programme did change their perception regarding stereotypes associated with IK, such as 'witchcraft' and that traditional medicine does not work. A teacher said *"Yes, previously people discredited the use of natural remedies and through this course knowledge was imparted on the relevance and use of IK".* Natural Sciences and Life Sciences teachers realised that there are medicinal properties in traditional plants, as they tested the medicinal plant in the laboratory using the Kirby-Bauer method.

Overall, the data showed that the object (CHAT diagram Figure 4-1), namely, affective development of the teacher who developed a more nuanced understanding and appreciation of indigenous knowledge was achieved through the intervention offered. Very little tension in the activity system was evident and a positive outlook from an ESDC viewpoint of indigenous knowledge was apparent in the analysed data. A teacher mentioned, *"IKS can influence learners in a positive way: learners will look at Life Sciences in a different perspective. (As I have today). Learner will relate to the content therefore enjoy and see the relevance of what they do (IKS) at home".* Another teacher said, *"IK encourages or stimulates participation as each learner gets to share information that they are familiar with"*, and lastly a teacher wrote that IK can *"promote the tolerance of each other and understanding of others culture. Keen to learn more about their environment".*

4.4.7 Analysis and discussion of personal interviews with teachers (NWU Intervention)

Five personal interviews were conducted during the NWU intervention (Potchefstroom). Table 4-18 shows the analysed (using Saldaña's code-to-theory method (2015)) data from the five personal interviews conducted. The interviews were analysed from an affective stance.

Table 4-18: Table showing data analysis for the personal interviews using Saldaña's code-to-theory method (2015).

Personal interviews					
Codes[16]	**Frequency of occurrence**	**Raw Data**	**Categories**	**Sub-theme/s**	**Theme**
L^R	5	*"Okay, I believe that if I have a multi-cultural kind of classroom, I must include a different indigenous knowledge from every culture*	Interest, fun and excitement in the classroom doing practicals (learner relevance). Includes a variety of indigenous knowledge in a multicultural		Teachers showed appreciation for the fact that, through the creation of contextualised learning opportunities,
LI^+	36				

[16] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

		because it will be more interesting." *"A teacher's attitude can change the attitude of a learner towards the subject because I believe that as a teacher, I should make learners be interested in my subject. It could be by incorporating different activities and also maybe by including excursions something that will really interest them and change their mind-set."* *"I believe that indigenous knowledge can change learner's mind-set because it relates to what these learners know which maybe they have not been exposed to academically in the classroom so it will definitely trigger interest in their learning."*	classroom. Learners share their own indigenous knowledge (class participation). Teachers motivated to make Life Sciences interesting using indigenous knowledge.		affective outcomes such as learner interest and motivation could be better achieved. (Jackson *et al.*, 2016)
LI^-	4	*"There are others that are interested in this Life Sciences, but the others are just doing it for examination."* *"Yes, they enjoy Life Sciences, but there's a certain percentage that just seem not to be interested."* *"I think somewhere somehow I did*	Teachers are of the opinion that learners are not interested in the subject. Learners learn only for examinations.		

		injustice to them because I was struggling a bit which method to apply and because of the misconceptions that most learners go with when we talk of indigenous knowledge they kind of like lost interest in this topic." *"Learners must have interest in Life Sciences so that they could be able to pass at the end of the year because if they don't have interest they won't even participate in the classroom. They won't be interested in learning so that will affect their results."*			
C^{+} (CHAT tension - negative)	4	*"Yes, I do, have a stereotype because you know some people that do this are not holy. Its diabolic, that's what people are, some people like indigenous knowledge people that are primitive, it's diabolic and that is not the truth."* *"We mostly look into the negative aspects of indigenous knowledge. For example most of us were raised knowing that a transitional leader are used to bewitched or are used to do witch*	IK is diabolical, not truth or fact – stereotypes. IK is 'witchcraft'.		Many teachers had negative attitudes about indigenous knowledge viewing it as 'myth' or 'witchcraft'. This results in teachers not teaching IK in the Natural Sciences and Life Sciences classroom. However the intervention did play a role in changing this attitude. (Jackson *et al*., 2016)

		craft."			
T-	3	*"No, we don't have enough time."* *"No, we don't have time always. I believe in my subject there are so many topics that we will have to cover and that disadvantages some of the teaching practices that will be good and bring good results."* *"We don't have enough time but we can make time, because really our time is never enough but if you want to reach the learners that is where we have to sacrifice and make other classes on Saturdays or any other days after school maybe, and we really have to make time because otherwise we won't be able to include everything that we are supposed to do."*	Not enough time to incorporate IK.	Teachers' lack of knowledge of context-specific indigenous knowledge and demotivation to teach indigenous knowledge should also be viewed in terms of available resources, time management and in-service programmes for professional development. (Jackson *et al.*, 2016)	
RM^0	1	*"I wish we should make a roundup of these people to be curious to know where they are, go to them, interview them, get that knowledge because it's not documented."*	Reference to not enough resources or documentation to effectively and affectively teach indigenous knowledge, but teachers taking the initiative to interview knowledge holders.		
PCK^0	2	Expectations from the course: *"I wanted to learn the skills on*	Lack of knowledge of how to incorporate IK into teaching practices. Lack of knowledge		

		exactly on actively involve my learners in class when teaching this topic." *"I was struggling a bit which method to apply and because of the misconceptions that most learners go with when we talk of indigenous knowledge."*	in terms of teaching pedagogies relating to infusion of IK.		
A^-	5	*"The affective domain um I think, I think the affective domain relates to um you're thinking what you cannot see."* *"You know affective domain according to my understanding is an effective way of reaching to the learners in terms of understanding the content that is taught to them."* *"Affective domain? I don't know how to answer this. Affective Domain. I don't know how to answer, yes umh I'm not sure what this is."*	Teachers lack an understanding of the affective domain.		Teachers often marginalise the affective domain and this should be emphasised more in pre- and in-service teacher education. (Jackson *et al*., 2016)
VL^3	22	*"Yes, I do value indigenous knowledge because remember it's linked to culture and things that are on earth."* *"I feel empowered and then I feel that it is important, and it will arise learners interest and then learners*	Teachers attach value to IK. Incorporate IK in their lessons because they value IK. Teachers feel empowered.	The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude (affective stance) towards indigenous	Teachers show an affective shift during the intervention regarding their values, beliefs perceptions and attitudes of IK and their responsibility toward incorporating indigenous knowledge in the Natural Sciences

		will have more knowledge of things that are nearer to them like in the field they want know that this plant is for this." *"I'm very passionate about indigenous knowledge systems and I'm actually excited that universities now have come to realise the value in indigenous knowledge systems."* *"My approach to teaching is that I should not only teach things that should definitely appear in the exam, but I should also teach learners, I am teaching education for self-reliance."*		knowledge and an improved skill set (including becoming reflective practitioners and setting professional goals) to incorporate IK into the classroom. (Jackson *et al.*, 2016)	and Life Sciences classroom. (Jackson *et al.*, 2016)
T^{R}	6	*"I feel very good about this course and I believe that I have gained a lot. Personally, I have grown, and I am also going to apply some of the things, especially talking about the methodology, you know, the Bono's hats and also the jigsaw method. I have really learnt a lot because I felt that I needed something that really interest my learners, because I am also concerned about their results, so it will about*	Evident that teachers show a connection towards indigenous knowledge. Teachers learn about a variety of indigenous knowledge from their learners.		
IKI^{+}	5		Teachers learnt a lot about IK during the intervention.		

		indigenous knowledge." *"I'm very much grateful and also interacting with other people made me to be a better person, because I am also learning or I have learned from other teachers who have maybe similar experiences like mine or who are excelling in their schools. I managed to gain a lot of information."* *"We have so many challenges in life today. So many challenges. I expect it to really open up new avenues to see how, how best indigenous knowledge systems can help in addressing social issues, social rules, unemployment, advancement of economy and many other things like, decisions that you have, how can that help and we should really speed up the process."*			

Another overlapping theme emerged from the personal interviews (analysed data), i.e., teachers acknowledged the use of indigenous knowledge to better contextualise the CAPS themes for learners and could address affective outcomes such as learner interest and motivation. A teacher mentioned that *"infusion of indigenous knowledge will make us see that science is everyday life and science is not only in America but in where we are living we also have science".*

One teacher placed value on indigenous knowledge, such as using medicinal practices to assist with ailments, and further mentions that "*I use my attitude, my emotions in solving real life problems"*. It is evident that this teacher is addressing the affective domain. During the interview Teacher 1 said *"I'm very passionate about indigenous knowledge systems and I'm excited that universities now have come to realise the value in indigenous knowledge system".* Again, the affective domain manifests in the answer, the teacher was 'excited' and saw 'value' in indigenous knowledge systems. This demonstrated affective development during the intervention. Furthermore, during the interview, the teacher mentioned that learners should apply what they have learnt in real life situations, this is owing to contextualising science from a warm lens (De Beer & Henning, 2010; Kural & Kocakülah, 2016). Warm conceptual change as seen in the data, influences teacher PCK, motivations, attitudes and values (Pintrich *et al.*, 1993), which can radiate to the learners. Another teacher mentions that learners' interest is dependent on the innovation and creativity of the teacher. However, learner interest can dwindle due to misconceptions.

Learners' lack of interest could be due to misconceptions of indigenous knowledge. A teacher said, *"I think somewhere somehow I did injustice to them because I was struggling a bit which method to apply and because of the misconceptions that most learners go with when we talk of indigenous knowledge they kind of like lost interest in this topic"*. This could be as a result of the teachers' own misconceptions regarding indigenous knowledge and that they do not have the necessary PCK to infuse it into their classroom. If this is the case, there is a need for interventions to build teacher skills, PCK and address misconceptions.

Again, tension in the activity system is evident when some teachers carry negative attitudes to IK, relating it to witchcraft. Another teacher mentioned that indigenous knowledge can be seen in a negative light, mentioning the words 'not holy' (personal interview 1, line 62, Appendix H) and 'diabolic' (personal interview 1, line 64, Appendix H). This is a strong theme that is emerging from all analysed data. However, the data indicates that the intervention changed the view of how Natural Sciences and Life Sciences teachers view indigenous knowledge and that they began to share a sense of ownership of IK. Teachers shared a sense of responsibility to collect information from the knowledge holders before the knowledge was lost. Teacher 1 mentions that *"I wish I could round up these people, I am curious to know where they are, go to them, interview them, get that knowledge, because it's not documented".* This sense of ownership was sparked during the intervention.

Teachers commented on the intervention and their expectations of the SLP. Teacher 1 commented, *"I expect it to really open up new avenues to see how, social rules, unemployment, advancement of economy and many other things".* Teacher 3 said *"I am really grateful about everything that I have learned from this course*". Teacher 4 said "I feel empowered". The intervention played a huge role in the affective development of the Natural Sciences and Life Sciences teachers.

4.4.8 Analysis and discussion of focus group interviews with teachers (Lenasia intervention)

Two focus group interviews were conducted at the Lenasia (Gauteng) intervention that was held from 2 - 3 July 2017. The focus group interviews provided rich data as teachers could bounce ideas off one another. The focus group interviews were analysed using Saldaña's code-to-theory method (2015) from an affective stance.

Table 4-19: Table showing data analysis for focus group interviews using Saldaña's code-to-theory method (2015).

Focus group interviews					
Codes[17]	**Frequency of occurrence**	**Raw Data**	**Categories**	**Sub-theme/s**	**Theme**
L^R	8	*"Well it's pretty much the heart in terms of education where it's taking something that's just from a theoretical point and actually making sure that it has actual relevance from an emotional connection for the learners and it's not just, you know, the cold hard theory but is a bit more relevant."* *"Well, the affective domain is pretty much the heart in terms of education where it's taking*	Learner interest and motivation.		Teachers acknowledge that teaching for the affective domain with regard to indigenous knowledge (IK) can stimulate learners' interest and motivation to learn Natural and Life Sciences by contextualising the learning. (Jackson *et al.*, 2016)
A	1		Motivate learners through reward. Scaffold learning using the affective domain.		

[17] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

		something that's just from a theoretical point and actually making sure that it has actual relevance from an emotional connection for the learners and it's not just, you know, the cold hard theory but is a bit more relevant."			
VL^3	7	*"We see the need now to revert back to the old medication. This is a sign that the information that we got from the older generation still has value and relevance in today's generation."* *"We need to start at grass roots level by teaching the learners in primary school on how to preserve and know the value of the trees or plants that have medicinal uses. So I think that we should continue to teach indigenous knowledge systems bearing in mind that if we do not control the harvesting of these medicinal plants, there might be nothing left for the next generation and that it is not sustainable."*	Teachers show appreciation for IK and want to instil this appreciation in the leaners (preserve and know the value of trees or plants that have medicinal uses – in focus group interview 1 line 55 and 56). Teachers mention exactly where they can incorporate IK into the content. Sustain IK for future generations.		The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude (affective stance) towards indigenous knowledge thus creating content relevant to learner's context. (Jackson *et al.*, 2016)
T^-	3	*"It seems like it is a lot and how will you finish in time and how will they learn."*	Not enough time to incorporate IK.		

		"Educators are hard pressed for time."			
C^+ (CHAT tension - negative)	2	*"When I saw it, I thought, I know what that is but in the community that I'm in now, if you had to say that I am trying to wash away bad spirits, people look at your funny. I had changed my perceptions and I forgot that you could actually use this indigenous knowledge with the Western world."* *"I'm a little intimidated by it. Similarly, you always think that indigenous knowledge is only African. You forget that there is European indigenous knowledge. We live in a world where we are very critical of these things. We feel that Western medicine is the only thing that works. That changed the way I feel about it. These remedies do work and we can use them."*	'bad spirits' 'intimidated by IK' Teacher misconceptions.		Many teachers had negative attitudes themselves about indigenous knowledge related to 'myth' or 'witchcraft', which leads to teachers not teaching IK in the Natural Sciences and Life Sciences classroom but the intervention did play a role in changing this. (Jackson *et al*., 2016)

One of the teachers from the focus group commented on the affective domain, saying "*Well it's pretty much the heart in terms of education where it's taking something that's just from a theoretical point and actually making sure that it has actual relevance from an emotional connection for the learners and it's not just, you know, the cold hard theory but is a bit more* *relevant".* Teachers recognise the value of teaching indigenous knowledge within the affective domain and contextualising the learning, thus including all spheres of IK.

One teacher mentioned that teachers need to be 'culturally inclusive' (focus group interview 1, line 102, Appendix I). Teachers mention that it is important to be sensitive to the variety of cultures that are presented in the classroom, and that it is important to consider a variety of different opinions, cultures and religions. Shizha (2008) said that teachers who are educated in the Western education system tend to lack sensitivity towards indigenous knowledge. It is vital that a debate is created among teachers to create awareness about the diversity in the Natural Sciences and Life Sciences classroom. Furthermore, a teacher mentioned (focus group interview 1, line 107, Appendix I) *"In reality you will be touching on other people's cultures and beliefs so if you say something wrong or say something that goes against another person's belief, it becomes a problem. You have got to be so careful, especially where you could be easily taken on because of the fact that you may be considered as politically incorrect or socially incorrect. You have got to be so careful*". Teaching indigenous knowledge for the affective domain requires sensitivity, understanding and fairness, this in turn can create a safe space for learners to share their own excitement regarding their indigenous knowledge.

In focus group interview 2, line 48 (Appendix I) the teacher makes reference to scaffolding through the affective domain, *"I think learners have to be motivated. Unfortunately, they don't want to study on their own. We all know that. So if you have a chocolate, or something like that, it's a good idea. So that they are motivated. I was also thinking that you could do little work sheets, write something in their books after the activity. Don't always overdo it with a test".* Teachers realise that assessment is not always the answer, but rather to create a sense of excitement, motivation and enthusiasm in the classroom, while using indigenous knowledge in a cooperative manner, within the context of the learning environment of the learners.

Teachers are aware and show value (Krathwohl's taxonomy (1964) level 3) that all learning styles should be accounted for while teaching indigenous knowledge, keeping in mind inclusive education. Affective development was also apparent in the focus group interview as one teacher states, *"I also liked the fact that we saw the different kinds of African herbs and muti and different kinds of teas. There is actually value in these plants. So yes, my opinion changed a lot".*

4.4.9 Analysis and discussion of classroom observation one and two

The reformed teaching observation protocol (RTOP) instrument (Sawada *et al.*, 2000) is a comprehensive instrument to evaluate the teacher during a lesson (see Appendix M), specifically looking at the integration of indigenous knowledge. This instrument provided a holistic approach for the researcher. The researcher acted as a 'passive observer' during the lesson observations. There was no interference with the lessons while the teacher was teaching. The data from the two classroom visits was analysed. The analysis can be seen in Table 4-20.

Table 4-20: Table showing data analysis for classroom observation one using Saldaña's code-to-theory method (2015).

Classroom observations (RTOP)		
Codes[18]	**Frequency of occurrence**	**Observations**
IK^+	1	Classroom visit one showed inclusion of some indigenous knowledge, using a variety of plant species on the PowerPoint presentation. Learner interest was sparked as soon as indigenous knowledge was introduced. The learners became livelier in class and learners' body language changed (more excitement).
IK^0	1	Classroom visit two had no indigenous knowledge presented during the lesson.
A	2	Affective domain only evident in classroom visit one when the teacher showed visuals of plants and discussed the medicinal value of them, such as the Karoo aloe. Affective domain was evident when the teacher did a hands-on activity.
VL^3	1	Only in classroom visit one, this teacher showed value towards indigenous knowledge.
OL^4	1	Classroom visit one had some evidence of organisation as the teacher purposefully expanded on some of the uses of the plants and asked the learners to contribute their own understanding of medicinal plants. Lesson two had no evidence of organising (level 4 – Krathwohl's taxonomy).
CL^5	0	Both classroom visits show no evidence of characterising by a value complex (level 5 – Krathwohl's taxonomy).
TS^-	2	Both classroom visits, the teachers did not incorporate problem-based learning or cooperative learning, as learnt during the indigenous knowledge intervention.

During both lessons the teacher had a behaviouristic teaching pattern (teacher-driven) and very little collaboration occurred among the learners (no cooperative learning strategies used). Learners entered the class, opened their notes and listened to the teacher. Both teachers used PowerPoint and asked the learners to read from their book (out loud). In both lesson one (see

[18] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

Appendix N) and lesson two (see Appendix O) the emphasis in terms of teacher behaviour was *explaining* concepts to the learners, with the learners *copying notes* from the PowerPoint slide. During classroom visit one, the teacher taught photosynthesis and during classroom visit two, the teacher taught the nervous system. These are two very different concepts. During classroom visit one only some indigenous knowledge was presented in the lesson, whereas in classroom visit two no indigenous knowledge was included in the lesson. This could be due to the topic; teachers do not have the PCK to know what and how to infuse indigenous knowledge into a variety of Natural Sciences and Life Sciences topics. In the case of the nervous system, the teacher could have researched a few indigenous knowledge facts surrounding the nervous system. For example, how certain medicinal plants could affect the nervous system, such as 'Imphepho' (*Helicrysum*) (Van Wyk, 1997), an African herb that is smoked, taking individuals into a trance state to communicate with ancestors. Another important medicinal plant in this regard is *Sceletium tortuosum*, or 'kougoed'. Van Wyk & Gericke (2018) indicate that the active alkaloids in the plant are a potent serotonin-uptake inhibitor. This suggests that it could be effective in therapeutic applications for anxiety and depression. However, teachers will not know this if they do not have any knowledge of these plants. This shows the importance of the indigenous knowledge intervention.

As seen in Table 4-20, there was no evidence from both classroom visits (RTOP instruments – refer to Appendix N and O) that teachers moved from a level 3 (Krathwohl's taxonomy) to a Level 4 or 5.

Finally, there was very little indigenous knowledge transfer during the classroom visits, therefore more emphasis must be placed on follow up sessions or refresher courses following the indigenous knowledge intervention.

These findings (limited transfer of indigenous knowledge, cooperative learning strategies and problem-based learning) support the statement made by De Beer & Mentz (2018) that teachers often *"discard the academy for what they perceive as the real world of teaching".* Zeichner and Tabachnick (1981:7) speak of the 'wash out' effect: newly acquired knowledge and skills obtained during teacher education programmes are often 'washed out' at the coalface of teaching in the classroom.

4.4.10 Analysis and discussion of classroom observation three – CAR Foldscope activity (Learner and teacher reflections)

The third classroom visit consisted of the classroom action research (CAR) conducted by two teachers. The CAR activity consisted of a water quality practical designed by one of the teachers. The CAR included various steps that the teacher followed during their research intervention, namely:

1. identify the problem (could the Foldscopes be used in PBL, and what are its affordances for addressing the affective domain?);
2. plan (the intervention entailed a water quality practical);
3. act and collect data (learners' artefacts and reflections);
4. analyse the data (teacher marked the worksheet and analysed how the learners engaged and faired in the water quality practical); and
5. evaluate and reflect (the learners and the teacher reflected).

The teacher followed the method of CAR as described above and which has been explained in detail in 2.4. The worksheet for the practical can be viewed in Appendix R. The data collected from the third classroom observation was the CAR, learner reflections (see Appendix Q) and teacher reflections (see Appendix P). This data was analysed using Saldaña's code-to-theory method (2015), see Table 4-21. CHAT was used to provide the researcher with a better theoretical understanding of the CAR of the teacher.

The following CHAT diagram (Figure 4-7) was used to analyse the data collected from the CAR and Foldscopes water quality practical. In this case CHAT was used on an interpersonal plane (Mentz & De Beer, 2017), focusing on the interaction between the learner (the subject in the right-hand activity system), and the teacher (the subject in the activity system on the left). The CHAT diagram assisted the researcher to see if there were any tensions or contradictions between the objects achieved by the Natural Sciences and Life Sciences teacher and learner respectively.

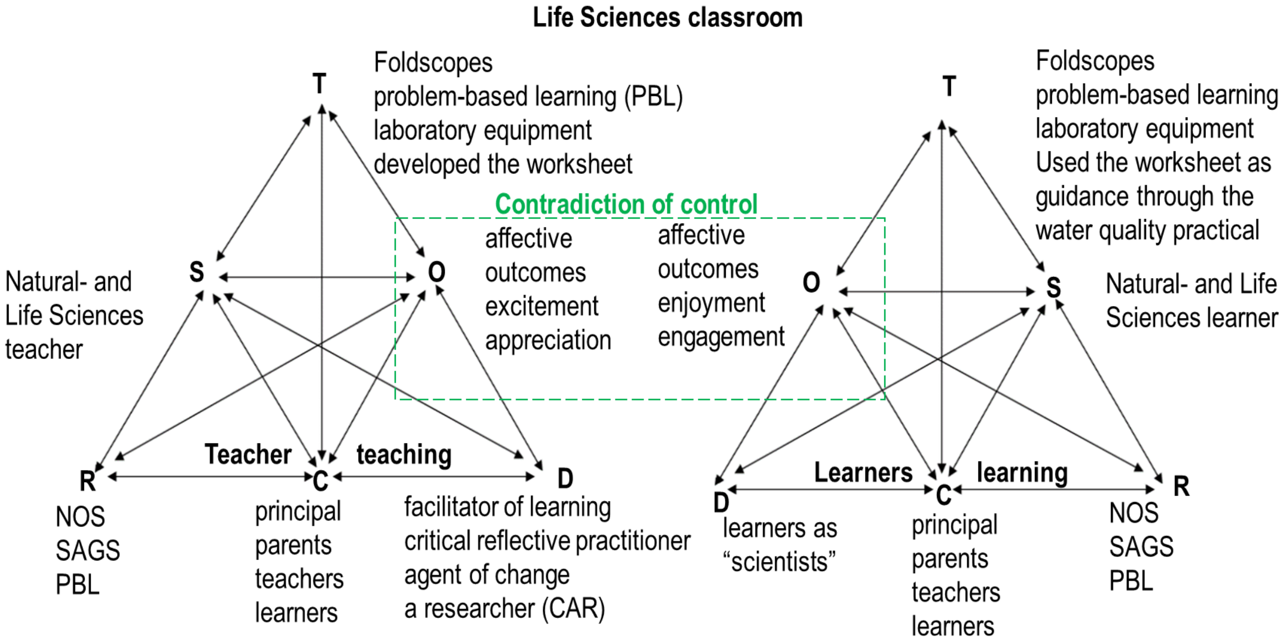


Figure 4-7: Using the third generation Cultural-Historical Activity Theory (CHAT) the unconventional way: Comparing the Natural Sciences and Life Sciences teacher and the learner adapted from Engeström (1987) and De Beer & Mentz (2017).

Table 4-21: Table showing data analysis for classroom observation three using Saldaña's code-to-theory method (2015).

Codes[19]	Frequency of occurrence	Raw Data	Categories	Sub-theme/s	Theme
CAR+	3	**Teacher reflections:** *"My first lesson was very daunting as the learners found the instructions very difficult to follow. I then looked for a video for the learners to follow and that seemed to work, and my second lesson went much better."* *"This was excellent for PBL as learners were required to investigate a problem hence the investigation of water quality in an area which learners live close*	Reflection on the first lesson to improve the second lesson that went more smoothly (using a video).	Teachers expressed satisfaction and appreciation using CAR. Teachers valued the role of classroom action research in their own professional development – especially reflecting. Teacher excited that learners enjoyed the water	The Natural Sciences and Life Sciences teacher becomes a more reflective practitioner, classroom action researcher and self-directed learner after the indigenous knowledge

[19] *Please note: See Table 4-3 for full details of the descriptors and codes used.*

		to. This will allow them to appreciate the fact that we have drinkable water." *"It was very fulfilling and it motivated me to tell other teachers about the CAR cycle and how beneficial it was in formulating practicals, etc. I recommend that all teachers use CAR in order to develop their professional skills."* *"Yes, it definitely did enhance my professional development. I learnt valuable skills associated with CAR including research and planning. A lot of research had to be done to identify how to test the quality of water, but also research methods that learners can use to test water in the class and at minimal cost, such as pH, temperature and the use of the Foldscope's."*		quality practical.	intervention. Teachers express satisfaction and appreciation engaging in CAR in the Natural Sciences and Life Sciences classroom. (Jackson *et al.,* 2016)
SDL	10	**Teacher reflections:** *"During the CAR reflection is vital, I did not realise the importance of reflection continually during the CAR, this is so valuable as this reflection allows me to be critical on myself in order to learn from mistakes or even how to improve the lesson for the next time. This is how you grow as a teacher to become a great teacher."*	Teacher reflections and CAR indicate research, reflection and SDL.		
CAPS^{+} VL^{3} T^{R}	12	**Teacher reflections:** *"Definitely valuable, at first it was difficult to fold and some Foldscopes didn't allow the learners to see anything, but they shared those that worked and assisted each other. It was incredible to see the amazement of the learners*	*Value of using the Foldscope in the classroom and reference to the Aim 3 in CAPS.*		Teachers internalise the affordances of indigenous knowledge in the Natural Sciences and Life

		of the unseen world, the learners really enjoyed this practical." *"The CAR forced me to use a variety of pedagogies in class. CAR was very valuable as it guided me to formulate a very meaningful activity which links to Aim 3 of the curriculum."* **Learner reflections:** *"Overall, I did enjoy the investigation, seeing what is going in our natural water sources. It was a bit difficult building the foldscope, but I do think that it is valuable towards the investigation. A good and cost-effective microscope that anyone can use."* *"My overall experience completing this practical, was educating. I learnt a lot about the quality of our water and how, if we don't take care of it and keep on contaminating it, then our drinking source will disappear/become no more and all this through the help of the foldscope which was very valuable because it helped me see all the dirt and dead/living organisms that are contaminating our water, I would have never seen this through the naked eye."* *"Being able to measure and identify (microscopically) the above indicators, we are able to determine and monitor changes in water quality and determine whether it is suitable for the health of the natural environment and the uses for which the water is required. Aquatic ecosystems are an integral*			Sciences classroom (CAR) as well as in society, therefore radiating to the learners who show an appreciation for the value of Natural Sciences and Life Sciences in Society (CAPS AIM 3). (Jackson *et al.,* 2016)

		part of our environment and play an important role in maintaining water quality.” *“Water is being polluted by waste (plastic) and different chemicals every day. Illegal disposal of waste is contributing towards not having a rich biodiversity which affects both animals and people. Leaking chemicals are killing animals that we eat (e.g. fish) and animals that die affect us as sea food is a source of food for people. If water is clean it will provide us with clean drinking water and a thriving agriculture.”*			
A	69	**Teacher reflections:** *“Learners were made aware of the number and variety of living creatures and unicellular organisms in the water. They explored the unseen world and they really were surprised and loved every second of it. One child said ‘best lesson ever’ and another said ‘this is so cool’.”* **Learner reflections:** *“It was a fun and somewhat frustrating experience.”* *“The folding of the foldscope microscope was very interesting and challenging.”* *“I really had a lot of fun and it was great to have to interact with those around you and really think.”* *“I enjoyed the experience, was fun and something new.”* *“I found it very difficult but*	Affective domain common categories: learners enjoyed, found it fun, interesting and excited. Interaction with fellow learners that assisted with the challenging folding parts.	The engagement of classroom action research (CAR) influenced teachers’ affective development and the engagement in the water quality practical using Foldscopes addressed learners’ affective development.	
LI+				The CAR activity designed by the Natural Sciences and Life Sciences teacher, allowed the learners to enjoy (affective domain) the overall experience of folding the Foldscope, was fun, interactive but learners found it challenging.	

		also fun at the same time." *"Everybody in the class helped one another and it was a very enjoyable."*			
LI-	34	**Teacher reflections:** *"Instructions were difficult to follow."* *"Building took a long time (60 min)."* *"Takes time to perfect the technique of making slides and viewing. Children aren't accustomed to paper model building and struggled with the instructions. The slots for holding paper sides were too small."* *"The water quality practical was very valuable to the learners to understand the quality of water; however it was difficult to build and use the Foldscope, but persistence allowed for learning to happen in many spheres."* **Learner reflections:** *"It was quite difficult because the instructions weren't specific. The pictures were not clear."* *"Folding and assembling the foldscope in my opinion was quite hard. The instructions were small and quite hard to read. The paper was sturdy although it felt like it was going to tear in some more intricate steps of assembly sometimes when folding I had to apply lots of pressure in order to bend*	Building took a long time. Frustration was highly evident.	Natural Sciences and Life Sciences teachers realise that some learners were frustrated that no 'quick-fix' guidelines were provided for the Foldscope microscopy activity, and that they had to devise their own experimental designs. Natural Sciences and Life Sciences teachers realise that learners lack of microscopy skills (required to investigate various medicinal properties of indigenous plants or water quality), therefore there is a need to introduce the Foldscope into the Natural Sciences and Life Sciences classroom, creating an exciting and stimulating learning experience. Learners are not used to inquiry lessons where clear instructions are not provided.	

		the material."			

In the case of the water quality project and the Foldscopes, the teacher identified the theoretical framework as social constructivism (Powell & Kalina, 2009). The conceptual framework was related to the affective domain, as it was important to see if learners affectively embraced the learning during the practical, and to see if learning occurred. Teachers were subjected to the affective domain during the interventions.

The CAR investigation using the Foldscopes was a great success, although the learners found it challenging, there was a lot of fun, excitement and stimulation in the learning environment.

Four sub-themes emerged from the data that was analysed. The sub-themes are as follows;

- Natural Sciences and Life Sciences teachers realised that some learners were frustrated that no 'quick-fix' guidelines were provided for the Foldscope microscopy activity, and that they had to devise own experimental designs;
- Natural Sciences and Life Sciences teachers realised that learners lack microscopy skills (required to investigate various medicinal properties of indigenous plants or water quality), therefore there is a need to introduce the Foldscope into the Natural Sciences and Life Sciences classroom, creating an exciting and stimulating learning experience. This practical contextualised learning, in that learners could see how science is used in practice to find solutions to problems in the environment and in society (Pretorius, Jackson, & De Beer, 2018);
- the CAR activity designed by the Natural Sciences and Life Sciences teacher, allowed the learners to enjoy (affective domain) the overall experience of folding and using the Foldscope, it was fun, interactive but learners found it challenging and
- affective domain is addressed during this hands-on water quality practical (as part of the teacher's CAR) using the Foldscope.

Based on teacher reflection on engaging with CAR, the data shows that both learners and teachers obtained affective outcomes. The teacher mentioned *"I really enjoyed designing the CAR activity and got a lot of satisfaction when the activity was designed. The donation of the Foldscopes motivated me to use the CAR to design this learning activity",* in addition the teacher mentioned, *"the water quality practical was very valuable to the learners to understand the* *quality of water; however it was difficult to build and use the Foldscope, but persistence allowed for learning to happen in many spheres".* It is evident that the teacher experienced satisfaction and appreciation that learners enjoyed the water practicum (project).

The teacher also valued the role of classroom action research in their own professional development – especially in making them more reflective practitioners. The teacher expressed, *"Yes, it definitely did enhance my professional development. I learnt valuable skills associated with CAR including research and planning. A lot of research had to be done to identify how to test the quality of water, but also research methods that learners can use to test water in the class and at minimal cost, such as pH, temperature and the use of the Foldscopes",* the teacher also mentioned, *"during the CAR reflection is vital, I did not realise the importance of reflection continually during the CAR, this is so valuable as this reflection allows me to be critical on myself in order to learn from mistakes or even how to improve the lesson for the next time. This is how you grow as a teacher to become a great teacher".*

In 2.12.2 the CHAT diagram with regard to the Foldscopes was explained, the diagram was used to distil the data. In Figure 4-7 focus was placed on the Life Sciences classroom (where Foldscopes were used), by identifying two co-dependent activity systems (Mentz & De Beer, 2017). The two activity systems in Figure 4-7 was the learner as subject, completing the Foldscope water quality activity (diagram on the right) and the teacher as subject facilitating the learning activity (diagram on the left). The teacher as a facilitator scaffolded the learning, e.g. by using the worksheet as a tool. From the data that was analysed the use of the Foldscopes created a shared outcome in a positive manner to allow for learning to occur, this is evident in the sub-themes and themes that have emerged. In this case analysed data indicates that there is a shared view in order to achieve the object (and hardly any 'contradiction of control'). Whereas there often are 'conflicts' in terms of contradicting (non-aligned) objects in the two activity systems, it is surprising to see that, in this case, there was good alignment between the objects in the two activity systems.

These themes will be discussed in more detail in Chapter 5.

4.4.11 Analysis and discussion of lesson plans submitted with the teacher portfolios (Limpopo, Potchefstroom, Lenasia and Calvinia interventions)

Teachers were required to complete the prescribed portfolio for the indigenous knowledge intervention. Teachers had three months to complete the portfolio. Teachers submitted the portfolios to the project supervisors who assessed the portfolios. If the teachers achieved all the criteria for passing the portfolio they received 16 credits, NQF level 6 (National Qualifications Framework). These portfolios were used as a data generating instrument, to see if any affective development took place.

Only a few portfolios from the teachers were selected and sections relevant to the affective domain were chosen. Portfolios were handled with the utmost discretion during analysis. Researchers' notes were added to the selected extracts to determine if there were any affective affordances.

Please note: Afrikaans portfolios have been translated to English by the researcher. The teachers' own words (written in their portfolios) below are in italics.

Teacher portfolio one (Lenasia intervention):

Below are selected sections from a teacher's portfolio with regard to the affective domain.

<u>*Introduction*</u> *Application of indigenous knowledge to the classroom at this stage may be extremely difficult to do for every topic and time-wise. The curricula are already extremely condensed and may need to be addressed to make more room for indigenous knowledge. However, despite certain constraints, it is possible to include certain elements to different topics, such as plant organs, ecology, fauna and flora of Johannesburg and so forth.* **Researcher's note: Again, teachers are concerned about the fact that they do not have time to incorporate IK in the Natural Sciences and Life Sciences classroom. This teacher mentioned the full curriculum, but said that room could be made to apply IK to some of the topics. This is a positive outlook towards IK.**

Lesson outcomes

a) Minds-on lesson outcomes

The learners should be able to create a detailed summary the structures of the plant (root, stem and leaf).

The learners should be able to compare their notes with other learners to form a cohesive summary through cooperative learning.

Researcher's note: This statement above shows a lack of understanding of the principles of cooperative learning, as formulated by Johnson & Johnson.

The learners should be able to apply their learnt 'expertise' to the core groups' assessment.

b) Hands-on lesson outcomes (where applicable)

c) Hearts-on lesson outcomes (where applicable)

The learners should be able to appreciate the importance of teamwork within

Researcher's note: The teacher addresses all three learning domains in the portfolio. It is important to point out that the teacher addresses the affective domain, specifically pointing out that learners should show appreciation (level 3 of Krathwohl's taxonomy) for IK and cooperative learning. Another aspect arising in this portfolio is that the affective domain cannot stand alone, the cognitive domain and the affective domain go hand-in-hand.

Contextualisation

The learners will be working with other learners on a topic; they will be using a form cooperative learning to master that topic which will be translated to their core group. Through this, they will have a 'knowledge responsibility', which will hold them accountable to their group.

Researcher's note: Knowledge responsibility is mentioned by the teacher which indicates that learners need to show respect towards each other and this addresses the affective domain (level 2 of Krathwohl's taxonomy).

Reflection

What went well?

The learners were lively and enjoyed discussing the topics with each other. They did take the task seriously.

What did not?

Too noisy and it took longer than what was needed as some of the learners did become a little social.

How would I do it differently?

I would put a loud time on to indicate the start and end of each section. I would also condense the sections required a little more from the note pack.

Researcher's note: Enjoyment (level 2 of Krathwohl's taxonomy evident).

Teacher portfolio two (Lenasia intervention):

Below are selected sections from a teacher's portfolio with regard to the affective domain.

<u>My reflection on the Kirby Bauer experiment</u>

We need to contextualise our curriculum and bring the IKS into our classrooms. Learners need to see how science links with their own indigenous knowledge. It is also a brilliant method of bringing a real-life laboratory experience into the classroom. You could also teach the learners about safety issues (when working with bacteria).

It is also possible to use other cultures' IKS as part of this activity by using any other Dutch/Afrikaner, Western or Indian remedies to test. The learners could even bring a remedy that they use at home to test its effectiveness. This is a very nice activity which links science and IKS and making active learning a priority in our class rooms.

Researcher's note: The teacher is linking indigenous knowledge to contextualise learning for Natural Sciences and Life Sciences learners.

<u>Reflection on cooperative learning</u>

The Jigsaw activity in our groups was kind of nerve wrecking, we were pressurised to learn as much as possible in a short space of time in our expert groups. What I enjoyed here was that people helped each other to remember certain things using certain methods. We had a lot of fun with it in the expert as well as the home groups, (even though our home group did exceptionally bad in the test). The wrap up afterwards, were the correct answers are given by the facilitator is a must in this type of activity in class. Learners need to consolidate their answers with the correct answers.

Researcher's note: The teacher actually experienced what the learners would experience doing the jigsaw activity. The teacher also mentioned that they 'enjoyed' this activity a lot; this is an aspect of the affective domain.

Reflection on my own experience (professional development) and career goals as well as SDL
I loved the experiments using shoe string science to illustrate different concepts to the learners. The problem-based learning activities made me reflect a lot on my own practice. I disagree to some degree with some of the instructions of the problem-based learning. If there is something that I have learnt through experience, it is that learners need guidance. Especially the type of learners we have today, some are progressed, and they come from a system where they are not motivated to learn. So, I agree that they should learn through discovery, but most learners need some direction or guidance to help them along this path.
This course encouraged me to read more about medicinal plants and their uses. I was thinking of how to incorporate this into everyday lessons in order to contextualise them and involving the learners in doing so.

Researcher's note: The teacher mentions the ZPD and realises that scaffolding is required, and that contextualisation of learning is necessary.

Teacher portfolio three (Lenasia intervention):
Below are selected sections from a teacher's portfolio with regard to the affective domain.

Reflection on short learning programme
I attended the course on the spur of the moment and was just curious to find out what it really entailed since it was for Life Science teachers. I felt apprehensive at first because I am not teaching Life Sciences. When the facilitator spoke about laboratory experiments that had to do with agar plates for testing anti-microbial plant substances, I started cringing [sic].

Researcher's note: The teacher expresses curiosity about the IK intervention.

The topic on Ayurveda was well detailed and supported with video and pictures. I enjoyed it thoroughly. I also appreciated the use of herbal remedies in treatment and prevention of ailments. Videos on Indians undergoing Ayurveda treatment together with their own *experiences kept me captivated and increased my appreciation of Indigenous Knowledge. Information on different types of plants and herbs used in South Africa to treat diseases and ailments was also given. I became enlighten on how IK has relevance to various topics in Life Science and how it can also be contextualised in Geography.*

In conclusion, my expectations were met. I am pleased to say, I felt rejuvenated as a teacher. I could not wait to go and implement some the strategies. For me they made learning funny and I would like to believe their comprehension of concepts is also improved. I benefitted a lot both at professional and personal level.

Researcher's note: The teacher realises that there are different indigenous knowledge systems. A classroom is filled with a variety of cultures and as a teacher it is necessary to learn more about other cultures. The teacher mentions that s/he has grown on a personal and professional level as a result of the intervention and after completing the portfolio. The teacher also said, *"I felt rejuvenated as a teacher"*; this is ultimately part of the affective domain and shows affective development. The teacher becomes a self-directed learner.

Teacher portfolio four (Calvinia intervention):

Below are selected sections from a teacher's portfolio with regard to the affective domain.

Lesson plan two

What do plants need to grow?

Reflection on lesson

Learners found the lesson very excited and interesting. There was a lot of interaction between the learners as before. Learners who do not like group work have found the lesson very interesting. There was teamwork among the learners. And learners prefer the jigsaw method because they learn better if they themselves must do the research.

Researcher's note: Teaching within the affective domain creates excitement among the learners as well as interaction using cooperative learning strategies that the teacher was exposed to during the indigenous knowledge intervention. Through this, a more affective learning atmosphere was created within the classroom and the educator can engage the learner in the lesson.

The portfolios showed that the intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude towards indigenous knowledge. It is also evident from the portfolios that the intervention played a role in making teachers more reflective practitioners, setting professional development goals for themselves to become self-directed learners.

Overall the portfolios were of a good quality and the number of portfolios submitted. The quality varied from the 1st DBR cycle to the 3rd DBR cycle. The quality of the portfolios was more professional, and use of the CAR cycle was evident in the 3rd DBR cycle. Teachers that were exposed to CAR showed an improvement in the quality of their write ups, lesson designs and reflections. The teachers from Calvinia (Cycle 3) scored higher marks than the teachers from Limpopo and NWU intervention (Cycle 1). This showed that the intervention presented to the Calvinia teachers had improved since the 1st intervention.

4.5 Triangulation

Data triangulation is a vital part of qualitative research, because data must be validated. This research employed various questionnaires, interviews (personal and focus group), reflections, observations and portfolios to ensure validity. Data triangulation provided the opportunity to identify tensions or contradictions (factors influencing the teaching of indigenous knowledge) while using CHAT as a research lens. Various analysis methods were also employed in this research to validate the sub-themes and themes, namely, Cronje's rubric method, Krathwohl's taxonomy and Saldaña's (2015) code-to-theory.

Many sub-themes and themes correlate from the analysed data over the variety of data collection methods. This indicates that there is a common thread that runs through the teachers' responses regarding the incorporation of indigenous knowledge into the classroom. This validates the findings. Overall teachers showed a more nuanced understanding and appreciation of indigenous knowledge which created a positive attitude (affective domain addressed) towards indigenous knowledge. Affective development is therefore evident from the data. This common thread ensures validity and reliability with regard to the findings.

Instruments were also validated, the VNOIK questionnaire was validated by a study done by Cronje (2015), the affective questionnaire as well as the interviewing questions for both the personal and focus group interviews were sent to the supervisor and co-supervisor for validation. Discussions with the supervisors assisted in making informed decisions on the various data capturing techniques.

Cultural-Historical Activity Theory was used as a theoretical research lens, which assisted as a reference point and validation of findings. Various intermediate theories such as Krathwohl's (1964) taxonomy for the affective domain, Warford's (2011) ZPTD, ESDC, conceptual change, professional development and SDL were guidelines while analysing and filtering the data, thus improving validly.

Various discussions with fellow researchers, Natural Sciences and Life Sciences teachers and supervisors assisted with the validation of the findings. Two conference papers were accepted and presented at the Conference for Mathematics, Science and Technology Education (ISTE).

Ultimately, the research aim, objectives and questions were addressed and aligned with the content as well as the data and this has improved the validity of the study.

4.6 Conclusion

Chapter 4 provided an overview of data synthesis. Various tables indicate how the data was synthesised using Cronje's (2015) rubric, Krathwohl's taxonomy for the affective domain and Saldaña's (2015) code-to-theory method. The collected data formed various sub-themes and themes which aimed to address the research questions. Triangulation was also discussed to show how this research was validated. The following chapter will provide an overview of the major findings, limitations, recommendations and conclusion for this research.

CHAPTER 5: MAJOR FINDINGS, LIMITATIONS, RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

Chapter 4 illustrated how the data was synthesised and evaluated. Chapter 4 included data tables, images and graphs that depict the findings from the data that was collected. The data was synthesised in a variety of ways, including Cronje's (2015) rubric to analyse the VNOIK data, Krathwohl's taxonomy for the affective domain and Saldaña's (2015) code-to-theory method. From the synthesised data, sub-themes and themes emerged. Chapter 5 outlines the major findings, limitations, recommendations and conclusion of this research.

5.2 Research considerations overview

This research addressed aspects around incorporating indigenous knowledge into the curriculum as well as to investigate the affordances of an indigenous knowledge intervention for Natural Sciences and Life Sciences teachers' affective development. Teachers participated in a variety of activities aimed at engaging with various teaching strategies, classroom action research, implementation of Foldscopes as well as reflecting on the tenant of indigenous knowledge and nature of science. The research aim, objectives and research questions can be revisited in chapter 1 (1.5) or chapter 3 (3.2).

5.3 Overview of formulating the sub-themes

Saldaña's code-to-theory method (2015) was utilised to distil the affective data collected from four different interventions hosted by the North-West University (NWU). The data was read through and descriptors (codes) were identified. These descriptors (codes) aided the researcher to see how many times the same descriptor (code) appeared in the data. From these, categories were formed and from the categories sub-themes emerged. The sub-themes ultimately provided the major themes that emerged from this research.

5.3.1 Sub-themes identified with regards to affective development during and after the indigenous knowledge intervention.

5.3.1.1 Sub-theme 1: Teachers' lack of knowledge on context-specific indigenous knowledge and demotivation to teach indigenous knowledge should also be viewed in terms of available resources, time management and in-service programmes for professional development.

One of the teachers said she felt *"confusion because most of the time it* (indigenous knowledge) *encompasses knowledge known within a community and that knowledge may be known only by tribal elders or people from rural areas*". This not only indicated that some teachers are not familiar with context-specific indigenous knowledge and are not aware of its value, but also that the textbooks used in schools do not adequately address context-specific indigenous knowledge. Teachers who are not aware (Krathwohl, 1964) of the value of indigenous knowledge and its affordance close the door on the use of resources such as knowledgeable holders of indigenous knowledge, for example, elders or traditional healers, or the use of pedagogies such as drama and puppetry that is aligned with the oral tradition of indigenous knowledge. Therefore, teachers cannot effectively infuse context-specific indigenous knowledge into their teaching of CAPS themes. Lack of resources for teaching indigenous knowledge, and similarly lack of PCK (e.g. in improvising materials that could be used to teach indigenous knowledge), are some of the tensions identified using the third-generation activity theory (CHAT). One of the teachers commented: "*I was so inspired by the anti-microbial lab activity we did, and I would love to go and do it in my classroom too, but we do not have the apparatus in my school, and I just cannot think of other ways of doing these experiments*". If one uses CHAT as a research lens, it shows that teachers do not always receive the necessary support in their professional development in their schools (e.g. the subject advisors who, as part of the 'community' in the activity system, should provide scaffolding, ideas and resources with regard to indigenous knowledge).

The data indicates that teachers have little time to complete the themes prescribed in the curriculum. A teacher said *"There not enough time. I believe in my subject. There are so many topics that we will have to cover and that disadvantages some of the teaching practices that will be good and bring good results".* Teachers have specific work schedules (pacesetter), lesson plans and assessment schedules that make it very restrictive and time-consuming for Natural Sciences and Life Sciences teachers to incorporate indigenous knowledge into their lessons (Department of Basic Education, 2011). The intervention played a role in terms of showing teachers how context-specific indigenous knowledge can be incorporated in strategic ways so as to contextualise the learning. Teachers were shown how to teach a topic using cooperative learning strategies. After the intervention one teacher mentioned, *“we don’t have enough time, but we can make time”*, another teacher mentioned, *“yes, there is enough time, only planning is important”*. This is very encouraging as these teachers realised the importance of incorporating context-specific indigenous knowledge and showed affective development and appreciation for indigenous knowledge.

5.3.1.2 Sub-theme 2: The intervention provided teachers with a more nuanced understanding and appreciation of indigenous knowledge which in turn created a positive attitude (affective stance) towards indigenous knowledge and an improved skill set (including becoming reflective practitioners and setting professional goals) with which to incorporate IK into the classroom.

The Views of the Nature of Indigenous Knowledge questionnaire captured teachers’ knowledge and views of indigenous knowledge. It is clear that there has been a general shift towards a more nuanced understanding of context-specific indigenous knowledge amongst teachers from all four interventions. A number of teachers progressed from an uninformed view of indigenous knowledge to a partially informed view. Several teachers also progressed from a partially informed to an informed view. It is evident that Natural Sciences and Life Sciences teachers who participated in the indigenous knowledge intervention benefited from this short learning programme.

The data points to the fact that teachers who attended the short learning programme realised the importance of being reflective practitioners and setting professional development goals for themselves after the indigenous knowledge intervention. Some goals teachers mention include the following: they will *“use the reflection protocol to reflect. Keep a reflective journal”, “reflect on lessons in order to improve the effectiveness of lessons”, “improve my skills on handling laboratory equipment” and “prepare learning activities differently”.* Ultimately these goals indicated that teachers are motivated to learn and become self-directed learners.

This shows that the short learning programme served to make teachers more aware of indigenous knowledge (receive – level 1 in Krathwohl’s taxonomy) (Krathwohl, 1964) because they were given the opportunity to engage with indigenous knowledge during the intervention (respond – level 2) (Krathwohl, 1964) and this led to them starting to value indigenous knowledge systems (value – level 3) (Krathwohl, 1964). A teacher responded, *“I have learnt* *new things that will help me be a better science teacher, it is never enough with learning, you will always discover new things".*

This data also shows that teachers are becoming more aware of the affordances of indigenous knowledge. The data suggests that teachers aim to develop their understanding of indigenous knowledge about such subjects as medicinal plants. This is evidence that teachers are 'accepting' indigenous knowledge and are more open to this notion. The various teachers listed skills that they have expanded after the intervention such as observation, laboratory, research and safety skills. This sub-theme ties in with theme 7.

Professional development interventions do benefit teachers' professional growth (Pretorius, 2015). These two-day and three-day short learning programmes allow teachers to grow professionally (Cronje, 2015) and develop a variety of skills. Teachers emerged from the intervention with a positive attitude to introducing indigenous knowledge into their classrooms through a warm lens (De Beer & Henning, 2010).

5.3.2 Sub-themes identified with regard to teachers' classroom action research (CAR) and using Foldscopes in the classroom

5.3.2.1 Sub-theme 1: Natural Sciences and Life Sciences teachers realise that some learners were frustrated that no 'quick-fix' guidelines were provided for the Foldscope microscopy activity, and that they had to devise their own experimental designs.

Some educational trends in education research include learner autonomy (Farahani, 2014) and teaching skills for the 21st century (Kereluik *et al.*, 2013). Educational pedagogies are moving towards learner-centred approaches (O'Neill & McMahon, 2005), including *cooperative learning strategies* (Johnson & Johnson, 1987), *flexible learning* (Taylor, 2000 cited in O'Niel *et al.*, 2005), *experiential learning* (Burnard, 1999 cited in O'Niel *et al.*, 2005) and *self-directed learning* (Knowles, 1975). Many teachers are not incorporating learner-centred pedagogies in the Natural Sciences and Life Sciences classroom due to a lack of PCK (Mothwa, 2011), time constrains, a full curriculum and a poor understanding of cooperative learning approaches (by confusing it with group work) (Jacobs, De Beer & Petersen, 2016). The data also showed that learners are so used to explicit instructions and 'recipes' that they struggle with complex problem-based learning approaches. This could be the result of teachers not regularly incorporating problem-based learning activities for learners.

Furthermore, learners are not familiar with cooperative learning strategies because some teachers are not implementing cooperative strategies in the classroom (O'Neill & McMahon, 2005). Learners rely on the teachers to include specific instructions and explain certain concepts, in other words 'spoon-feeding' for the exam, consequently reducing 'out-of-the-box thinking'. Teachers are also restricted to the curricula (CAPS or SAGS); therefore, the curricula also reduce agency. We sit with a system that only wants the correct answers and doesn't allow for agency. Learner 33 said "*[it] took a while for me to gain trust in myself, as I didn't want to make a mistake*". Teachers are now becoming aware that learners need to be prepared for 'life beyond the classroom' (Farahani, 2014). Evidence from this research shows that children are still used to being 'spoon-fed'. This is demonstrated by the great difficulty they have in following instructions on their own. During the CAR, the data indicated that learners find lateral thinking very difficult. Learner 1 says "*it was difficult because the instructions weren't specific*" and Learner 2 said *"it was extremely difficult to fold the microscope as the instructions were not very clear and many of the parts looked similar to each other*". This shows that learners are used to being 'spoon-fed', despite the learner-centred approaches to initiate 'self-feeding' (Farahani, 2014).

Certain learners also realised that they required psychomotor skills during this activity, Learner 56 indicated that *"folding the Foldscope was difficult because it required the use of fine motor skills, something many people lack, it also required careful and meticulous following of instructions within a short time period"*. This once again demonstrates that our education system does not allow for self-discovery, self-feeding and shows a lack of awareness of and responsiveness towards autonomous learning (Farahani, 2014). There is therefore, a need for more interventions, which include CAR, to ensure teachers become more aware of autonomous learning, both for themselves and the learners they teach.

5.3.2.2 Sub-theme 2: Natural Sciences and Life Sciences teachers realise that learners lack microscopy skills (required to investigate various medicinal properties of indigenous plants or water quality). Therefore there is a need to introduce the Foldscope into the Natural Sciences and Life Sciences classroom, creating an exciting and stimulating learning experience.

Many South African schools lack proper laboratory equipment (Cronje, 2015; Jacobs, 2015; Pretorius, 2015), thus making it difficult for learners to master microscopy skills. Hence, there is a need for 'frugal science' (Ahuja, 2014). The $1 Foldscope makes it possible for learners to be exposed to microscopes, especially those who attend schools that do not have proper laboratory equipment. Lack of equipment can lead to poor academic performance, motivation and interest in the class (Hidi & Harackiewicz, 2000). The $1 Foldscope is an inexpensive and accessible means to improve learners' practical skills. In a reflection after the activity, learner 24 said: *"the Foldscope has provided me with the opportunity to view the wide biodiversity within water in an easily accessible way and affordable manner without the financial barriers, the topic of ecology and biodiversity can be explored by learners in any financial position"*.

5.3.2.3 Sub-theme 3: The CAR activity designed by the Natural Sciences and Life Sciences teacher, allowed the learners to enjoy (affective domain) the overall experience of folding the Foldscope, was fun and interactive, but learners found it challenging.

Cognitive dissonance is evident in the data. Festinger (1962:93) explains that "*two items of information that psychologically do not fit together are said to be in a dissonant relation to each other"*. The learners experienced conflicting emotions. Although the learners found the activity very difficult and consequently frustrating, they found it rewarding when they had successfully mastered the task. Learner 7 indicates that "*the folding of the Foldscope microscope was very interesting and challenging"* and Learner 44 said "*it pushed me out of my comfort zone as normally I do not build things or enjoy making things, but I really enjoyed building the Foldscope"*. Taking learners out of their comfort zone, creates a sense of cognitive dissonance, learners engage in the learning material, but find it challenging, yet towards the end, learners enjoyed it and learnt a lot from the Foldscope activity. Learner 27 said "*the folding of the foldscope microscope was a challenging, and yet rewarding task – at times I truly struggled to interpret the instructions that were provided on the instruction manual and thus the folding was quite tricky at stages – and yet, it was exhilarating at the same time, every time I folded a piece of the microscope. During certain stages of the folding process, I experienced irritation and agitation due to the fact that I could not achieve the desired outcome / fold the different pieces together in the manner that was depicted on the instruction leaflet"*.

Not only was the Foldscope activity challenging for the learners, but data also showed that learners were fearful of completing this activity and gave up easily, Teacher 2 said: "*those who persisted did see things but some gave up"*. Learner 55 said, *"I was just a bit scared that I was going to tear it but if you work carefully you won't"*. This showed some anxiety in the classroom (CHAT tension), thus indicating that teachers don't often give learners hands-on activities to stretch themselves.

5.3.2.4 Sub-theme 4: The engagement of classroom action research (CAR) influenced teachers' affective development and the engagement in the water quality practical using Foldscopes addressed learners' affective development.

Teachers' engagement in classroom action research showed affective affordances such as motivation and improvement in their professional development. One teacher mentioned: "y*es, it definitely did enhance my professional development. I learnt valuable skills associated with CAR including research and planning. A lot of research had to be done to identify how to test the quality of water, but also research methods that learners can use to test water in the class and at minimal cost, such as pH, temperature and the use of the Foldscopes"*. Classroom action research provided a guideline for teachers to create stimulating activities that could enhance learning in the classroom. Teachers learned valuable skills related to teaching pedagogies. During the CAR the teachers reflected (a vital component of CAR) on their planning, research and development of the learning activity. This indicated level 4 (organising) of Krathwohl's (1964) affective taxonomy. *Organising* refers to some internalisation of a teacher's own professional development and professional philosophy.

Learners indicated that the use of Foldscopes and the water quality practical was a stimulating and fun task. Another trend in Science, Technology, Engineering and Mathematics (STEM) education is the Arts (Science, Technology, Engineering, the Arts and Mathematics Education: STEAM). Learners engage in learning tasks in *Homo ludens* mode, which means the playing human (pedagogy of play) (Huizinga, 1955 as cited in Jautse, Thambe & De Beer, 2016). This mode and its affordances for the affective domain were evident in the data. Learner 2, 5, 9, 12, 28, 33, 35, 40 and 41 indicated that the Foldscope activity was "*fun*". This shows that learners really enjoyed the hands-on Foldscope activity.

The data showed that the affective domain was evident in this learning opportunity. The affective domain is "*penetrating the innermost recess of the heart, affective education attaches greater meaning to what learners learn and makes the overall learning experience more memorable, fulfilling and relevant to the real world*" (Green & Batool, 2017). Learners showed respect for each other when asking their classmates for assistance with folding the Foldscope. Learner 7 said "*I found myself asking for help whilst constructing it more than once, my classmates were very helpful and we all tried to help each other if need be".* Furthermore, this activity created a mutual learning zone (cooperative learning), and at the same time improved their patience and creativity. Learner 42 said "*it allowed us to let lo[o]se, be creative and embrace our inner child".*

Learners showed awareness and responded well to the task at hand (level 2 of Krathwohl's taxonomy (1964)). Learner 5: "*this practical was a fun learning adventure which taught me many new things, it gave me problem solving skills".*

Another affective outcome was that learners showed appreciation for nature, learner 28: "*you feel like a proper biologist"*. Learner 17: "*it is eye-opening and almost humbling to realise that a tiny living thing can affect your life drastically"*.

Learners also showed self-fulfilment and found it very rewarding, which is another affective outcome. Learners showed value (level 3 of Krathwohl's taxonomy (1964)) towards the Foldscope learning activity. Learner 21 said "*it looked really cool*", while learner 27 said "*the experience was positive and enjoyable*" and learner 31 said "*I had to be very involved and attentive*".

Overall, the data indicated that affective learning took place during this Foldscope activity, learners found it new, enjoyable, exciting, and fun.

5.4 Major findings identified in this research

5.4.1 Theme 1: Teachers acknowledged that teaching for the affective domain using indigenous knowledge (IK) and by contextualising the learning could possibly stimulate learners' interest and motivation to learn Natural Sciences and Life Sciences.

The first major theme that emerged was that teachers acknowledged the affordances of the affective domain with regards to indigenous knowledge for more effective science teaching and learning. Teachers showed appreciation for the fact that, through the creation of contextualised learning opportunities, affective outcomes such as learner interest and motivation could be better achieved. One teacher commented that *"[l]earners mostly do not relate with the scientific knowledge so indigenous knowledge will contribute to their learning process*". Another teacher stated that "*I can see how my class will become alive, when we start discussing traditional healing. This course has made me realise that I as a teacher should ensure that I stimulate learners' interest in science*". Another teacher mentioned that indigenous knowledge can "*help them attach importance to what they are learning*". This is pertinent to context-sensitive science (Mode 2 knowledge production) as suggested by Gibbons (2000). Science education and society cannot be separated; it is important to integrate the two spheres to make learning more meaningful. Learners can relate better to their own indigenous knowledge and teachers can integrate indigenous knowledge into science content to foster mode 2 knowledge production rather than the traditional mode 1 cognitive approach.

Many teachers realised that using indigenous knowledge to create content relevance to the learners' contexts was important. Indigenous knowledge can be used to create curiosity and excitement in the Natural Sciences and Life Sciences classroom. Contextualising learning or creating a contextualised learning opportunity and sharing a variety of indigenous knowledge in the class (not only African IK) can create multiple viewpoints allowing learners to become critical thinkers, ultimately addressing the affective outcomes such as learner interest and motivation.

5.4.2 Theme 2: Teachers often marginalise the affective domain, yet data shows that affective domain and cognitive domain go hand-in-hand in teachers' professional development.

One of the reasons for South Africa's dismal performance, is the marginalisation of the affective domain (De Beer, 2016). In fact, the affective domain, as a learning domain, has been neglected by the entire education community (Garritz, 2010). The cognitive domain is centralized in education, yet the affective domain (values and attitudes, such as perseverance, tolerance, etc.) is a driver for cognitive development. Research done by Dubinsky *et al.* (2013) in neuroscience indicates that experiences linked to emotion are ingrained in the memory.

Life Sciences teachers often experience that some learners do not enjoy, engage or prosper academically in Life Sciences (Hidi & Harackiewicz, 2000) because of this lack of motivation. Furthermore, research shows that teachers who are not knowledgeable about indigenous knowledge (thus having an underdeveloped pedagogical content knowledge) become unmotivated to incorporate indigenous knowledge into their teaching. This could also create poor learner interest in indigenous knowledge. One of the teachers stated that "*I have never considered teaching indigenous knowledge, because I did not have the necessary knowledge. I guess that made me negative about indigenous knowledge. This course has changed it, and I feel inspired to infuse all these new ideas into my teaching*". The flipside is also true. Where teachers have negative perceptions (affective domain) of indigenous knowledge, they might not teach it: "*I always saw indigenous knowledge as mumbo-jumbo and not as real science, so I did not teach it. After these three days, I feel inspired to go and teach indigenous knowledge in my Natural Science class*". These statements show how important the affective domain is in teacher professional development, and that the emphasis should not only be on cognitive outcomes.

Birbeck and Andre (2009) advocate fusion of the cognitive and affective domains, and that neither one be neglected, in order to ensure that learners embrace affective qualities of Natural Sciences and Life Sciences. The affective domain should be emphasised more in pre- and in-service teacher education.

5.4.3 Theme 3: Teachers showed an affective shift during the intervention regarding their values, beliefs perceptions and attitudes of IK and their responsibility toward incorporating indigenous knowledge in the Natural Sciences and Life Sciences classroom.

Affective development was evident in the analysed data. Teachers' attitudes, values and beliefs changed in a positive manner as seen from the data highlighted in Chapter 4. A teacher mentioned *"to be effective, there is one principle. If you love what you are studying or if you love what you are teaching, automatically you are going to understand everything. This brings about learners to love what they are studying".* This teacher is referring to the affective domain.

The affective domain can stretch teachers to become self-directed learners. If they are passionate about their subject and want to contextualise the learning using indigenous knowledge, then there is a deeper significance learning (Candy, 1991).

Teachers in the second focus group interview mentioned that their views of indigenous knowledge had changed; this is affective development, a changed perspective regarding their understanding of IK. One of the teachers (focus group interview 2, line 14, Appendix I) said: *"yes it has changed a lot. I liked the research we saw on the different plants. How they really work; it's not just a myth. I also liked the fact that we saw the different kinds of African herbs and muti and different kinds of teas. There is actually value in these plants. So yes, my opinion changed a lot"*. Teachers in this group also realised that there is a variety of indigenous knowledge and not just African IK (focus group interview 2, line 19, Appendix I), *"this changed my opinion because I always thought that this was just Zulu traditional medicine and that is the indigenous knowledge that exists. So when I saw that there is Indian and Dutch, etc. indigenous knowledge, I thought this is interesting, I was living in my own world. I thought it was only the Zulu traditional medicine that exists. So yes, it opened my mind".* This indicates that there was an affective shift during the indigenous knowledge intervention.

5.4.4 Theme 4: Many teachers had negative attitudes themselves about indigenous knowledge believing it to be ‘myth’ or ‘witchcraft’, which resulted in teachers not teaching IK in the Natural Sciences and Life Sciences classroom. However, the intervention did play a role in changing this.

This theme is evident in almost all the data that was collected in this research. The data confirms Keane’s (2015) idea that some teachers as well as learners often view indigenous knowledge as ‘myth’ or ‘witchcraft’. A teacher said before the intervention, *“I do not believe in this stuff”.* Evidence shows that teachers had negative attitudes themselves about indigenous knowledge, believing it to be supernatural practices that do not align with religion. One teacher noted that *“some believe it is witchcraft and do not believe in it”* and another teacher said that *“there is a contradiction to rules and regulations of God our creator*”. Teachers and learners have misconceptions about indigenous knowledge as a result of the various cultures and religions existing in the classroom.

However, several teachers indicated that they have changed their views on indigenous knowledge after the course. One of the teachers commented: “*It was so interesting to hear that there is scientific merit in using ‘Impinda’, and that it is not witchcraft. I was impressed with this indigenous knowledge*”.

5.4.5 Theme 5: Teachers internalise (affective) the affordances of indigenous knowledge in the Natural Sciences and Life Sciences classroom (CAR) as well as in society, therefore enabling them to transmit this to the learners who show an appreciation for the value of Natural Sciences and Life Sciences in society (CAPS AIM 3).

The curriculum and assessment policy statement (CAPS) includes 3 aims. Aim 1: knowing in Natural Sciences and Life Sciences; Aim 2: investigating phenomena in Natural Sciences and Life Sciences and Aim 3: appreciating and understanding the history, importance and application of Natural Sciences and Life Sciences in society (Department of Basic Education, 2011:1).

The data indicates that learners and teachers showed appreciation towards the role of science in society. Learner 5 reflected, *“the Foldscope was a valuable tool as it brings microscopes to everyone at a very cheap price, which will end up exposing more people to biology and increase knowledge and learning within schools, the overall practical gave me some insight into how people cause pollution”*. The learners realised that, because the Foldscope was small and portable, it could be used to view organisms anywhere, not only in the school laboratory, but also in the community where it could be used to investigate, for example, the quality of water. Furthermore, Learner 9 added: *"it gives me great pride to know that under privileged children will soon feel the joy and curiosity one feels when they look down a microscope".*

This demonstrates a science and society link as illustrated by Aim 3 in the CAPS. The Foldscope created a relevant learning context that could be applied in their daily lives, thus creating a warm learning experience (De Beer & Henning, 2010). Learner 21 further reinforces the Foldscope and society link; *"if you were at a place with no electricity you wouldn't be able to use the light microscope and so the Foldscope could really help"*, moreover, Learner 15 argued, *"very often people assume water is safe to drink because the water looks clear which indicates there's nothing in the water. Through the use of the Foldscope it was found that there is in fact many organisms that inhabit the water"*. Learners indicated that there is a lack of scientific literacy in the community, but with the use of the Foldscope, more people would become aware of scientific reasoning.

5.4.6 Theme 6: The Natural Sciences and Life Sciences teacher becomes a more reflective practitioner, classroom action researcher and self-directed learner after the indigenous knowledge intervention. Teachers express satisfaction and appreciation engaging in CAR in the Natural Sciences and Life Sciences classroom.

The primary question in this research asks, what are the affordances of an indigenous knowledge professional development intervention for the affective development of Natural Sciences and Life Sciences teachers? Ultimately the indigenous knowledge intervention allowed teachers to stretch themselves professionally. The data indicates that Natural Sciences and Life Sciences teachers became reflective practitioners, researchers and self-directed learners through the intervention as well as engaging in CAR.

The teacher reflections indicate that designing and implementing problem-based activities are 'daunting' for them, as shown by studies mentioned in the literature review (Chapter 2), and thus teachers avoid using problem-based pedagogies (De Beer & Petersen, 2016). The Foldscope was also a new tool that teachers were not familiar with and did not really know what to expect, therefore a variety of skills were required from the teachers.

Teachers who engaged in classroom action research (CAR) and became reflective practitioners, become researchers and self-directed learners. During the CAR teachers had to formulate a problem to investigate and chose to focus on the marginalisation of the affective domain and how learners' interests could be stimulated using Foldscopes. Teachers first had to research and design a water quality practical using the Foldscopes. Teachers also had to have knowledge on how to use the Foldscope, therefore they had to find out how to fold the Foldscope, use the Foldscope as a microscope and make prepared slides. Teachers also constantly had to reflect during the whole process, i.e., reflect on action and reflect in action (Gravett & De Beer, 2015), thus practicing critical reflective skills.

Teacher 1 (from the CAR) conducted the Foldscope activity with two classes. The first lesson was challenging as the teacher realised that the instructions were difficult for the learners to follow. Therefore, the teacher reflected "*how can I improve my next lesson?*". The teacher found videos that showed step-by-step instructions for the learners to follow, thus the second lesson was much better. Learner 9 said *"the instructions on the paper in the package was very difficult to follow and was unclear, but the video was helpful"*.

Teacher 2 (from the CAR) indicated that it takes a lot of time to perfect a technique, and as a result valuable teaching time is lost. Again, time is a major factor in the Natural Sciences and Life Sciences classroom, and many teachers avoid doing practicals because of this. Teacher 2 indicated that there is value to doing hands-on activities in the Natural Sciences and Life Sciences classroom to develop fine motor skills because "*children aren't accustomed to paper model building and struggles with instructions*".

It is evident that engaging in CAR assists teachers to become better researchers and reflective practitioners, ultimately becoming self-directed learners. Teachers expressed satisfaction and appreciation for engaging in CAR. Teachers become motivated and aspired (affective affordances) to learn more about their teaching pedagogies. One teacher mentioned, *"I really enjoyed designing the CAR activity and got a lot of satisfaction when the activity was designed. The donation of the Foldscopes motivated me to use the CAR to design this learning activity".*

Figure 5-1: Natural Sciences and Life Sciences teacher using the Foldscope during classroom action research (CAR).

5.5 Limitations

The researcher faced a number of issues or challenges during the research process. One huge limitation was that, due to work commitments, the researcher could not attend all four of the interventions. As a part-time post-graduate student, it was often difficult to balance teaching and research responsibilities. However, as a co-researcher in this is a large NRF-funded project, all data was made available for this thesis' research. Although research was conducted on all four different interventions (cycles) in this dissertation, the sample size does not warrant generalisation.

Another limitation of this research was that teachers were reluctant to participate in the post-intervention data gathering such as filling in questionnaires; often post-intervention questionnaires were not completed. The teachers might have felt that there were too many questionnaires that needed to be completed. There were a variety of niches in the larger project therefore there were many questionnaires, this may have overwhelmed the teachers. During the intervention there was limited time to conduct the interviews, and teachers had to give up their lunch time to answer a few questions.

Another limitation was the securing of classroom visits. Teachers did not want to commit to researchers viewing their lessons. Those who were willing to open their classrooms struggled to incorporate indigenous knowledge throughout the lesson. A mention of indigenous knowledge was evident, but this was probably because the researcher was present in the lesson. It was therefore very difficult to research the extent to which transfer took place in the classroom. Teachers were required to provide lesson plans in their portfolios, and there was evidence of good integration of indigenous knowledge in CAPS themes. However, these lessons were generally not observed by the researcher.

The Foldscopes were handed out to the teachers with limited explanation on how to fold the Foldscope. It would have been an advantage to set aside some time during the intervention to show teachers how to use the Foldscope effectively.

Another limitation was the submission of the portfolios. Teachers did not adhere to the submission criteria and therefore did not achieve the credits offered by the course.

The 2- and 3-day short learning programme was not sufficient for full affective development in terms of reaching level 5 of Krathwohl's taxonomy.

The SLP is constantly evolving and improving through the various DBR cycles, should there be any issue, it may be rectified at the next SLP. This was evident in the Calvinia intervention as there was evidence of inquiry and problem-based learning where teachers moved away from transmission mode teaching practices.

5.6 Recommendations

Recommendations put forward from this research would be to:

5.6.1 Provide more longitudinal and systemic in-service teacher education

Attention should be given to continued professional teacher development (CPTD) programmes (Pretorius, 2015), including creating a community of practice among teachers. A limitation of this research, especially during Cycle 1 (Limpopo), was that teachers were not adequately supported after the short learning programme. Online communities of practice (e.g. through the Blackboard system) are needed to further support teachers regarding the use of indigenous knowledge in their professional development after the SLP. Possible further research question could be; 'How can in-service teacher education create sustainability of teacher knowledge?'

5.6.2 Emphasis on self-directed learning and classroom action research during in-service teacher education

Further research into the integration of 'self-directed professional development' programmes (Brown *et al.*, 2001), with more emphasis on classroom action research (CAR) and scaffolding teacher learning across the zone of proximal teacher development (ZPTD) (Warford, 2011) is needed. This could assist with greater internalisation (Krathwohl, 1964) of teaching indigenous knowledge in an affective manner. Possible further research question could be; 'What is the relationship between self-directed learning and classroom action research in teacher education?'

5.6.3 New design principles for the SLPs should be distilled

It is important to relook at how the portfolios are submitted and to provide easier communication channels. Prompt feedback and continual support is vital. Teachers need support while preparing their portfolios.

More focus should be placed on the affective domain when designing interventions such as these. If more focus is placed on the affective domain, then hot topics such as indigenous knowledge may be addressed affectively. Teachers often marginalise the affective domain, and this should be emphasized more in pre- and in-service teacher education (one of the sub-themes that emerged from the data). Attitudes and values may be addressed, and teachers can see the value of incorporating indigenous knowledge into their teaching practices. Teachers should be encouraged to engage more in classroom action research (CAR), to challenge themselves and to become reflective practitioners. More research can be completed with the extended version of Neuman's taxonomy of affective learning (Neuman & Friedman, 2010).

5.6.4 Teachers should engage in authentic laboratory experiences

Teachers should be given the opportunity to engage in authentic laboratory experiences to develop a more nuanced understanding of the nature of science. The limited exposure to laboratory activities (through the Kirby-Bauer method), and the data obtained, show that teachers need more engagement in authentic laboratory activities that could foster true inquiry learning, and give learners a better understanding of the tenets of science. Two examples of this is the 'Target Inquiry at the Miami University' (TIMU) in the USA (MacKenzie, 2001), and then the A-Team intervention (Pretorius, 2015) where teachers engaged in authentic learning at the African Centre for DNA Barcoding. Possible further research question could be; 'How can authentic laboratory experiences benefit learner understanding, engagement and curiosity of Natural Sciences or Life Sciences?'

5.6.5 Focusing on frugal science (such as Foldscopes) in science education in South African schools

This research of mine introduced Foldscopes to sciences education in South African school, and such frugal science initiatives hold promise to enhance inquiry learning in South Africa. Possible further research question could be; 'What benefits does frugal science, like the Foldscope, have in South African schools?'

5.7 Contribution of this research

The gap identified included the marginalisation of the affective domain and how indigenous knowledge could address this. This research revealed teachers' affective development of indigenous knowledge and the gap between their own knowledge of indigenous knowledge and what they learnt during an intervention and how some perceptions shifted.

The data shows that teachers' overall perceptions of indigenous knowledge changed. Teachers made reference to the value of incorporating indigenous knowledge into the class contextualising learning.

This research contributed from a theoretical perspective and a methodological perspective. From a theoretical perspective this research addressed the theories surrounding the affective domain, NOS and the value of indigenous knowledge systems. Emphasis was placed on the affective development of Natural Sciences and Life Sciences teachers after the intervention. Teachers acknowledged that teaching for the affective domain with regard to indigenous knowledge can create learner interest and curiosity. Another contribution was to confirm that the affective domain cannot exist without the cognitive domain; they must go hand-in-hand. From a theoretical perspective Natural Sciences and Life Sciences teachers' perceptions changed after the indigenous knowledge intervention. Teachers were left excited, challenged by and appreciative of indigenous knowledge.

From a methodological perspective, this research contributed towards classroom action research (CAR) and the use of Foldscopes in the classroom. The water-quality Foldscope practical was a huge success. Teachers and learners learnt a variety of skills and showed appreciation for Natural Sciences and Life Sciences in society. This research contributed to meaningful conceptual learning as well as contributing to teachers affectively embracing the range of indigenous knowledge in the Natural Sciences and Life Sciences classroom. Ultimately the contribution was to empower teachers to embrace and value indigenous knowledge. This research also made a methodological contribution, including contributing to the growing volume of research literature on Cultural-Historical Activity Theory.

5.8 Conclusion and further research

This research suggests that teachers do benefit from the three-day indigenous knowledge intervention, in terms of both cognitive and affective outcomes. It is unlikely that the teachers developed their affective domain fully (i.e. reached level 5 of Krathwohl's taxonomy) during the intervention and it is therefore important that teacher professional development is further developed and supported within well-functioning communities of practice – an aspect that has not been achieved yet despite three cycles of the indigenous knowledge intervention. The intervention is only a stepping stone toward a more nuanced view of indigenous knowledge pedagogy, and will not allow for organisation (level 4) (Krathwohl, 1964) and characterisation of values (level 5) (Krathwohl, 1964). It is recommended that the affective development of teachers receives more emphasis in both pre-service and in-service teacher education.

Teacher professional development programmes and mode 2 knowledge production as suggested by Gibbons (2000) should receive more attention in teacher professional development. Teachers should understand how important it is to contextualise Natural Sciences and Life Sciences so that it is more meaningful to the learners, but for indigenous knowledge to be meaningful to learners, it must start with the teachers' affective development, and nuanced understanding and appreciation of indigenous knowledge. There is a call for further research in this regard especially in the South African context. So often teacher PCK development and conceptual change is only viewed through cold lenses (Pintrich, Marx & Boyle, 1993), and not a hot lens that also focuses on teachers' affective development, values and attitudes towards indigenous knowledge. Another aspect that should be emphasised in teacher education is classroom action research (CAR).

Teachers benefited through understanding and implementing classroom action research. Not only did teachers indicate that their engagement in CAR assisted them to become more critical reflective practitioners, but the learners also achieved valuable affective outcomes through their participation in the Foldscope learning activity. Teachers that engaged in the CAR found it very stimulating and exciting to create successful activities that contributed to learners' enjoyment of science. Teachers also improved their research skills, which hopefully enhanced teaching and learning in the Natural Sciences and Life Sciences classroom.

Although there is positive evidence of affective teacher professional development, there is still a need for 'systemic and longitudinal interventions' (De Beer & Kriek, n.d.). Further research can be done concerning prolepsis, where the teacher teaches in a way that *"assumes that learners know more than they do*" (Warford, 2011:254). This will ultimately allow learners to grow their own learning, confidence and value in Natural Sciences and Life Sciences.

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LIST OF APPENDICES

APPENDIX A: RESEARCH OUTLINE HANDOUT TO TEACHERS

Private Bag X05, Noordbrug
South Africa 2522

Tel: 018 299-2000
Web: http://www.nwu.ac.za

Faculty of Education
School Mathematics, Science and technology Education
Tel: 018 285 2626
Email: josef.debeer@nwu.ac.za

May 2018

Science/ Mathematics/ Technology Teacher

Dear Teacher

THE AFFORDANCES OF INDIGENOUS KNOWLEDGE FOR SELF-DIRECTED LEARNING: PARTICIPATION IN THIS RESEARCH PROJECT AND INFORMED CONSENT

Welcome to this short learning programme on indigenous knowledge! I trust that you will enjoy the next three days, and that it will be valuable in your own professional development as a teacher. 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, I 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 science/ technology/ mathematics teachers' perceptions of indigenous knowledge and its link with the nature of science (or technology/ mathematics). There are no right or wrong answers or views, and I would appreciate it if you could share your thoughts with me. We would also like to establish, after the three-day programme, if your views on indigenous knowledge changed, and whether you plan on incorporating indigenous knowledge in your own teaching. You will also be invited to participate (in a blended learning mode) on eFundi/ Blackboard, and we would like to also capture your experiences of such blended learning.

2. ETHICAL GUIDELINES FOLLOWED IN OUR RESEARCH

- 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 learning programme, 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.
- 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 learning programme. We are interested in your experiences in teaching IK 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.
- You are more than welcome to contact me, if anything is unclear to you, or you can also contact the Research Ethics Committee of the Faculty of Education (EduREC): Ms Erna Greyling, e-mail: Erna.Greyling@nwu.ac.za or (018) 299 4656.

Thank you very much!

Regards

JOSEF DE BEER (PROF)

(CELL: 082 923-2865)

APPENDIX B: CONSENT FORM

CONSENT LETTER

Research project: The affordances of indigenous knowledge for self-directed learning

Name of Researcher: Prof Josef de Beer ([Office] (018) 285-2626; josef.debeer@nwu.ac.za

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. 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 where I incorporated indigenous knowledge.

Signature ______________________ Date _________________

APPENDIX C: PROGRAM FOR INTERVENTION 18-20 JULY 2016

The affordances of

INDIGENOUS KNOWLEDGE
for Self-Directed Learning

SHORT COURSE FOR *LIFE- & NATURAL SCIENCES* TEACHERS

18 – 20 JULY 2016

National Research Foundation

Programme

Day 1 (Mphebatho Museum)

07:00	Arrival North-West University Potchefstroom (President Street entrance; Building B10, Room G01) Completion of registration forms
07:45	Bus transport to Mphebatho Museum in the Pilanesberg
10:15	Registration at Mphebatho Museum Tea/coffee
	Cultural activities of Bakgatla culture; medicinal plants/ LUNCH
14:30	Leave for Potchefstroom
17:00	Arrival at NWU

Day 2 (North-West University)

08:00	Registration C5, G01 (Education lab) Tea/coffee
08:15 – 10:00	Welcome; Introduction to IKS (Prof Josef de Beer)
10:00 – 13:00	Testing muthi plants for anti-microbial activity (Dr Jaco Bezuidenhout, Dept of Microbiology)
13:00 – 13:45:	LUNCH
13:45 – 16:00	Problem – based learning in the Life Sciences classroom (Prof Josef de Beer; C5, G01)

National Research Foundation · University of Limpopo · University of Johannesburg · Georgia State University · mphebatho museum

1

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

Day 3 (NWU, C5, G01)

08:00:	Registration/ Tea/coffee (C5, G01)
08:15 – 09:15	Matrix method, herbarium vouchers, and identification of plants; Medicinal plants (Prof Josef de Beer, C5, G01)
09:15 – 12:30:	IKS in the science classroom using the jigsaw method (Cooperative learning) (Dr Neal Petersen, C5, G01)
12:30 – 13:15:	Lunch
13:15 – 14:00:	Assessment of incubations; Conclusion (Dr Jaco Bezuidenhout, Microbiology)
14:00 – 15:30	De Bono's Hat activity & Being a reflective practitioner (reflection and professional development) (Mrs Dehlia Coetzee, C5, G01)
15:30 – 15:50	Conclusion & Evidence-based portfolios
15:50 – 16:00	Closure

National Research Foundation

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APPENDIX D: PROGRAM FOR INTERVENTION 2-3 JULY 2017

SDL SELF DIRECTED LEARNING

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

5. Programme

DAY 1: MONDAY 3 JULY 2017

08:30: Registration

09:00: Welcome, and administrative matters

09:45: The affordances of indigenous knowledge for self-directed learning in Life Sciences

11:00 – 12:30: Ayurveda- ancient yet relevant Indian Indigenous Knowledge

12:30 – 13:15: LUNCH

13:15: The Kirby-Bauer technique: testing anti-microbial activity of muthi plants

15:00: TEA/ COFFEE

15:15: Kirby-Bauer technique (continued); Planning inquiry activities in Life Sciences, by infusing indigenous knowledge in CAPS themes

16:30: Closing

DAY 2: TUESDAY 4 JULY 2017

08:30: Problem-based learning in Life Sciences

09:30: Cooperative learning in Life Sciences: The jigsaw method

10:45: TEA/ COFFEE

11:00: Cooperative learning in Life Sciences: De Bono's thinking hats

12:45: LUNCH

13:30: The 'arts' in STEAM: Puppetry as a pedagogy in Life Sciences education

14:30: Portfolios

15:00: Questionnaires

16:00: Closing

National Research Foundation

UNIVERSITY OF JOHANNESBURG

Georgia State University

mphebatho MUSEUM

15

APPENDIX E: VNOIK QUESTIONNAIRE

VIEWS OF THE NATURE OF INDIGENOUS KNOWLEDGE QUESTIONNAIRE

(VNOIK questionnaire; Cronje, 2015:117) (**NATURAL SCIENCES AND LIFE SCIENCES)**

Name or pseudonym: ……………………………………………………………………………….

Instructions:

- Please answer each of the following questions. Include relevant examples whenever possible.
- There is no 'right' or 'wrong' answer to the questions. We are only interested in your opinion on a number of issues regarding indigenous knowledge.

1. In your view what is indigenous (or traditional) knowledge? What makes indigenous knowledge different from other types of knowledge systems (such as Western knowledge)?

2. Practitioners of indigenous knowledge (e.g., elders, herbalists, traditional healers) observe nature to generate knowledge. Do they do experiments and tests to verify or validate this knowledge?

- If yes, explain how they test or validate their knowledge
- If no, explain why not

3. Practitioners of indigenous knowledge observe nature and give explanations about their observations. Elders in a community can, for example, explain where lightning comes from. Do the elders always use natural causes to explain their observations such as lightning, or do they sometimes include supernatural causes in their explanations?

- If they only use natural causes, explain why and give examples of some of the causes.
- If they sometimes use supernatural causes, explain why and give examples of some of the causes.

4. Indigenous knowledge is transferred from one generation to the next over many decades and centuries. Does this knowledge stay the same or does it change over time?

- If yes, explain why it stays the same
- If no, explain the causes of such changes

5. *Hoodia gordonii* is a plant that was used by Khoi-San hunters to suppress their hunger and thirst when they went on hunting expeditions. How do you think the Khoi-San people come to know that this particular plant has these properties?

6. Sustainable development is an emerging concept that includes topics such as hunger, poverty and underdevelopment. Globally governments and organisations struggle to find solutions for these important issues. Do you think indigenous knowledge can be used to alleviate some of these problems?

- If you say yes, please explain why and how indigenous knowledge can be
- If you say no, please explain why it cannot be used to solve these problems.

7. An athlete regularly competing in marathons struggles with pain in his legs during the last part of a marathon and can sometimes not complete a marathon due to this. The athlete decides to consult a traditional healer to determine why his legs pain during the last part of a marathon.

- What methods do you think the traditional healer will apply to diagnose the problem when consulting with the athlete?
- What possible treatment or advice do you think he will give the athlete?

8. Myths are stories that are told in different cultures by elders from one generation to the other. Do you think myths and rituals play any important role in indigenous knowledge systems?

- If yes, explain why and provide examples.

- If no, explain why and provide examples.

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9. Some claim that indigenous knowledge is infused with social and cultural values. That is, indigenous knowledge reflects the social and political values, philosophical assumptions, and intellectual norms of the specific culture in which it is practiced. Indigenous knowledge is thus generated locally and can only be used in a specific area. It cannot be used universally in other contexts or globally to solve different problems.

- Do you believe that indigenous knowledge reflects the social and cultural values of a specific community? Explain with the use of examples how indigenous knowledge reflects the social and cultural values of a local community.
- Do you believe that indigenous knowledge can only be used in a specific area or do you believe it can be used in other areas or globally to solve problems? Explain your answer with examples.

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10. Indigenous knowledge is passed from one generation to the other by elders. The elders are deemed very important and some people believe their ways of knowing knowledge) is truth and cannot be challenged. Does this mean that current practitioners of indigenous knowledge must use this knowledge exactly as it was passed on to them, or can they use their creativity and imagination to modify the indigenous knowledge to solve current problems?

- If you say yes and believe that indigenous knowledge practitioners cannot change this knowledge, explain why. Use examples if possible.

- If you say no and believe that indigenous knowledge practitioners can change and modify their knowledge, explain why. Use examples if possible.

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THANK YOU FOR COMPLETING THIS QUESTIONNAIRE.

If you have any questions, you are welcome to contact Prof Josef de Beer at the following contact numbers:
(W) (018) 285-2626
Cell: 082 923-2865
E-mail: josef.debeer@nwu.ac.za

APPENDIX F: PRE- AND POST-INTERVENTION AFFECTIVE QUESTIONNAIRES

NWU®
NORTH-WEST UNIVERSITY
NOORDWES-UNIVERSITEIT
UNIBESITI YA BOKONE-BOPHIRIMA

Pre-intervention questionnaire

Dear colleagues,

Thank you for taking part in this exhilarating professional development experience.

I would really appreciate if you would take the time in completing this questionnaire.

Please note, that all the information provided in this questionnaire is confidential and you have the right to withdraw from this research at any point. Your integrity will not be compromised by answering this questionnaire.

There are no 'right' or 'wrong' answers, your first reaction is most valid, do not ponder too long over questions.

Thank you for your time and your co-operation. Cherine Jackson.

Name or Pseudonym: ____

1. Mindful of your responsibilities as a Natural Sciences and Life Sciences teacher, what is your understanding of your **role and responsibility** of teaching indigenous knowledge in your classroom?

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2. Briefly explain your understanding of teaching for the **affective domain.**

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3. Do you currently **practice affective teaching** with regard to **indigenous knowledge**?

YES or NO (Please circle)

If so, please indicate whether your lessons are purposely aimed at achieving this (list some strategies) or you just teach hoping that these affective skills will be developed.

4. With reference to the affective domain, what are the **biggest challenges or hurdles** that a Natural or Life Science teacher faces in teaching indigenous knowledge?

5. Do you as a Natural Sciences and Life Sciences teacher **value** indigenous knowledge?

YES or NO (Please circle)

Motivate why?

6. Describe a **stereotype** that you would associate with indigenous knowledge.

7. How can teaching indigenous knowledge influence **learners' view and enjoyment** of Science?

8. Rate the following outcomes in terms of importance:

With 1 being the LEAST important, and 6 being the MOST important:

Rating	Item
	Learners should have a sound knowledge of Natural Sciences or Life Sciences
	My biggest role as a teacher is to ensure that most learners pass the exam
	Learners should be able to think critically and substantiate opinion with relevant data
	Learners should be able to plan and execute an experiment
	Learners should appreciate value of Natural Sciences and Life Sciences in everyday life
	Learners should be able to analyse and synthesise when studying Natural Sciences and Life Sciences
	I am motivated and positive to teach indigenous knowledge in my classroom
	My role as a teacher encompasses cultivating an interest in Natural Sciences and Life Sciences in the learners
	Learners should be biologically literate citizens that value the contribution of Natural Sciences and Life Sciences in modern society
	Learners should be scientifically literate citizens who can compete in a global society
	Learners should appreciate the science underpinning many indigenous knowledge practices

Thank you very much for completing this questionnaire!

Cherine Jackson

cherinejackson@outlook.com

Post-intervention questionnaire

Dear colleagues,

Thank you for taking part in this exhilarating professional development experience.

I would really appreciate if you would take the time in completing this questionnaire.

Please note, that all the information provided in this questionnaire is confidential and you have the right to withdraw from this research at any point. Your integrity will not be compromised by answering this questionnaire.

There are no 'right' or 'wrong' answers, your first reaction is most valid, do not ponder too long over questions.

Thank you for your time and your co-operation. Cherine Jackson.

Name or Pseudonym: ____

1. After attending this course and mindful of your responsibilities as a Natural or Natural Sciences and Life Sciences teacher, what is your understanding of your **role and responsibility** of teaching indigenous knowledge in your classroom?

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2. Briefly explain your understanding of teaching for the **affective domain.**

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3. After attending this course, would you **practice affective teaching** *(Hearts-on domain)* with regard to **indigenous knowledge**?

YES or NO (Please circle)

How would you incorporate indigenous knowledge for the affective domain in your teaching?

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4. After attending this course, what are the **biggest challenges or hurdles** that you foresee as a Natural or Life Science teacher when teaching indigenous knowledge, with reference to the affective domain? How could these challenges be addressed?

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5. Do you as a Natural Sciences and Life Sciences teacher **value** indigenous knowledge?

YES or NO (Please circle)

Motivate why?

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6. Describe a **stereotype** that you would associate with indigenous knowledge. Has this stereotype changed after attending the course?

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7. How can teaching indigenous knowledge influence **learners' view and enjoyment** of Life Science?

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8. Rate the following outcomes in terms of importance:

With 1 being the LEAST important, and 6 being the MOST important:

Rating	Item
	Learners should have a sound knowledge of Natural Sciences or Life Sciences
	My biggest role as a teacher is to ensure that most learners pass the exam
	Learners should be able to think critically and substantiate opinion with relevant data
	Learners should be able to plan and execute an experiment
	Learners should appreciate value of Natural Sciences and Life Sciences in everyday life
	Learners should be able to analyse and synthesise when studying Natural Sciences and Life Sciences
	I am motivated and positive to teach indigenous knowledge in my classroom
	My role as a teacher encompasses cultivating an interest in Natural Sciences and Life Sciences in the learners
	Learners should be biologically literate citizens that value the contribution of Natural Sciences and Life Sciences in modern society
	Learners should be scientifically literate citizens who can compete in a global society
	Learners should appreciate the science underpinning many indigenous knowledge practices

Thank you very much for completing this questionnaire!

Cherine Jackson <u>cherinejackson@outlook.com</u>

APPENDIX G: INDIVIDUAL INTERVIEW QUESTIONS

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May 2018

PERSONAL TEACHER INTERVIEW SCHEDULE

RESEARCH PROJECT TITLE: TEACHERS' AFFECTIVE DEVELOPMENT DURING AN INDIGENOUS KNOWLEDGE PROFESSIONAL TEACHER INTERVENTION

Thank you for your willingness to answer a few questions. The purpose of this short interview is to determine what your views are on this indigenous knowledge short learning programme. There are no right or wrong answers. Your real name will not be revealed when we report on the findings.

Name/ pseudonym:

1. What do you understand under the 'affective domain'?
2. Is learners' interest in Natural Sciences and Life Sciences just as important as to passing the examination? Why do you say so?
3. Do learners enjoy Natural Sciences and Life Sciences? If no, what could be the reasons?
4. Describe what you think your unique indigenous knowledge is, using examples.
5. Do you value indigenous knowledge? Why?

6. How do you feel about indigenous knowledge in the Natural Sciences and Life Sciences classroom?
7. Describe a stereotype that you would associate with indigenous knowledge.
8. How can teaching indigenous knowledge influence learners' view and enjoyment of Science?
9. Traditional healers or herbalists use medicinal plants and herbs to help treat ailments (illnesses). Would you use this medicine given to you or is Western medicine more reliable? Do you see value in using medicinal plants and herbs?

(Any other questions relevant to the research questions, based on the feedback by the respondent, may be asked at this point).

Thank you for making the time to discuss the short learning programme with me. I greatly appreciate your feedback.

APPENDIX H: TRANSCRIPTS OF INDIVIDUAL INTERVIEW

<u>Indigenous Knowledge SLP (Affective Domain) 18- 20 July 2016</u>

Interview: Teacher 1

Researcher:	Okay, my first question to you is: Do you understand the term or what do you understand under the affective domain?
Teacher:	Effective domain?
Researcher:	Affective.
Teacher:	Effective or affective?
Researcher:	Affective. So there is three domains, cognitive, affective and psychomotor
Teacher:	I thin affective domain tells me more of its matter of the heart. It deals with the matters of the heart. Something that is dear to you, things that you value so much that is next to your heart. I think that is what it means.
Researcher:	Okay, thank you and tell me now you've said that there is value that matters to the heart. How do you feel about indigenous knowledge? What does it bring to your heart?
Teacher:	No I'm, I'm, I'm, I'm very passionate about indigenous knowledge systems and I'm actually excited that universities now have come to realise the value in, in indigenous knowledge systems and then you know, it, it, it tells more about our forefathers, so having to associate myself, the world and the divisions of learning, higher learning with, with, with, with what our forefathers discovered, and used as their way of life makes me excited and I want to know more about indigenous knowledge system and it is also need to carry total attitude and to tell um, mind shift of, of, of, what actually indigenous knowledge is all about because I fell, I should start the fresh now to, to turn a new leave and see the world from the other side as well.
Researcher:	Okay my next question for you is: Is learners interest in science just as important as passing an examination? The interest of the learner is it just as important as passing an examination? Do you just do content, content, content or do you see the value in that?
Teacher:	No, I, I, I, I attach value in but I am teaching, you know my high school teacher he used to say: these things are not only for, for, for, for exam, but they are also for life. So my approach to teaching is that I we should not only teach things that should definitely appear in the exam but I should also teach learners, I am teaching education for self-reliance. Leaners beyond examination learners should be able to draw from what they have learnt apply in real life situations.
Researcher:	That's very good thank you. Umh, do learners enjoy Natural Sciences and Life Sciences in your class?

Teacher:	Yeah, they do, they do, they do
Researcher:	Why do you say that?
Teacher:	You see whenever you come up with some of the new topics, you'll see their eyes that tells you that really they and if they have to lay their hands on things that we deal with, experiments and so on. They get so interested in those things
Researcher:	Okay, good, so they like their hands on?
Teacher:	Yes, they like hands on. In fact, we are advocating to what's assisting where it will be maybe eh, 60/40 type of thing where 60 will be more practical and 40 theory
Researcher:	So you think the children learn more in practical version than to sit at home and to study?
Teacher:	Yes, I think so.
Researcher:	Okay, Okay. My next question for you is: can you describe your indigenous knowledge to me, your unique indigenous knowledge. What do you see as your indigenous knowledge? Do you know what I mean by that? What's your culture? What's your indigenous knowledge? What's important to you?
Teacher:	Okay, yes. Eh, what is important to me is the eh, eh, eh, eh the way I, the things that I use to, to, to, my attitude, my emotions in solving real life problems. Yes, like for instance if I'm sick, maybe I have a, a, a, a runny tummy, then I should be able to call my forefathers, the type of herb that they can go and take and I how to prepare it and process it, so at the end of the day I am healthy. So that's what I value to, because, and also headache, if I've got pain pills all those things.
Researcher:	So you really do value indigenous knowledge?
Teacher:	Yes I do, I do, I do
Researcher:	All indigenous knowledge's or specifically yours?
Teacher:	No, I incorporate a lot of, anything that works for me I put it into practice.
Researcher:	Okay that's interesting, do you associate any stereotypes to indigenous knowledge?
Teacher:	Yes, I do, because you know some people will that you that this what you are doing is not, it's not holy. Its, its, its, its diabolic, that's what people are, some people are think that indigenous knowledge people that are primitive that its diabolic and that is not the truth
Researcher:	So you feel hurt about that especially because you value it so much?
Teacher:	Yes I do, I do, because I also respect other people's culture and I get offended if somebody does not want to respect my culture.
Researcher:	Yes, okay, we are almost there, two more questions. Thank you. How can teaching indigenous knowledge influence a learners view of the enjoyment of science?
Teacher:	It, it, it can help them to really attach importance to what they are learning. You know

	if the learners know that this is what my forefathers used to do, it gives this learner a sense of entitlement, to the course itself, to say no. This is something that is not a type of a thing. This is what your father did what is happening now is that I am learning it from a book. My father couldn't write, couldn't read so it, it, it makes learners to be interested to want to learn more on how possible was it to, and also to realise that those people who, those old people who even when they were not trained, they were wise upstairs. So it's a sense of entitlement.
Researcher:	Okay, umh, my last question is: what's your expectation of the short learning programme you are busy doing now? What do you expect?
Teacher:	I expect this course to really help us. We are having so many challenges of life today. So many challenges. I expect it to really open up new avenues to see how, how best can indigenous knowledge systems help in addressing social issues, social rules, unemployment, advancement of economy and many other things like, decisions that you have, how can that help and we should really speed up the process because people who know these things are dying now. The old generation they are dying, our forefathers. I wish we should make a roundup of these people to be curious to know where they are, go to them, interview them, get that knowledge before they, because it's not documented.
Researcher:	So you would encourage your other colleagues at school to do something?
Teacher:	Yes, I am definitely going to do that. Yes I promise to be one.
Researcher:	Yes, I like that, positive teachers. Thank you so much, I appreciate it.
Teacher:	Thank you, thank you!

Interview: Teacher 2

Researcher:	What do you understand under the affective domain?
Teacher:	The affective domain umh I think, I think the affective domain relates to umh your thinking what you cannot see.
Researcher:	Is learners' interest in Natural Sciences and Life Sciences just as important as to passing the examination? Why do you say so?
Teacher:	Sorry? Their interest is?
Researcher:	Is there interest more important in passing an examination or is the examination more important?
Teacher:	Umh the interest is very important because it will lead to good marks in the examination.
Researcher:	Okay so you think the two are linked?
Teacher:	The two are linked.
Researcher:	Do learners enjoy Natural Sciences and Life Sciences in your class?

Teacher:	Yes, they do but there’s a certain percentage that just seem not to be interested and I believe the problem arises with the fact that at the beginning of the year especially the Grade 10’s. At the beginning of the year they will just uh they will just went with the noise that I am going to do Natural Sciences and Life Sciences umh the underperform because they are in a class where they, they not plan to be in. They just went with the noise and ended up in the class
Researcher:	Wrong subject choice
Teacher:	Wrong subject choice
Researcher:	So that is where the interest comes in, not all of them are interested? So how do you think we can make them be more interested though as learners?
Teacher:	I think, I think because in, in my school, I realised that the Grade 9’s don’t go to career specialists. I think it will be vital if the career exhibitions are not only for grade 12’s but they also umh become extended to the lower grades.
Researcher:	Describe your indigenous knowledge to me, if you’ve got examples you can add it for me.
Teacher:	Umh indigenous knowledge, umh talks about things that umh that umh that are original. Things that belongs to the earth. And umh they the perception of these things by different communities. Each community has a different perception of umh of, of, of things I would say. For an example let’s take a lightning, umh in Tswana most of Botswana cultures believe that when someone is struck by lightning it is saint when there is no rain but when it’s raining a lightning will strike then umh it will be believed to be nature.
Researcher:	Do you value indigenous knowledge? Why?
Teacher:	Yes, I do value indigenous knowledge because umh remember it’s linked to culture and things that are on earth. Umh that means umh we use science to get to, to get to indigenous knowledge
Researcher:	So you think that we can link Western science and indigenous knowledge to help learner interest
Teacher:	Definitely, definitely
Researcher:	How do you feel about your subject Natural Sciences and Life Sciences?
Teacher:	Science and emotion? I think so, I think they can interact though Ill fail to explain why.
Researcher:	Describe a stereotype that you would associate with indigenous knowledge.
Teacher:	Umh we always, we mostly look into the negative aspects of indigenous knowledge. For example umh most of us where raised knowing that a transitional hemps are used to bewitched or are used to do witch craft and that statement is wrong because they can be used to cure and heel people.
Researcher:	And when did you learn that?

Teacher:	I've learned that, I think it was in 2011 it was my first year in the nokose university. Okay it was, it was, it was. I have learnt before then that I got to expand the knowledge in university. Umh in 2011 there was a chapter on bottom so we went to the botanical gardens and I found a lot of herbs there
Researcher:	How can teaching indigenous knowledge influence learners' view and enjoyment of Science
Teacher:	Our learners that take sciences something that comes from heaven but with the infusion of indigenous knowledge it will make us see that science is everyday life and science is not only in America but in where we are living we also have science
Researcher:	Do you think there is time in your class to incorporate indigenous knowledge into various content?
Teacher:	Umh not always. I believe, I believe in my subject. Umh there is so many topics that we will have to cover and that disadvantages some of the teaching practices that will be good and bring good results.
Researcher:	Why did you decide to do this course?
Teacher:	The indigenous knowledge system? Umh I wanted to learn the skills on exactly how to, how to actively involve my learners in class when teaching this topic because you also have it in Grade 10 and umh I think, I think somewhere somehow I did injustice to them because I was struggling a bit which method to apply and because of the misconceptions that most learners go with when we talk of indigenous knowledge umh they they kind of like lost interest in this topic but with the umh with the clarity I got and the skills to teach this class I can now go out and be a better teacher.
Researcher:	The stuff we have done so far in this course how do you think you can bring It into your class? What have you just thought about here and there?
Teacher:	Umh... diabetes I'm teaching grade 12, we have diabetes there. We have umh reprint reproduction there is umh what do you call it? Umh the pills that prevents you from getting pregnant. Contraception. I have I have seen that there is another medicine that's used by the cough syrup to make abortion so I think, I think I can, I can introduce it to my learners.
Researcher:	Wonderful. Thank you so much.
Teacher:	Thank you

Interview: Teacher 3

Researcher:	Right so, can you tell me what you understand about the affective domain?
Teacher:	Okay, you know affective domain according to my understanding is an effective way of reaching to the learners in terms of understanding the content that is taught to them.
Researcher:	Okay, thank you. Okay is the learners interests in Natural Sciences and Life Sciences just as important as passing an examination and why do you say that?
Teacher:	Yes, learners must have interest in Natural Sciences and Life Sciences so that they could be able to pass at the end of the year because if they don’t have interest they won’t even participate in the classroom. They won’t be interested in learning so that will affect their results and then they get
Researcher:	Do you think the teacher has a lot to do with that, the interest of the learners?
Teacher:	I believe so, because if a teacher is not innovative and is not creative then learners will lose interest in the subject.
Researcher:	Wonderful, thank you. Right so tell me do learners enjoy Natural Sciences and Life Sciences in your classroom?
Teacher:	My learners enjoy Natural Sciences and Life Sciences but really I have some reservations here and there. There isn’t mean that there are those learners really who end up, who are stuck in Natural Sciences and Life Sciences because at my school there is no broader you know option when it comes choosing the subjects witch learners want to do, so you’ll find that there’s no any other option they just have to do it
Researcher:	So is there negative attitude towards the subject for those learners?
Teacher:	Yes for those learners really they even say it out that if they had any choice they would have been doing any other different subject except Natural Sciences and Life Sciences
Researcher:	So tell me now umh a teachers attitude, do you think that it can change the attitude of a learner like that?
Teacher:	Yes, a teacher’s attitude can because I believe that as a teacher a, I should make learners to be interested in my subject. It could be by incorporating different activities and also maybe by including excretions something that will really interest them and change their mind-set
Researcher:	Change their mind-set, so do you think indigenous knowledge can do that?
Teacher:	I believe that indigenous knowledge can do that because it relates to what these learners know which maybe they have not been exposed to academically in the classroom so it will definitely trigger interest in their learning

Researcher:	Right so tell me can you describe your indigenous knowledge to me, your own unique, you can use some examples if you want to.
Teacher:	Okay, my indigenous knowledge is like as I was growing up as a kid, like if I had the flu my parents would get a particular herb you know you will help me with the name of that herb you know we did it previously. Is it African wood something, yes that's the scientific name which I'm not used to but in our language, it is called Lantana neh? It is bitter in taste and it also an it is used to healing flu and colds and it really worked.
Researcher:	So how can you bring that into your classroom, which content can we connect that too?
Teacher:	It is connected to Natural Sciences and Life Sciences, ingenious knowledge system. Yes, It is connected to Natural Sciences and Life Sciences.
Researcher:	So which content do you think in our syllabus?
Teacher:	Oh, in our syllabus. Eh I believe that eh environmental studies. Yes that is where it can fit.
Researcher:	Okay wonderful thank you so do you value indigenous knowledge and can you tell me why if you do value it or not?
Teacher:	Yes I do value it because especially maybe if I can just be racial for a moment, most of us blacks you know we have grown up in society where indigenous knowledge is more valued than the Western kind of knowledge. So, according to me it is very valuable and it relates you know to what is happening practically at the different households of our learners.
Researcher:	Okay and that leads me to my next question, so what do you think the stereotype is associated with indigenous knowledge
Teacher:	Ja, sometimes it really stereotype individuals because you know if for example a my parent believe that this particular herb heals or cures a particular ailment and it has worked for him or her that mean he will never ever have room for something else that could work better than the one he is used to or she is used to.
Researcher:	Okay, thank you. Right so how can teaching indigenous knowledge influence the view of a learner to make it more enjoyable to them? How do you think it will react them so say for instance you have got a multi-cultural classroom in front of you, different cultures and you teaching one cultures indigenous knowledge? How can you bring interest to the kids or enjoyment to the kids?
Teacher:	Okay, I believe that if I have a multi-cultural kind of classroom, I must eh include a different indigenous knowledge from every culture because it do be more interesting as learners will be learning how other cultures are using or the kind of knowledge uses indigenous to very culture and that is going to be very much

	interesting and some of them may even apply because I think it goes with, if something really works other people will try to use, do that particular thing.
Researcher:	Okay, thank you. Tell me do we have time in a classroom to bring in this indigenous knowledge into the curriculum?
Teacher:	Eh, we don’t have enough time but we can make time, because really our time is never enough but if you want to reach the learners that is where we have to sacrifice and eh making other classes on Saturdays or any other days after school maybe, and we really have to make time because otherwise we won’t be able to include everything that we are supposed to do.
Researcher:	Wonderful, and prepare the learners for society actually, do you agree to that?
Teacher:	Yes.
Researcher:	Okay so can you tell me how, what your feelings are around this course that you just competed now?
Teacher:	Oh you know what? I feel very good about this course and I believe that I have gained a lot. Personally, I have grown and I am also going to apply some of the things, especially talking about the methodology, you know, the Bono’s hats and also the jigsaw method. I have really learnt a lot because eh, I felt that I needed something that really interest my learners, because I am also concerned about their results, so it will about indigenous knowledge but again it will support methodology and of which years and of which I’m very much grateful and also interacting with other people made me to be a better person, because I am also learning or I have learned from other teachers who have maybe similar experiences like mine or who are excelling in their schools. I managed to gain a lot of information.
Researcher:	Wonderful. Thank You and what was your favourite out of everything we have done?
Teacher:	Eh what I really enjoyed most was coming to the lab and you know, seeing how everything is supposed to be done, especially you know as a teacher that was supposed to maybe prepare these experiments before learners could come. It was the most exciting part.
Researcher:	Oh wonderful.
Teacher:	Yes.
Researcher:	Do you want to add anything else?
Teacher:	Mm mm, I don’t think there is anything more that I want to add because really I am grateful about everything that I have learned from this course.
Researcher:	Wonderful
Teacher:	Thank you very much

Researcher:	111.	Thank you very much.

Interview: Teacher 4

Researcher:	1.	What do you understand under the affective domain?
Teacher:	2. 3.	Affective domain? I don't know how to answer this. Affective Domain. I don't know how to answer, yes umh I'm not sure what this is
Researcher:	4. 5.	Okay number 2: Is learners interest in Natural Sciences and Life Sciences just as important as passing an examination?
Teacher:	6. 7.	There are others that are interested in this Natural Sciences and Life Sciences but the others are just doing it for examination.
Researcher:	8. 9.	And how do you feel about it? Do you just want them to pass or do you want them to have an interest in it?
Teacher:	10. 11.	Umh, I want them to have interest because Natural Sciences and Life Sciences what we experience in everyday life
Researcher:	12.	Wonderful, thank you. Okay, umh do learners enjoy Natural Sciences and Life Sciences in your class?
Teacher:	13.	Yah, especially the young ones they enjoy it.
Researcher:	14. 15.	Okay, do, do when you maybe start a topic like laboratory do they go 'aah' or are they excited?
Teacher:	16.	Because they enjoy the life science they, they become excited
Researcher:	17. 18.	Ok so all of your kids enjoy Natural Sciences and Life Sciences? Most of them you say, not all of them?
Teacher:	19. 20. 21.	Hmmm yes most of them because there are others that umh natural leader. Wrong subject. The other they are just lazy. When we do experiment we will see that the one just touching and on.
Researcher:	22. 23.	Wonderful. Okay, can you describe your indigenous knowledge to me? You can use examples if you want to
Teacher:	24. 25. 26. 27. 28. 29.	One that I have experienced and know of is umh the knowledge of cutting the, I don't know the scientific name of that tree (Simonchalo) Brown thorns, if you cut it during winter where there is thunderstorms, the light and then you, you cut the tree and then you drag it. The lightning will just go on that. Hmmm where the (Macghalo) tree should not be cut during summer. You should only cut it during winter. That is, I experienced it two times.
Researcher:	30.	Okay, wow that's interesting. Okay, so do you value indigenous knowledge?
Teacher:	31.	Very much, even if it is very in specific communities, I value it
Researcher:	32.	So you will also value different knowledge, even Chinese?
Teacher:	33.	Yes, even Chinese. I want to study those.

Researcher:	And you want to bring it into your class? Do you think that will stimulate the learners interest?
Teacher:	MmmmMmmm and I see that the excellent knowledge.
Researcher:	Wonderful, thank you. Ok how do you feel teaching indigenous knowledge in the Natural Sciences and Life Sciences classroom or the natural sciences classroom? How do you feel about it?
Teacher:	Myself? I feel empowered and then I feel that it is important and it will arose learners interest and then learners will have more knowledge of things that are nearer to them like in the field they want know that this plant is for this, this is for this.
Researcher:	Okay, wonderful. Can you describe a stereotype that's been associated with indigenous knowledge?
Teacher:	Umh, the stereotype will be when you do not do research about those, indigenous knowledge of others. You must research this so that you are not stereotyped, then you should learn from others so that you are not learning only about yours
Researcher:	OK, wonderful thank you. Ok, how can teaching indigenous knowledge in your class influence the learners interest. What would you do that's interesting, how would you bring what you have learnt here into your class, how would you teach them indigenous knowledge? To make them even more interested?
Teacher:	Umh, by bringing various.
Researcher:	So what would you do would you bring plants in the class, what would you do to make them more interested? The interest of the learners.
Teacher:	Hmmm, I'm not sure, the way I was talking I thought I going to answer that.
Researcher:	Ok so what I'm asking is, maybe if I put it differently. How would you in your classroom bring in indigenous knowledge to make them more interested? How would you do it? Just a practical example? So for example if I think about my class I would bring umh this plant to show them like I showed you. Ah wow, I can actually see it so now what would you do to bring interest in your class?
Teacher:	By experimenting and testing those plants.
Researcher:	So what we did earlier you think you would do that in your class?
Teacher:	Yes
Researcher:	You think that will be very good
Teacher:	Very interesting. They are not very interested
Researcher:	Just again like you said they are hands on
Teacher:	Yes ma
Researcher:	Excellent, thank you. Okay, umh, do you think that you'll have time in class to incorporated indigenous knowledge into your content? All of the content we do,

	is there enough time in the classroom?
Teacher:	Yes, there is enough time, only planning is important
Researcher:	Planning is important. Okay and tell me would you use some of these medicinal plants for yourself?
Teacher:	Yes!
Researcher:	Is it?
Teacher:	Yes.
Researcher:	Okay, wonderful and why did, my last question, and you why did you decide to do this course?
Teacher:	I was very interested in this plant from this so when I say indigenous, indigenous it's about traditional things or the olden days things, so I came to see what, what is indigenous knowledge so that the things that I do thinking about that.
Researcher:	Thank you very much for doing this interview with me.

Interview: Teacher 5

Researcher:	So what do you understand under the affective domain?
Teacher:	After affective domain?
Researcher:	Affective domain
Teacher:	Effective?
Researcher:	Affective
Teacher:	Joh I don't understand the term now.
Researcher:	So affective I'll explain to you means your values and your feelings and that kind of thing. Okay so my next question to you is: Is learners interest, so the interest of learners in Natural Sciences and Life Sciences, are they interested in the class?
Teacher:	Some are interested but some, most of them are not because I'm teaching in the township, because yes now the problems that in class we talk about issues that they are not familiar with.
Researcher:	Okay and, and, and do they have interest in plants like umh?
Teacher:	Yes, umh they do have interest in plants because they know some of the plants, yes they have a little bit of indigenous knowledge.
Researcher:	Okay good, okay and then tell me, umh do you think that the content is umh important or do you think that the indigenous knowledge is important to make them more interested?
Teacher:	I think it is important because you know whenever you talk about things that they know they become actively involved in class and like for instance even you

	the teachers you might not know all the muties for example: but they will tell you about some of them muties and they also know what they used for and how are they prepared.
Researcher:	Okay, so you say you learn a lot form the children as well?
Teacher:	We also learn a lot form the children because some of the children they come from a, a families where you'll find that one of that parent is a herbalist or a traditional healer.
Researcher:	So you think you can use this indigenous knowledge to give them more interest or make science more interesting for them?
Teacher:	Yes, my dear and I think if I, we use more of indigenous knowledge even the results can improve.
Researcher:	Wonderful, thank you. Okay my next question. Okay can you describe your indigenous knowledge to me with some examples you have?
Teacher:	Okay, umh you know the way I, I understand this term indigenous knowledge I think it is the knowledge that people have even if they did not go to school, but because people umh especially black people, I'm sorry to say that especially the black people know we respect our culture, yes and we also umh practice rituals like for instance let me say for example if umh your husband has passed on then before you can umh move on with your life or before you can get married or get a, enter into a new relationship there are things that you must do, you have to wash with a certain mutie to remove bad luck form you, yes and also to clean your blood umh they believe that if your husband has passed on his spirit is still in you so you have to do some things to remove that spirit.
Researcher:	Okay, that's interesting, thank you. So do you value only your indigenous knowledge or are you willing to value other indigenous knowledge's too? Say for example the indigenous knowledge of the Dutch people and the indigenous knowledge of the Indian people?
Teacher:	No, I, I, I value all indigenous knowledge from different races from different people.
Researcher:	So are you willing to also bring this into your classroom?
Teacher:	Yes, yes
Researcher:	Right umh so, what stereotype do you associate with indigenous knowledge? What do you think people stereotype about it?
Teacher:	You know that umh, people stereotype about it because people they think that umh like for instance. The stereotype part of it umh people that are umh mostly umh preferring to use traditional method they think that. Umh like for instance the mutie right? They think that and strongly believes that if you use the

	Western medicine you have to pay money but for traditional umh medicine they just take it from the soil and they also believe that the umh Western medicine has after effects according to the acknowledge that is the stereotype part of it.
Researcher:	Okay so do you think that there’s time in class to incorporate indigenous knowledge to various contents? So say for instance you’ll bring it in, in most of the context or only certain ones, and do you have enough time to do so?
Teacher:	Umh no we don’t have enough time but we do corporate it in Grade 10 neh? There’s a chapter on cancer the learners have to know the causes the treatment and also the symptoms of cancer so thy know that they must also know that umh cancer is treated in different ways it can be treated in a Western style or in a traditional style, like for instance in a traditional method they know that they have to use a an African potato, yes and that African potato is not scares there, they know it they know that you they have to boil it and then you have to drink that water and how many times you should drink it they also know the quantity.
Researcher:	So do u you think this course is going to help you incorporate it more in your class learn more things to tell your kids then they’ll get more excited?
Teacher:	Yes, I think so.
Researcher:	Wonderful. Thank you very much for doing this

APPENDIX I: FOCUS GROUP INTERVIEW QUESTIONS

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May 2018

FOCUS GROUP INTERVIEW SCHEDULE

RESEARCH PROJECT TITLE: NATURAL SCIENCES AND LIFE SCIENCES TEACHERS' AFFECTIVE DEVELOPMENT DURING AN INDIGENOUS KNOWLEDGE PROFESSIONAL TEACHER INTERVENTION

Thank you for your willingness to answer a few questions. The purpose of this short interview is to determine what your views are on this indigenous knowledge short learning programme. There are no right or wrong answers. Your real name will not be revealed when we report on the findings.

Name/ pseudonym:

1. What is your understanding of the affective domain?
2. After attending this course, define what you think indigenous knowledge is.
3. Why do you think indigenous knowledge should be taught or not taught in the Natural or Life Science classroom?
4. How do you feel about bringing in Indigenous knowledge and Indian Indigenous Knowledge?
5. How do you include indigenous knowledge in the classroom?

6. How can you make Indigenous Knowledge exciting in the class?
7. Do you encounter any challenges or hurdles by including indigenous knowledge in your classroom?
8. Describe what you think your unique indigenous knowledge is, using examples.
9. Do you value indigenous knowledge? Why?
10. How did the problem-based activity influence your affective domain?
11. How do you think the learners would feel about problem-based learning?
12. We have now looked at Indigenous knowledge, Indian Indigenous Knowledge and nature of science, what would be effective pedagogies to show this? How do you now feel about the characteristics of IK and NOS?
13. Can you think of pedagogies that would honour both tenets?

(Any other questions relevant to the research questions, based on the feedback by the respondent, may be asked at this point).

Thank you for making the time to discuss the short learning programme with me. I greatly appreciate your feedback.

APPENDIX J: TRANSCRIPTS OF FOCUS GROUP INTERVIEW

TEACHERS AFFECTIVE DEVELOPMENT DURING AN INDIGENOUS KNOWLEDGE PROFESSIONAL TEACHER INTERVENTION

FOCUS GROUP INTERVIEW 1

OK we are just going to ask a few questions so that you can respond and discuss.

So first of all, who can tell me what they understand by the affected domain.

Well, I can tell you lots about that, I studied it.

Okay.

Well it's pretty much the heart in terms of education where it's taking something that's just from a theoretical point and actually making sure that it has actual relevance from an emotional connection for the learners and it's not just, you know, the cold hard theory but is a bit more relevant.

Okay, anyone else? Right, yes, you're next.

Now that you have been here for the past two days, what is your definition of indigenous knowledge? Has it changed or has it been defined since you've been here.

Indigenous knowledge …….. the society ….it changes, so we see that a lot of things are taking place, for example we do a paradigm shift from using the traditional medication to the … medication. We see the need now to revert back to the old medication. This is a sign that the information that we got from the older generation still has value and relevance in today's generation.

I think that as much as it has changed, it still is very authentic, because at the end of the day we realise that we need to go back to our roots as mentioned because going back to our roots has solved a lot of problems in my experience.

To me I see that the knowledge does not change but people are just taking another route whereby they try to neglect the other party of blame in the inner….. but still it has its importance and if we can incorporate it into this western life or medications, it can bring in, maybe, a better treatment. You see what is indigenous and fast….. to me, what I see, is by using the resources which are applicable, the natural resources, so that you can maybe treat your body or your soul.

Okay.

And then, do you think indigenous knowledge should be taught in the classroom and how do you feel about bringing it in. Have you before or will you now, after the course. So how do you really feel about bringing indigenous knowledge into the class?

We have been teaching indigenous knowledge already.

Oh good.

Although we teach it on a small scale. There is a small section on plant specification, plant and animal diversity where i.e. the African potato ………………………………………………………… and so forth but it doesn't elaborate like the …… okay, it is not as elaborate and as clinical as this program. I think that we should open up because we are sitting with a wealth of information but we don't know to …. it so that we can make it part of our curriculum.

Okay.

I think I would like it to be brought into the classroom ………………………………………… where we are looking at a course of action, bio diversity and to bring in indigenous knowledge people would get an appreciation that is not just a concept. It has long been practiced so when you bring out that information they will know how it was practiced in that it is not different from what is being done now. So it actually builds up appreciation of it.

I think that we have not used indigenous knowledge before but I think that it is very relevant now and in the media it is shown that medicine is too expensive. And the medicine itself is contradictory. We know that with one tablet that cures or solves an ailment, it causes another problem. This indigenous medicine solves so many problems.

In Durban, there are Registered traditional healers that use more than 3000 types of plants so we know that some of these plants are unique and can only be found in certain areas so we want to have a control.We need to start at grass roots level by teaching the learners in primary school on how to preserve and know the value of the trees or plants that have medicinal uses. So I think that we should continue to teach indigenous knowledge systems bearing in mind that if we do not control the harvesting of these medicinal plants, there might be nothing left for the next generation and that it is not sustainable. So what are the rules in harvesting medicinal plants? Some of these kids could actually plant some of these and maybe sell or extract to get some knowledge.

Plant only indigenous plants?

Yes.

I was talking to the professor and I said "You know I can get money" My dream is to plant indigenous plants, especially fruit plants. There is no fruit that does not have a medicinal quality. Especially the wild ones. As I was saying, the people back then would live to a 100, 120 years. What was the secret behind it? Then there were no hospitals, no clinics, you understand. It is because of their lifestyle. What they used to eat. How they use to balances their dishes. That was maybe how they lived longer.

Yes.

Indigenous knowledge is good and it is important that it is introduced into other classes. When I say other classes, I mean, basically, when you are teaching it, you are teaching it in specific classes. Sometimes even the learners don't know the relevance of teaching that. The only problem I see in indigenous knowledge teaching is the people. People like to have a soft life. If you check the indigenous knowledge, all the treatments – you have to take maybe a cup of this herb, they see that taking just one cup is easy for them.............................. this western style. People need to be desensitized so that they can understand the importance of this indigenous knowledge and how good it could be in their life.

The biggest argument, I have to say, is that it is nice to have an idea of indigenous knowledge with all the different knowledge and their culture that comes in, but the question is, whose indigenous knowledge do we focus on because the reality is we all come from various back grounds. So do we follow Northern Sotho or Zulu or Indians? Maybe someone has come from Scotland. Whose knowledge do we follow on because all of it is actually relevant? If somebody in South Africa is sitting here and then goes, to say, Scotland, they want to know a bit of the knowledge there. What if, they go into the bush and they need, for instance, knowledge of the grasslands. What knowledge do they need to know then? So whose indigenous knowledge do we focus on?

We are not living in a global village where information .... and we can capitalise on that. On government to government, we have had regional meetings where the scientists from all over the place meet. I know from this side, they are doing very well. Maybe for instance, in

India, they don't have it. When we have this kind of platform we can interact and share information and it can benefit other people and borders are not closed. We can bring stuff from India. We can take stuff from South Africa. Some people are coming to get the rhino horn at their own expense but I think that at government level, registration must be implemented into parliament. Opinion leaders should become involved so that they can ensure that this IKS can become a subject in schools.

I really like that because when you are sitting in front of multi-cultural children and so already there are like eleven different cultures. I don't know exactly how many there are. It would be nice to have like an "icebreaker" at the beginning of the year. So explain what indigenous knowledge is and they go back and bring something little from their cultures. Go and ask your Grandmother and Grandfathers so that's also something for our collections, for yourself as a teacher.

I think that you need to make sure that you are culturally inclusive and that you are not just focusing on African culture or whatever. The problem is for instance, if I had to teach African Indigenous Knowledge, I might know it but there will be children who feel like they are not included or feel segregated from the rest of the group because their knowledge has been pushed aside. So we have some very fine lines. Also there is a very fine line between whether it is okay or not okay to teach it in the classroom. In reality you will be touching on other people's cultures and beliefs so if you say something wrong or say something that goes against another person's belief, it becomes a problem. You have got to be so careful, especially where you could be easily taken on because of the fact that you may be considered as politically incorrect or socially incorrect. You have got to be so careful.

They say that knowledge is power so you realise that despite the fact that we are in Africa. we need to talk about African Indigenous Knowledge Systems. We need to talk about medicinal plants that are affected by our climate, etc. So I am coming back to that point again. Every culture has something good and something there. Take out the good and leave out the bad.

There again, what is African Indigenous Knowledge where technically we are all African.

What is so exciting is that already our textbooks have case studies of other cultures. They talk about the Indian kids, Cape Town people etc. They already are giving us a glimpse of case studies from different quarters. So we can cut the lines with that and make it broader to include other regions now. For example Venda. There are certain things that we know.

We don't have to go to the place but we just need to accept these things. We did not have money, a long time ago, and if you had a headache, you would just use a plant. So we want that type of information so it can continue to be used.

I think we should not be afraid of change because we are already in a comfortable zone. We are used to the way things are being done now. We should be broad minded to change. We should also take it as an opportunity to learn about other countries and their cultures. The more we learn about other countries cultures it gives us more solutions. We should not see that as a challenge but rather as a blessing. If we don't a solution here in South Africa, there could be a solution from India.

That's very interesting.

Here is a question which doesn't really need an answer but are the owners of this knowledge willing to share that knowledge and are there people who are willing to receive it. Are the owners of this knowledge prepared to give it out? Some of these people went through some hardships to obtain this knowledge and they are not willing to give it out. I had a lot of trouble obtaining some information about the plants in some small places in my country, in some villages. So that's why I'm asking if the owners of that information, are willing to give it out - no 1. And No 2 - are there people willing to receive this information, because they will see it in a different aspect.

Okay.

I think all of the discussions have touched on our questions really. You have done great.

So the activity that you have been doing. The problem based learning and what you have learnt so far. How do you think it will affect your teaching in terms of affective domain coming into the class room? Will you be resistant or will go with the human factor, as we spoke about earlier.

Again, I think it's very much class based because there are some classes where you do have children who require specific needs and attention needs where the moment you give them that sort of leeway or the space to explore something, they just go literally wild. I think it has to do with the type of class and type of child you have. I think a lot of the problem based ones, certain areas of learning are more suitable to them. Also I think it's more suitable for certain grades. I wouldn't suggest this for the babies i.e. Gr 8's, Gr 9's and younger where they are still learning skills that are needed. I think it would be more suitable for the seniors. They need that more critical tuning.

To be affective, there is one principal. If you love what you are studying or if you love what you are teaching, automatically you are going to understand everything. This brings about learners to love what they are studying.

I think in my case, it's going to work because we as Educators are hard pressed for time. We wonder how we can come up with something very critical in a very short time. So this is going to bring diversity in my teaching. At first I thought these learners are not going to take it seriously. It's going to look like 40 minutes has just been wasted. So it is what we do at the end of the lesson that counts. After they have discussed and brain stormed, you need to be able to summarise the lesson. You need to have a motivation at the end. Something like giving them a new book or something but then you need to have a budget for it.

But you know as teachers we must not be afraid to spend a little bit of this money. I am not talking about thousands of Rands but a small amount. You know if it's a R10 sweet, it means more to the child who is receiving it than what it's worth.

Yes, yes.

Thank you very much, please go and enjoy your lunch.

TEACHERS AFFECTIVE DEVELOPMENT DURING AN INDIGENOUS KNOWLEDGE PROFESSIONAL TEACHER INTERVENTION

FOCUS GROUP INTERVIEW 2

Welcome to the Focus Group.

I'm going to start with a question. Firstly I want to know what your understanding is of the affective domain.

My idea of the affective domain is like Prof said "the heart on domain". So what makes learners passionate about the topic your teaching? What attracts them to the emotional side of it or what makes them feel that they can feel or relate to that topic.

Okay.

Now that you have been here for two days, has your view of indigenous knowledge changed in any way?

Yes it has changed a lot. I liked the research we saw on the different plants. How they really work; it's not just a myth. I also liked the fact that we saw the different kinds of African herbs and muti and different kinds of teas. There is actually value in these plants. So yes, my opinion changed a lot.

Okay, with me, I grew up in rural areas where they actual practiced using traditional medicines, so this kind of changed my opinion because I always thought that this was just Zulu traditional medicine and that is the indigenous knowledge that exists. So when I saw that there is Indian and Dutch etc indigenous knowledge, I thought this is interesting, I was living in my own world. I thought it was only the Zulu traditional medicine that exists. So yes, it opened my mind.

The other thing about me, with westernisation and urbanisation and me being a very rural person and being in academics, you tend to forget where you come from. I forgot everything that I was taught. When is saw it, I thought, I know what that is but in the community that I'm in now, if you had to say that I am trying to wash away bad spirits in ….., people look at your funny. I had changed my perceptions and I forgot that you could actually use this indigenous knowledge with the western world. You kind of mix it together to form a product, so yes.

For me it was more of a thing that, children don't know this, learners don't know this and because of everything that we learnt here, we can go and tell them about this. They can see and practice this. They can research it and see what's going on so they will also know what to do and how to do it.

I'm a little intimidated by it. Similarly, you always think that indigenous knowledge is only African. You forget that there is European indigenous knowledge. We live in a world where we are very critical of these things. We feel that Western medicine is the only thing that works. That changed the way I feel about it. These remedies do work and we can use them.

So, now learning all of these problem based jigsaws and you are going to learn more about the ...., how do you think you can incorporate indigenous knowledge into your classroom.

I think making exams easier. Not really doing the exam but helping them study for the exam. Taking the basis of the study material, giving it to each group and they can study it that way. Makes it easier. It will pick up their marks because they will learn and hear everything in class again.

I was thinking, when I saw the end of this activity that you have to have a carrot at the end of it. I think learners have to be motivated. Unfortunately, they don't want to study on their own. We all know that. So if you have a chocolate, or something like that, it's a good idea. So that they are motivated. I was also thinking that you could do little work sheets, write something in their books after the activity. Don't always overdo it with a test. The test is a nice round off, to give them that sense of urgency, to win or to get the chocolate or the prize or whatever it is. Overall I think it is a brilliant way of reaching all the children and co-operative learning. I think it's brilliant.

Going back to what Buhle said regarding that she forgot about all the things she knew once she became an academic. In terms of using what I learnt, it think it would be best that I make the content relevant to my learners because if I'm going to use maybe the .... theme, they don't know but as soon as I bring in a word that they commonly use, they then think "Oh, we actually grow that, at the back of my house". So to make it relevant to them and then that way they are going to have the confidence to study and read the content because it's actually something that they do know. It's not that learners don't know anything. She knows what I.... is, I know what I... is. So it's not that they don't know. It's not that learners just come to school with back packs. They do know something. So you build from there.

It's not that they come to school as a blank slate.

We have a lot of key knowledge and everyday knowledge and in school we often forget about it.

And they might even know more than us.

You are quite right.

You are all answering a lot of the questions that we tried to ask so we are not going to go through everything. The one question I would like to ask is that now that we have looked at these methods and so on, do you think that they are effective in terms of pedagogy, in our teaching style – which we can use in our classrooms. To convey this knowledge.

Okay, yes, I think they are effective and like she said. I was thinking how will they do their home groups and then they do their expert groups and then present and all of that. Then she said that they can do their home groups on one period today and then do the expert group on one day. So they are very effective and they could really help. I am a student of UG and I was taught by Prof De Beer so I know the ....and the jigsaw method so I use them a lot. I used them as a Student Teacher. So I am not practising yet but know that I have learnt more about what she mentioned, now I actually know how to go about it. It seems like it is a lot and how will you finish in time and how will they learn. Will it be just about finishing or will it be just about them understanding. So yes, it really helps a lot.

I thinks these methods are actually the best methods for these types of knowledge. As one of our colleagues said .... (INAUDIBLE)

With the teaching strategies – I think we as Teachers need to understand how to use them and when to use them. With the............ you can't use them in every topic in Life Sciences. Doc mentioned you need to be careful in conflict situations. As a Teacher you need to be careful of how you use them and when you use them.

To add on to what Phindi is saying, whatever teaching strategy that you use, it should accommodate the learning style of the learner. If you are going to use the jigsaw puzzle for example. There are auditory learners, there are ones that learn by reading. We should accommodate all learning styles although academics say learning styles do not exist. In certain context they do exist. I am doing an honours in ICT in education. They tell you that learning styles in ICT do not exist but it's been proven that they do exist but for the 4 years in my undergrad I knew those learning styles. I am that person who wants to write everything down but in ICT, we were told that writing everything down does not work. So in the teaching context we are kicking ICT out. In the classroom context you need to know your learners learning style and incorporate all of them and as part of inclusion. We are going towards inclusive education.

APPENDIX K: CONSENT LETTER TO PRINCIPAL AND GOODWILL PERMISSION LETTER TO SCHOOL GOVERNING BODY

NWU®
NORTH-WEST UNIVERSITY
NOORDWES-UNIVERSITEIT
UNIBESITI YA BOKONE-BOPHIRIMA

Private Bag X05, Noordbrug
South Africa 2522

Tel: 018 299-2000

School for Natural Science and Technology for Education
Tel: 018 285 2626
Email: josef.debeer@nwu.ac.za

The School Principal

To whom it may concern,

PERMISSION TO CONDUCT RESEARCH IN YOUR SCHOOL: THE AFFORDANCES OF INDIGENOUS KNOWLEDGE FOR SELF-DIRECTED LEARNING

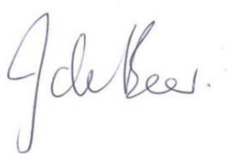
Some of your Natural Sciences and Life Sciences teachers recently attended a short learning programme that the North-West University Potchefstroom Campus developed on infusing indigenous knowledge in the teaching of the Curriculum- and Assessment Policy Statement.

To capture teachers' lived experiences of incorporating indigenous knowledge in their lessons, we would like to observe a few lessons upon invitation of the teachers. We have obtained permission for such school visits from the District Director, but obviously we also need to obtain your permission to visit your school.

Learners are not involved in this research at all, but since there will be a researcher (as observer) in the classroom, we have drafted letters to parents and learners to ask for permission to conduct such observation. Lessons will not be interrupted at all. We utilise an instrument (the Reformed Teaching Observation Protocol) to record data, so no video-recordings will be done.

Your assistance in this regard would be greatly appreciated. I can be contacted at the number listed above, or on my cell phone 082 923-2865, or you can also contact the Research Ethics Committee of the Faculty of Education (EduREC): Ms Erna Greyling, e-mail: Erna.Greyling@nwu.ac.za or (018) 299 4656.

Yours sincerely,



Josef de Beer (Prof)

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

Private Bag X05, Noordbrug
South Africa 2522

Tel: 018 299-2000

School for Natural Science and Technology for Education
Tel: 018 285 2626
Email: josef.debeer@nwu.ac.za

School Governing body

To whom it may concern,

THE AFFORDANCES OF INDIGENOUS KNOWLEDGE FOR SELF-DIRECTED LEARNING – THE AFFECTIVE DOMAIN

Some of the schools Natural Sciences and Life Sciences teachers attended a short learning programme that the North-West University Potchefstroom Campus developed on infusing indigenous knowledge in the teaching of the Curriculum- and Assessment Policy Statement.

To capture teachers' lived experiences of incorporating indigenous knowledge in their lessons, we are obtaining permission from the school principal to observe a lesson upon invitation of the teachers. We have obtained permission for such school visits from the District Director, but obviously we also need to obtain your permission to visit your school.

Learners are not involved in this research at all, but since there will be a researcher (as observer) in the classroom, we have drafted letters to parents and learners to ask for permission to conduct such observation. Lessons will not be interrupted at all. We utilise an instrument (the Reformed Teaching Observation Protocol) to record data, so no video-recordings will be done.

Should you have any queries, please don't hesitate to contact me. I can be contacted at the number listed above, or on my cell phone 082 923-2865.

You can also contact the Research Ethics Committee of the Faculty of Education (EduREC): Ms Erna Greyling, e-mail: Erna.Greyling@nwu.ac.za or (018) 299 4656.

Yours sincerely,

Josef de Beer (Prof)

APPENDIX L: PERMISSION LETTER TO PARENTS FOR CLASSROOM VISIT

Private Bag X05, Noordbrug
South Africa 2522

Tel: 018 299-2000

School for Natural Science and Technology for Education
Tel: 018 285 2626/ 082 923-2865
Email: josef.debeer@nwu.ac.za

Parent or Guardian

Dear Parent

PERMISISON TO OBSERVE LESSONS

Researchers from the North-West University is doing research on how teachers infuse indigenous knowledge in their teaching of Life Science topics. As part of this research, a NWU researcher would like to observe a few lessons. The Natural Sciences and Life Sciences class that your child attends have been selected for this research. We would like to ask your permission for observing the lesson. The **researcher will have no contact or communication with your child whatsoever**, and will sit at the back of the class, observing the lesson. He/ she will make notes on the teacher's lesson. Your child will not be influenced in any way. There will also be no video-recordings of the lesson. Provision will be made at school for any learners whose parents do not give permission. Learners will not miss out on any academic content.

We would appreciate your permission that we could do these observations, as this research project aspires to assist teachers in making the teaching of Natural Sciences and Life Sciences more meaningful for children.

You are more than welcome to contact me, if anything is unclear to you, or you can contact the Research Ethics Committee of the Faculty of Education (EdUREC) on (018)

299 4656 or the Chairperson at Jako.Olivier@nwu.ac.za.

Yours sincerely

J de Beer.

Josef de Beer (Prof)

STATEMENT BY PARENT

By signing this document, I (full name) ………………………………………………………..,
the mother/ father/ guardian of (name of child)
………………………………………………….. give permission that a researcher of the North-West University may observe my child's Natural Sciences or Life Sciences class. I understand that my child will not be involved in this research whatsoever, and that no contact will be made with my child by the researcher.

Signed at (place) …………………………………………on (date)
……………………………..

………………………………………….

SIGNATURE

APPENDIX M: RTOP INSTRUMENT

(Sawada *et al.*, 2000)

Reformed Teaching Observation Protocol (RTOP)

Daiyo Sawada — External Evaluator
Michael Piburn — Internal Evaluator

and

Kathleen Falconer, Jeff Turley, Russell Benford and Irene Bloom
Evaluation Facilitation Group (EFG)

Technical Report No. IN00-1
Arizona Collaborative for Excellence in the Preparation of Teachers
Arizona State University

I. BACKGROUND INFORMATION

Name of teacher ______________________ Announced Observation? ______________________ (yes, no, or explain)

Location of class ____ (district, school, room)

Years of Teaching ______________________ Teaching Certification ______________________ (K-8 or 7-12)

Subject observed ______________________ Grade level ______________________

Observer ______________________ Date of observation ______________________

Start time ______________________ End time ______________________

II. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.

2000 Revision

Record here events which may help in documenting the ratings.

Time	Description of Events

III. LESSON DESIGN AND IMPLEMENTATION

		Never Occurred				Very Descriptive
1)	The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	0	1	2	3	4
2)	The lesson was designed to engage students as members of a learning community.	0	1	2	3	4
3)	In this lesson, student exploration preceded formal presentation.	0	1	2	3	4
4)	This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	0	1	2	3	4
5)	The focus and direction of the lesson was often determined by ideas originating with students.	0	1	2	3	4

IV. CONTENT

Propositional knowledge

6)	The lesson involved fundamental concepts of the subject.	0	1	2	3	4
7)	The lesson promoted strongly coherent conceptual understanding.	0	1	2	3	4
8)	The teacher had a solid grasp of the subject matter content inherent in the lesson.	0	1	2	3	4
9)	Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.	0	1	2	3	4
10)	Connections with other content disciplines and/or real world phenomena were explored and valued.	0	1	2	3	4

Procedural Knowledge

11)	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	0	1	2	3	4
12)	Students made predictions, estimations and/or hypotheses and devised means for testing them.	0	1	2	3	4
13)	Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	0	1	2	3	4
14)	Students were reflective about their learning.	0	1	2	3	4
15)	Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	0	1	2	3	4

Continue recording salient events here.

Time	Description of Events

2000 Revision

V. CLASSROOM CULTURE

	Communicative Interactions	Never Occurred				Very Descriptive
16)	Students were involved in the communication of their ideas to others using a variety of means and media.	0	1	2	3	4
17)	The teacher's questions triggered divergent modes of thinking.	0	1	2	3	4
18)	There was a high proportion of student talk and a significant amount of it occurred between and among students.	0	1	2	3	4
19)	Student questions and comments often determined the focus and direction of classroom discourse.	0	1	2	3	4
20)	There was a climate of respect for what others had to say.	0	1	2	3	4
	Student/Teacher Relationships					
21)	Active participation of students was encouraged and valued.	0	1	2	3	4
22)	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	0	1	2	3	4
23)	In general the teacher was patient with students.	0	1	2	3	4
24)	The teacher acted as a resource person, working to support and enhance student investigations.	0	1	2	3	4
25)	The metaphor "teacher as listener" was very characteristic of this classroom.	0	1	2	3	4

Additional comments you may wish to make about this lesson.

APPENDIX N: COMPLETED RTOP OBSERVATION WITH AUTHENTIC LESSON 1

Reformed Teaching Observation Protocol (RTOP)

Daiyo Sawada External Evaluator — *Michael Piburn* Internal Evaluator

and

Kathleen Falconer, Jeff Turley, Russell Benford and Irene Bloom
Evaluation Facilitation Group (EFG)

Technical Report No. IN00-1
Arizona Collaborative for Excellence in the Preparation of Teachers
Arizona State University

I. BACKGROUND INFORMATION

Name of teacher ______ Announced Observation? Yes - invitation (yes, no, or explain)

Location of class Johannesburg (district, school, room)

Years of Teaching 3 years Teaching Certification BEd Honours (K-8 or 7-12)

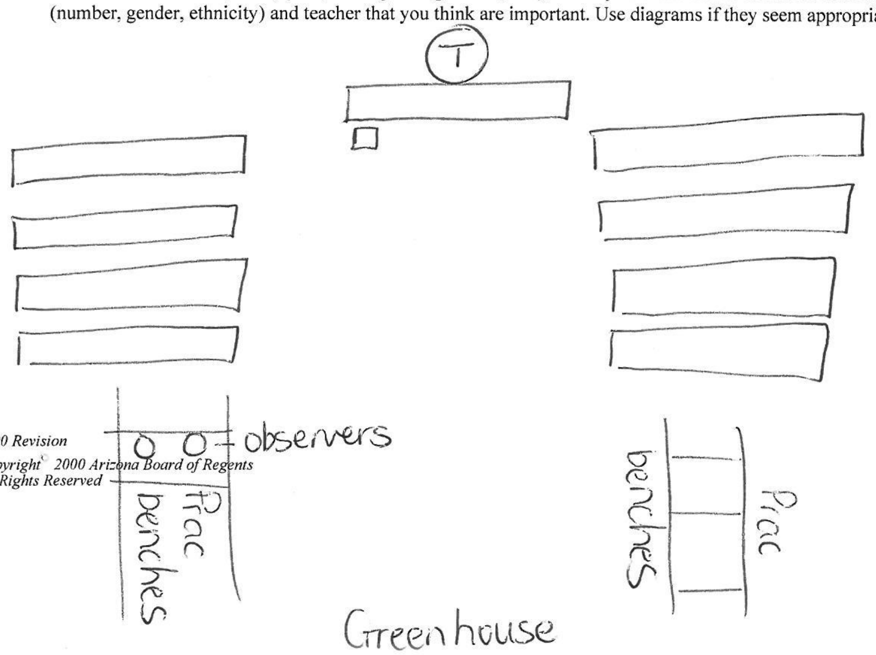
Subject observed Life Sciences Grade level 10

Observer Cherine Jackson Date of observation 8 August 2017

Start time 9:25 End time 10:10

II. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.



Grade 10

* Children sitting quietly.

Record here events which may help in documenting the ratings.

Time	Description of Events
9.26	Learners enter class quietly, greeting the teacher
9:30	Teacher greeted learners - they must take out their notes
	Powerpoint up - type of photosynthesis
	Teacher driven
9:31	Learner reading from notes children follow.
9:32	Teacher correct learner which skipped a line from reading.
9:35	Children continue reading
9:36	Powerpoint up → common plants
	Linking plants with common plants
9:37	Children communicating asking questions with regard to plants
9:38	Teacher praise learners for identifying plants
9:39	Jokes purple "African" daisy "American" → laughing.

Powerpoint not very clear

2000 Revision

* ~~No~~ Some fusion of IK — later on in lesson

Teacher-driven

2

Record here events which may help in documenting the ratings.

Time	Description of Events
9:40	While teacher is talking, learners listen – allow interaction quiet them down. Explaining global warming. C_4 plants ⇒ children reading again
9:45	(sentence per learner).
9:46	Global warming – teacher explaining Child/learning asking questions. Explaining misconception that learner has regarding O_2 and CO_2 in photosynthesis.
9:47	~~Learning~~ discipline the learner – children/learners writing info down from powerpoint. Teacher reading from ppt. Focus mainly on one side of the class. – Children still sitting quietly.
9:50	Some fusion of IK ⇒ sugar cane – skin – teeth. – digestive aid. – gastro – electrolites bact. Really? Learners spark interest. ↳ learners ask How does it taste? ↳ sugary water.

Learners – eating in class

③

9:52 Teacher ask which plants are these?
Chew on the stem (bottom)
Clovers
Yellow nut sage → learners
spark interest - ask questions
Explaining (bulbs), what is this?
Plant-Yes .... that so smart ...??
Explaing alien species.
9:55 CAM plants - questions from
learners again.
Pine needles fall → kill everything on ground
Willow trees conditions unfavourable.
↓ use a lot of water
9:56 Learner reading notes again.
Read whole thing → needed to give
another learner chance to read.
CAM plant - desert plants
9:57 Does this make sense? Teacher
asks learner
9:58 Which aloe is this? Karoo aloe
Succulent - don't know name?
Learners shouting out different names
of plants
What does it smell like? Learner asks

III. LESSON DESIGN AND IMPLEMENTATION

		Never Occurred				Very Descriptive
1)	The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	0	1	2	3	4
2)	The lesson was designed to engage students as members of a learning community.	0	1	2	3	4
3)	In this lesson, student exploration preceded formal presentation.	0	1	2	3	4
4)	This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	0	1	2	3	4
5)	The focus and direction of the lesson was often determined by ideas originating with students.	0	1	2	3	4

IV. CONTENT

Propositional knowledge

6)	The lesson involved fundamental concepts of the subject.	0	1	2	3	4
7)	The lesson promoted strongly coherent conceptual understanding.	0	1	2	3	4
8)	The teacher had a solid grasp of the subject matter content inherent in the lesson.	0	1	2	3	4
9)	Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.	0	1	2	3	4
10)	Connections with other content disciplines and/or real world phenomena were explored and valued.	0	1	2	3	4

Some IK with regard to plants

Procedural Knowledge

11)	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	0	1	2	3	4
12)	Students made predictions, estimations and/or hypotheses and devised means for testing them.	0	1	2	3	4
13)	Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	0	1	2	3	4
14)	Students were reflective about their learning.	0	1	2	3	4
15)	Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	0	1	2	3	4

notes + task ppt.

task is done individually and quietly

Some praise

* lab tech

4

Continue recording salient events here.

Time	Description of Events
9:59	Cost of plants?
	Homework to write down...
	Why does grass dies if dogs urinate? Acidity maybe, lots of factors that go into it.
10:00	Learners to complete activity/task
	Summary for exams
	Make table....
	Teacher walking around - checking that work/summary's are complete.
	- Children sitting quietly and working on their task.
	- Learners ask questions here and there.
	- Have a good day.
10:10	End of lesson
	Revision session after school

till 3pm.

2000 Revision

V. CLASSROOM CULTURE

	Communicative Interactions	Never Occurred				Very Descriptive
16)	Students were involved in the communication of their ideas to others using a variety of means and media.	0	1	2	3	4
17)	The teacher's questions triggered divergent modes of thinking.	0	1	2	3	4
18)	There was a high proportion of student talk and a significant amount of it occurred between and among students.	0	1	2	3	4
19)	Student questions and comments often determined the focus and direction of classroom discourse.	0	1	2	3	4
20)	There was a climate of respect for what others had to say.	0	1	2	3	4
	Student/Teacher Relationships					
21)	Active participation of students was encouraged and valued.	0	1	2	3	4
22)	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	0	1	2	3	4
23)	In general the teacher was patient with students.	0	1	2	3	4
24)	The teacher acted as a resource person, working to support and enhance student investigations.	0	1	2	3	4
25)	The metaphor "teacher as listener" was very characteristic of this classroom.	0	1	2	3	4

Additional comments you may wish to make about this lesson.

Teacher-centered

Relevant work with IK
less content
based.

2000 Revision

APPENDIX O: COMPLETED RTOP OBSERVATION WITH AUTHENTIC LESSON 2

Reformed Teaching Observation Protocol (RTOP)

Daiyo Sawada
External Evaluator

Michael Piburn
Internal Evaluator

and

Kathleen Falconer, Jeff Turley, Russell Benford and Irene Bloom
Evaluation Facilitation Group (EFG)

Technical Report No. IN00-1
Arizona Collaborative for Excellence in the Preparation of Teachers
Arizona State University

I. BACKGROUND INFORMATION

Name of teacher ______ Announced Observation? Yes (yes, no, or explain)

Location of class Trinityhouse High School Little Falls (district, school, room)

Years of Teaching 4 years Teaching Certification B.Ed Honours (K-8 or 7-12)

Subject observed Life Sciences Grade level 11

Observer C. Jackson Date of observation 18 May 2018

Start time 11:45 End time 12:30

II. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.

9 learners White, Indian, Black

No bell

Dark in the Class. Only natural light.

White board.

Teacher desk

Mind action Series Textbook Grade 11 IEB purple cover.

prac space

p 1 of 1

Record here events which may help in documenting the ratings.

Teacher a bit nervous

Time	Description of Events
11:50	Greet children/learners Activity 1 H/W Who has done it? pg 141 Teacher checking homework and stamping Discipling the learner Co-ordination topic PNS/CNS
11:52	Marking the homework Teacher explaining homework and correcting learners.
11:53	Human nervous system Teacher orientated teaching Teacher using textbook → explaining CNS/PNS
11:56	Powerpoint → lots of writing Interactive with learners Explaining spinal cord - drawing on the board → vertebrae.
11:58	Learners working in notes/textbook Quiet → learners
12:01	Learners filling in answers
12:03	Teacher asking if learners understand.

2000 Revision

III. LESSON DESIGN AND IMPLEMENTATION

		Never Occurred			Very Descriptive	
1)	The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	0	1	2	3	4
2)	The lesson was designed to engage students as members of a learning community.	0	1	2	3	4
3)	In this lesson, student exploration preceded formal presentation.	0	1	2	3	4
4)	This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	0	1	2	3	4
5)	The focus and direction of the lesson was often determined by ideas originating with students.	0	1	2	3	4

IV. CONTENT

Propositional knowledge

6)	The lesson involved fundamental concepts of the subject.	0	1	2	3	4
7)	The lesson promoted strongly coherent conceptual understanding.	0	1	2	3	4
8)	The teacher had a solid grasp of the subject matter content inherent in the lesson.	0	1	2	3	4
9)	Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so. ↳ only drawing on board.	0	1	2	3	4
10)	Connections with other content disciplines and/or real world phenomena were explored and valued.	0	1	2	3	4

Procedural Knowledge

11)	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	0	1	2	3	4
12)	Students made predictions, estimations and/or hypotheses and devised means for testing them.	0	1	2	3	4
13)	Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures. X	0	1	2	3	4
14)	Students were reflective about their learning.	0	1	2	3	4
15)	Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	0	1	2	3	4

2000 Revision

* No IK integration
* ~~No~~ co-opperative strategies Limited.

Continue recording salient events here.

Time	Description of Events
12:04	Take 3 colours to colour the meniges in the brain. Drawing on the board → learners to Colour in their notes to understand the concept. Learners asking questions to understand the colouring. Dura mata – Durable → good connection words to make connections for learners to remember.
12:09	Video – parts of the brain
12:11	Continue with the cranium
12:12	Learners are standing around teachers Cross hands, put hands on surface to explaing the brain – White and grey matter → show corpus collosum. → bring family's together eg: Connect two hemisphers. Frontal lobe → fingers out. Wrist → brain stem.
12:16	More learner engagement with this activity
12:21	Learners sit down again – do the following! Read p142-144 } rest of the lesson Act 2 – learn
	* Difficult to integrate IK into Life Sciences topic

* Could have tried to integrate IK → ie: medicinal Medicine that improve concentration etc.

V. CLASSROOM CULTURE

	Communicative Interactions	Never Occurred				Very Descriptive
16)	Students were involved in the communication of their ideas to others using a variety of means and media.	0	1	2	3	4
17)	The teacher's questions triggered divergent modes of thinking.	0	1	2	3	4
18)	There was a high proportion of student talk and a significant amount of it occurred between and among students.	0	1	2	3	4
19)	Student questions and comments often determined the focus and direction of classroom discourse.	0	1	2	3	4
20)	There was a climate of respect for what others had to say.	0	1	2	3	4
	Student/Teacher Relationships					
21)	Active participation of students was encouraged and valued.	0	1	2	3	4
22)	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	0	1	2	3	4
23)	In general the teacher was patient with students.	0	1	2	3	4
24)	The teacher acted as a resource person, working to support and enhance student investigations.	0	1	2	3	4
25)	The metaphor "teacher as listener" was very characteristic of this classroom.	0	1	2	3	4

Additional comments you may wish to make about this lesson.

- Teacher-orientated. with little learner engagement

APPENDIX P: TEACHER REFLECTION REGARDING WATER QUALITY FOLDSCOPE ACTIVITY

Transcriptions -Teacher Foldscope activity and CAR

The affordances of Foldscopes in Life Sciences Education in South Africa.

Teacher 1

1. Describe your first experience using the Foldscope in your classroom

My first lesson was very daunting as the learners found the instructions very difficult to follow. I then looked for a video for the learners to follow and that seemed to work, and my second lesson went much better. I suggest that teachers fold the Foldscope before the lesson.

2. How could this lesson (water quality investigation) enhance problem-based learning (PBL)?

This was excellent for PBL as learners were required to investigate a problem hence the investigation of water quality in an area learners live close to. This will allow them to appreciate the fact that we have drinkable water.

3. Analyse possible problems/issues/challenges of rolling out Foldscopes in the classroom?

- Instructions are difficult to follow
- Need to be the appropriate age for the use of the Foldscopes
- Some learners couldn't see their specimens
- Teachers must be prepared. Use videos to explain to learners on how to fold the Foldscope, how to make a Foldscope slide and how to see the Foldscope slide.

4. Theorise any other possibilities of using the Foldscope in the classroom?

Foldscopes can be used for any other microscopes activity including making wet mount slide and looking at a variety of specimens.

5. Explain your overall experience teaching this practical especially referring to the Foldscope. Is it valuable to use the Foldscope?

Definitely valuable, at first it was difficult to fold and some Foldscopes didn't allow the learners to see anything, but they shared those that worked and assisted each other. It was incredible to see the amazement of the learners of the unseen world, the learners really enjoyed this practical.

How do you think the Foldscopes enhanced learners understanding of this topic? (Water quality in Ecology and Biodiversity)?

Learners were made aware of the number and variety of living creatures and unicellular organisms in the water. They explored the unseen world and they really were surprised and loved every second of it. One child said "best lesson ever" and another said "this is so cool."

Teacher 2

1. **Describe your first experience using the Foldscope in your classroom.**

Building took a long time (60min). The video was played simultaneously with the second class who found it easier to build which watching the video. Instructions for inserting the lens needs revision, many didn't detach it from the 3rd black square first.

2. **How could this lesson (water quality investigation) enhance problem-based learning (PBL)?**

Allows viewing of microscopic organisms e.g. Trypanosomes, adds to the chemical tests for water quality. Frustration was highly evident. Those that persisted did see things but most gave up.

3. **Analyse possible problems/issues/challenges of rolling out Foldscopes in the classroom?**

Need online video available. Difficult to use. Takes time to perfect the technique of making slides and viewing. Children aren't accustomed to paper model building and struggled with the instructions. The slots for holding paper sides were too small.

4. **Theorise any other possibilities of using the Foldscope in the classroom?**

Cheek cells and plant cells.

5. **Explain your overall experience teaching this practical especially referring to the Foldscope. Is it valuable to use the Foldscope?**

Not in this situation – light microscope easier to use. Took too long. Where no other option can be used the Foldscopes are valuable.

How do you think the Foldscopes enhanced learners understanding of this topic? (Water quality in Ecology and Biodiversity)?

The water quality practical was very valuable to the learners to understand the quality of water, however it was difficult to build and use the Foldscope, but persistence allowed for learning to happen in many spheres.

Teacher who designed the water quality practical using CAR, please answer the following questions:

How did you experience CAR (Classroom Action Research)? Reflect on your engagement with CAR (Classroom Action Research)?

I was not familiar with the CAR cycle. I did a bit of research and learnt that it is very similar to the scientific method and used it to design this learning activity. I wanted to do something exciting for the learners and at the same time design a practical that was relevant to them and is in line with the curriculum. We were busy with Ecology. I really enjoyed designing the CAR activity and got a lot of satisfaction when the activity was designed. The donation of the Foldscopes motivated me to use the CAR to design this learning activity.

The CAR forced me to use a variety of pedagogies in class. CAR was very valuable as it guided me to formulate a very meaningful activity which links to Aim 3 of the curriculum.

It was very fulfilling it motivated me to tell other teachers about the CAR cycle and how beneficial it was in formulating practical's etc. I recommend that all teachers use CAR in order to develop their professional skills.

During the CAR reflection is vital, I did not realise the importance of reflection continually during the CAR, this is so valuable as this reflection allows me to be critical on myself in order to learn from mistakes or even how to improve the lesson for the next time. This is how you grow as a teacher to become a great teacher.

Did CAR (Classroom Action Research) assist with your professional development?

Yes, it definitely did. I learnt valuable skills associated with CAR including research and planning. A lot of research had to be done to identify how to test the quality of water, but also research methods that learners can use to test water in the class and at minimal cost, such as pH, temperature and the use of the Foldscope's.

APPENDIX Q: LEARNER REFLECTION TRANSCRIPTS REGARDING WATER QUALITY FOLDSCOPE ACTIVITY

Q 2.5	**Reflect on your experience of folding the foldscope microscope? I.e was it difficult, easy, explain your answer.**
L1	It was quite difficult because the instructions weren't specific. The pictures were not clear. The foldscope was designed by an American and so American terminology was used to describe the parts of the microscopes which made it even more difficult to understand. It took a while to fully fold the microscope which left less time to view organisms.
L2	It was a little difficult to follow and understand the instructions but the assembling went well. The cardboard folded nicely and it was easy to pop out the parts without tearing them. The pieces fit together nicely.
L3	The instructions for the fold microscope weren't easy to read making it difficult and more time consuming to make the microscope. It was difficult because of how 'knit-picky' it was, fiddley almost making it difficult to work with and to hold and fold the paper. Mistakes could be easily made.
L4	Folding the foldscope microscope wasn't very easy, but it was also not very difficult. At times the instructions made it difficult to understand what was going ton, but h the addition of pictures in the instruction manual did assist in these times. The actual folding and assembling was very simple. So in conclusion, it was actually quite easy to fold, but it would have been easier had the instructions been more detailed.
L5	Folding and assembling the foldscope in my opinion was quite hard. The instructions were small and quite hard to read. The paper was sturdy although it felt like it was going to tear in some more intricate steps of assembly sometimes when folding I had to apply lots of pressure to bend the material. I though it might end up breaking it. I don't have long ails which made it difficult to pull some of the pieces apart or gently place them onto one another. It was a fun and somewhat frustrating experience.
L6	I like to have a bit of a challenge and so I enjoyed the experience of assembling the foldscope. The instructions were tricky to understand at first, but after a bit of trial and error, I found them easier to follow and managed to fold the foldscope without any problems. It was helpful to me that all the equipment was presented to us in such an organized manner so that I had no problem finding the parts I was looking for. I found it easier to follow the written instructions than the video because everyone was folding at different speeds and so we weren't all at the same stage in the video.

L7	The folding of the foldscope microscope was very interesting and challenging. There were a couple of instructions that were confusing and I found myself asking for help whilst constructing it more than once. My classmates were very helpful and we all tried to help each other if need be. It was an experience that reminded me that you have to have patience and you need to focus when building a complex thing.
L8	It was difficult to assemble and to take the pieces out of the paper it came in. It was difficult to see through the lens and see the magnified organism. As we were building the foldscope it was difficult not to break it or tear it. The directions were confusing as you could not see what they were using or how to achieve that step.
L9	Folding the foldscope was a fun task. It was, however, difficult as the paper material it was made from would tear easily. The instructions on the paper in the package was very difficult to follow and was unclear, but the video was helpful. I really had a lot of fun and it was great to have to interact with those around you and really think. The fact that the foldscope's sides were different colors, and the colours showed on the instructions was extremely helpful.
L10	Yes, it was difficult. I stuck lenses the wrong way and the instructions were unclear.
L11	It was extremely difficult to fold the microscope as the instructions were not very clear and many of the parts looked similar to each other. The fold lines were not very clear and it was extremely difficult to get the folds right. The video on the folding of the microscope did help but people in rural areas may not have access to the internet to watch the video. Overall I think it would be made better by clearer instructions and better marked pieces
L12	I found it easy. The steps were easy to follow. The one problem I had was by putting the lens in the wrong way. The pieces easily fitted together (slid or clipped in quickly). There wasn't a lot of pieces and they were colour coded (which helped me find out which way and where the pieces connected.). Once everything was clipped together the magnets held everything firmly so when a slide was put in, it wouldn't move.
L13	Folding the foldscope was difficult at first because the instructions were vague, but when sitting down and trying multiple times, it became easy. We were also aided by a video to show us exactly how to fold it.
L14	It was difficult because when it came to reading the instructions it was hard because you could not see the way it was supposed to be folded, but when I watched the video it was easier.
L15	The initial process of folding the foldscope wasn't particularly hard. There were a few

	large pieces and smaller pieces, that were the sides, and few stickers. There was a bit of confusion during the process as it wasn't clear what to do with some of the pieces as the instructions weren't very detailed. Although the instructions weren't the best, they were still understandable enough for the foldscope to be built.
L16	I found folding the foldscope to be very fun and interactive. The instructions were nice and clear making it very easy to follow. The video we watched based on how to put together the foldscope also made a great guide. Overall I found that the only tricky part was determining which way to fold the paper/cardboard when they instructed we should fold on the dotted lines. Easiest part for me was sticking on the foldscope ID sticker. I found it easy to fold the foldscope for I have long nails so it … (incomplete sentence)
L17	I found assembling the foldscope was difficult as the instructions were confusing and the material was delicate. While folding I was scared of pushing too hard and breaking a piece, which I ended up doing anyway. I did enjoy folding the foldscope, however, as a class we all helped each other out and discussed if were doing it correctly or not.
L18	The folding of the microscope was somewhat easy with aid of a video. The pieces were simple to 'tear' out and good colour coding as a whole to indicate folds and insertions, etc. The only thing that was slightly difficult was to insert lens and magnetic coupler, as it was a little confusing which side to insert in, because a wrong side meant the foldscope useless and blurry.
L19	The foldscope was difficult to construct. The instructions were difficult to follow as the images were not always specific. The text was unclear. The video was confusing as it was unclear. For example, the lady would refer to 'the yellow page' but more than one page consisted of yellow. It was difficult to fit some pieces onto their places and so more specific instructions would have only made it slightly easier to construct.
L20	At first it was a little difficult as there were so many pieces that you had to arrange carefully to put the foldscope together properly. Also, some of the pieces had to be aligned correctly in order for it to work properly which proved to be a challenge. The folding of the focus ramp was tricky as there was a lot of folding and unfolding involved to create the tapering from a thick end to a thinner end. The fastening and the fixing of everything together was finicky and you had to work carefully and neatly as the slots were quite small and could tear easily. It also took a reasonably long time to build.
L21	It was a little difficult at first but after a while I understood what was going on and was able to finish it quickly and start making my slide. While making it I struggled to understand and see how this would even be a microscope and how it would work. When I finished building it I thought it looked really cool and it was clever on how they made

	and designed it. Making the slide I found it quick and easy and put it in the microscope, and looked at my algae in the water I collected.
L22	Folding the microscope was a fairly short task but it had its challenges. The actual folding was easy because it was clearly marked and all the lines were perforated. It showed you how to fold it, however the difficulties came when we had to connect the two main parts and identifying what parts went where. Checking which part was which also was a challenge because the lens and the couplet looked quite similar.
L23	(Unable to read print – unclear…)
L24	My experience of folding the foldscope was challenging because the instructions given were hard to follow and the photos supporting the instructions weren't clear. The 'folding' lines were hard to distinguish from the 'tearing' lines therefore made me skeptical to tear any pieces. This slowed me down and I fell behind from the rest of the class. This was a fairly new experience for me because I don't fold paper (origami, etc.) very often and only on rare occasion, therefor it was a challenge to adapt to it and learn how to do it in a short period of time. I felt a lot of pressure on building the Foldscopes due to my foldscope being used by following students. The overall experience was challenging but educational.
L25	It was very difficult to me, some pieces were very delicate and broke easily, but assembling the scope was easier.
L26	I found the folding of the foldscope fairly difficult as I found the instructions regarding the foldscope vague and unspecific. In the end I managed to fold it successfully after a few lessons of struggle.
L27	The folding of the foldscope microscope was a challenging, and yet rewarding task – at times I truly struggled to interpret the instructions that were provided on the instruction manual and thus the folding was quite tricky at stages – and yet, it was exhilarating at the same time, every time I folded a piece of the microscope, I remembered that I was one of the first people in South Africa to do so. During certain stages of the folding process, I experienced irritation and agitation due to the fact that I could not achieve the desired outcome / fold the different pieces together in the manner that was depicted on the instruction leaflet. The folding of the foldscope was stressful at times, as the constant worry existed within me that I would tear/damage the foldscope to the extent of no repair, however, overall the experience was positive and enjoyable.
L28	Folding the foldscope microscope wasn't as challenging as I expected it to be. It was very straight forward, because the instruction manual was precise and readable.

	Not only did the manual explain in words, but there were visual steps of what to do, making the build a lot easier and understandable. The folding of the microscope was not very time consuming, but instead quick to build. I enjoyed the experience, was fun and something new.
L29	The foldscope was very difficult to fold accurately. Some instructions weren't clear so I had to rely on the pictures. The pictures were easy to follow because I could visually see what I was supposed to do.
L30	It was quite difficult and I found it intimidating because I was definitely not expecting cardboard and folding. My first impression was that it looked like something that could break easily. I ended up needing help because I was afraid that it was going to break, but in the end I managed to build the microscope and it was a great experience.
L31	(First line unclear)…However I became more confident folding the different pieces as the instructions were clear to follow. It was easy folding the pieces and watching the foldscope come together. As I progressed through the instructions it became more difficult. Although I was helped by other students it took some time to figure out how to (…unclear print…) took it apart and built it again. Overall it was a enjoyable experience as I had to be very involved and attentive. I enjoyed the task and it was exciting to be able to finish building the foldscope successfully.
L32	In the beginning it was difficult because I had to find all the pieces and I was scared to break the foldscope but it is strong so it did not break. I overall enjoyed the learning experience because it was easy towards the end noticing the dotted line that indicate where you should bend the foldscope.
L33	I was really excited to start building the foldscope and I didn't really consider the challenges I face. At first it took a while for me to gain trust in myself as I didn't want to make a mistake – even though I could just unfold it if I needed to. It wasn't difficult of you followed the booklets steps that were given. In the end I was one of the first people to finish folding it which gave me a feeling of accomplishment.
L34	It was not difficult to physically fold this microscope, as the pieces were easy to remove from the 'base' (cardboard) and there were dotted lines on the cardboard to indicate where it should be folded and to make the cardboard more flexible. The instructions on how to fold were confusing and not very easy to follow – they were not user-friendly. The pictures next to the instructions however did help in figuring out what to do and what your microscope should look like once folded correctly. Trying to push certain folds into the slits was difficult as the slits were very small in comparison to the size of folds that needed to go through them. Folding the foldscope microscope was not the most

	challenging part of building the foldscope microscope. It was a moderate level of difficulty.
L35	I found it very difficult but also fun at the same time. Picking out the cardboard pieces took forever and took a very long time you also had to be careful.
L36	I found using the instruction paper to fold the foldscope quite challenging, because there were barely any clear and detailed instructions as to how to assemble the foldscope, for example, which way you place in the magnets. There were mainly images of how the foldscope should look at each step; which for me, was futile. I preferred watching video, as I could see physically what to do and the lady who partook in the video communicated each step which made it much easier and quicker to finish folding.
L37	It was easy to understand the instructions are straight forward and clear. It was difficult making the foldscope. It was hard getting the individual pieces out of the cardboard. Some pieces were easy to fold and some were hard to fold.
L38	Using the foldscope was a new experience and was quite difficult to understand at first as following the directions manual was a bit confusing. But once we started to watch the video tutorial it became a lot easier to handle and construct. Although it was a bit confusing, I think this foldscope is a great problem solving exercise and really allowed the students to think about how to construct it. It gave great insight towards knowledge of water.
L39	The foldscope building procedure was quite complicated for a few of the steps, but is still possible to be built. Some of the steps were unclear on how to do it exactly and it did take some time to figure it out.
L40	The Experience wasn't difficult or easy. It was in between. The foldscope instructions aren't the clearest. But was quite fun assembling it all together. It didn't take me that long to put the whole thing together which is a positive.
L41	I enjoyed folding the foldscope. It was a lovely way to learn how to follow instructions but also about teamwork. Everybody in the class helped one another and it was a very enjoyable 2-3 lessons. The instructions were mediocre. It could have given more information but luckily we had videos to follow. The foldscope was easy to get out of the cardboard and noting ripped.
L42	The folding of the foldscope was a very creative and interesting task. It was something that I had never done before. It allowed us to let lose, be creative and embrace our inner child. It did take a bit of time for me to get the hang of it but the instructions that we were given were really clear and very easy to read. For me personally, I didn't like using the

	foldscope because I didn't manage to get to use it properly, I could figure it out and see a clear picture of the specimen.
L43	Building the foldscope was very tricky. It took a lot of concentration and time. The instructions were not 100% clear / to the point so we looked at a video tutorial.
L44	No, it was very challenging in a good way. It pushed me out of my comfort zone as normally do not build things or enjoy making thins but I really enjoyed building the foldscope. I think it's a new and efficient way of viewing organisms. It's a very interesting microscope as it makes use of our phones which is very efficient as teenagers always have our phones with us.
L45	When building the foldscope it was a bit confusing only if you didn't listen or follow the instructions carefully. As I carried on building it, it became easier and simpler to understand.
L46	My experience of folding the foldscope microscope started of easy but as we went further, it became more difficult. We first started by taking out some pieces of the foldscope then proceeded by folding the tips which were easy, but the further we went as in folding them together to make foldscope, the difficult it became. The video was going a bit fast so it was hard to keep with the lady in the video, the hardest for me was when we had to make a cover slip, I messed up the placement of the slips by pasting the none sticky surface onto the sticky surface while forgetting that the water was supposed to be on both of the sticky surface. Overall it was a learning experience that I would do again.
L47	The experience was not hard – it just needed concentration. If you were not willing to follow the steps properly then you were bound to fall behind. There were many cases however, when the video went too fast, I couldn't keep up but once I eventually did catch up and was on track, the experience was a fun one – one that I might do again. I feel as though the experience teaches you patience while you have fun doing so it is interesting to learn that an actual working microscope can be made using the right pieces of cardboard paper and the right lenses.
L48	Building the foldscope was difficult if you fell behind and did not listen to instructions it became a boring process but if you listened and stayed on track if you do so it will be a fun and memorable experience.
L49	Assembling the foldscope was a moderately difficult task as there were many pieces to join together. Building/folding the foldscope required the students to meticulously follow many instructions, a few of which were rather complex, which became tedious and frustrating especially if one failed to complete the step effectively after multiple attempts.

	With aid of a video that explained how each instruction needed to be executed the task gradually became easier as we were able to see how the small parts and intricate folds needed to be assembled and folded. Overall, it was a unique experience that proved to be worthwhile in the end.
L50	Folding the foldscope was not as difficult as initially expected. If the instructions in the instructions booklet were read carefully and followed exactly, the foldscope was easy to assemble. The hardest part of putting the foldscope together was tearing the pieces of the foldscope from the cardboard it was attached as there was fear that it would accidentally rip.
L51	Building the foldscope was not to difficult to build. Although I needed a lot of concentration and listening skills. The only thing I found quite challenging was the extraction of the pieces which was a bit tricky.
L52	Folding the foldscope was a fun and entertaining experience, it was a bit tricky at first, but it was certainly not hard. The instructions on paper given were more hard to follow than the instructions given from the video. These instructions allowed us to complete the build quickly folding all of the different folds and was easy, but putting certain parts together was tricky as some parts did not fit exactly, so we had to bend and force some parts. Overall everything was easy.
L53	It was tricky at first because I did not know what all the pieces were. Watching the video was definitely easier than trying to read and follow the instructions as with the video we could see what we were doing.
L54	I found folding the microscope difficult because I fell behind in the beginning and then I struggled to catch up. I am also not very good with using my hands. The instructions helped me catch up and then once I had caught up it was a lot easier. I also had class members that helped me catch up.
L55	The foldscope was easy to build if you followed the instructions. I was just a bit scared that I was going to tear it but if you work carefully you won't. I think that the foldscope is a good idea because it is easy to use if you follow the instructions and it is inexpensive and portable if someone would want to go look at organisms displayed on the screen of your phone through your camera. It is very interesting, fun to build and not like other microscopes. Another advantage is that you can take pictures of the organisms more easily to see them properly or even a video of them moving. A good thing about the foldscope is that you don't need electricity for the light source but you must just hold it up to the sun and if there is a power failure you can still continue.

L56	Folding the foldscope was a difficult because it required the use of fine motor skills, something many people lack. It also required careful and meticulous following of instructions within a short time period.
L57	Assembling the foldscope was quite fun and easy to do. The video was not difficult to follow and I managed to complete it fairly quickly. However, there was a missing magnetic cupler in the kit, which on the video, proved to be very useful in viewing the slide.
L58	The fold microscope was a difficult task. The folding and assembling of the microscope was frustrating because of the fact that everything had to be done perfectly or else it could hinder the viewing of the specimen.
L59	Difficult. There is a lot of technicality when it came to folding the foldscope microscope. The video giving us instructions was fast paced but explained the concept of the microscope more vividly then that of the instruction booklet.
L60	Folding the foldscope was an easy experience for me the only part I found difficult was following the instructions from the video but found it easier following instructions from the manual.
L61	(Did not have a question 2.5)
L62	I found it easy to assemble the foldscope as the instructions were clear and informative.
L63	Personally I found that the foldscope microscope was difficult and annoying to assemble because some of the folding lines were not as easy to fold than the others. The microscopes were to hard to fit into the fitted slots and assembling build parts with the other parts was challenging because, the video that we watched confused me on how to build the microscope, the lines that we had to fold were hard to find.

APPENDIX R: WATER QUALITY PRACTICAL DESIGNED FOR THE LEARNERS, USING CAR.

GRADE 10 INVESTIGATION
WATER QUALITY USING THE FOLDSCOPE

Core Skills: Communicating; organisational skills; fine-motor skills; conceptual thinking; analytical thinking and practical skills – Equipment use, microscopy, tabulation and graphing.

IEB SAGS Aim 2 - Investigating phenomena in life sciences.

IEB SAGS Aim 3 - Appreciating and understanding the history, importance and applications of Life sciences in society. Show awareness and sensitivity towards the environments. Knowledge and understanding of the environment and the human impact. Show attitudes and values that reflect concern for the environment.

Total: 50 marks

Due dates:

Water collection due date: ___________________________________

Practical element in class: ___________________________________

Final hand-in due date: ______________________________________

Problem:

More and more people are realising that we need to find better ways to share our world's natural resources with each other and with other species to ensure that the planet can support life in the future. Water is becoming a scarce resource and as such needs to be managed more. By allowing poison into our water sources, we are slowly drinking it ourselves. Everything we do affects our water. We are beginning to see how important each of us are to make the world a better place to live, no matter what kind of work we do or how intelligent society says we are. Extra information: http://www.dwaf.gov.za/Dir_WQM/wqmFrame.htm.

Image from: https://www.enca.com/south-africa/sa-may-soon-face-water-crisis

1

Introduction: Testing the quality of water in our South African Dams and Rivers

Water is becoming a scarce commodity as the world population increases and global warming raises temperatures.

Better management of water resources is required in order to maximise efficiency in using and distributing water. Without water, life on this planet cannot be sustained.

South Africa is a country where water is precious but many of our rivers and natural water sources are contaminated by effluent (waste), both industrial and domestic. Toxins in our water reduce the purity of water, in turn reducing available drinking water.

Each of us play a role in getting involved to protect our water sources and using them wisely. We need to make South Africa a better place to live for all its people ensuring a safe water supply for all.

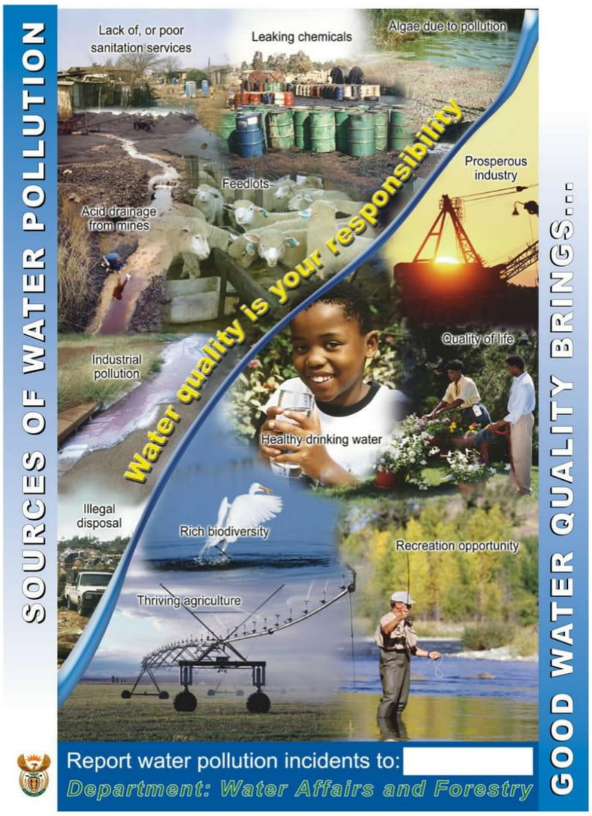


Image from: http://www.dwaf.gov.za/Dir_WQM/postBig09.htm

2

Task Overview

In this investigation you will complete the following:

Exercise 1 – at the water site

- Collect water from a water source near you.
- Test the water for pH and temperature at the source.

Note: You will be provided with a thermometer that will be signed out. If it breaks or you lost it, you will need to be replaced.

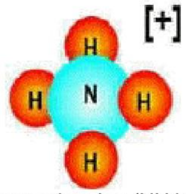
Exercise 2 – in the laboratory (class)

- Test the water for pH, temperature and dissolved oxygen.
- View the water sample using the foldscope microscope.
- Complete practical write up.

Background information for investigation

Ways in which the quality of water can be tested.

Testing for ammonia in water (NH3)



Ammonium Ion (NH4+)

Hyperplasia
Gill Damage

Image from: https://www.water-research.net/index.php/ammonia-in-groundwater-runoff-and-streams

Nitrogen is an essential nutrient that is required by all plants and animals for the formation of amino acids. In its molecular form, nitrogen cannot be used by most aquatic plants, therefore it must be converted to another form.

One such form is ammonia (NH_3). Ammonia is taken up by bacteria to convert into nitrite (NO_2) and finally into nitrate (NO_3^-), which is then taken up by plants.

Ammonia (NH3+) is a colorless gas with a strong pungent odor. Ammonia will react with water to form a weak base. When dissolved in water, normal ammonia (NH_3) reacts to form an ionized species called ammonium (NH_4^+)

One molecule of ammonia reacts with one molecule of water to form one ammonium ion. This is precisely what happens as the pH of water increases; that is the water becomes more alkaline. At any given time, there will be both ammonia molecules and ammonium ions present. The quantity of each is dependent on both pH and temperature.

NH_3 is the principal form of toxic ammonia. It has been reported toxic to freshwater organisms at concentrations ranging from 0.53 to 22.8 mg/L. Toxic levels are both pH and temperature dependent. Toxicity increases as pH increases and as temperature increases. Plants are more tolerant of ammonia than animals, and invertebrates are more tolerant than fish. Hatching and growth rates of fishes may be affected. In the structural development, changes in tissues of gills, liver, and kidneys may also occur. Toxic concentrations of ammonia in humans may cause loss of equilibrium, convulsions, coma, and death. Ammonia levels in excess of the recommended limits may harm aquatic life. Ammonia toxicity is thought to be one of the main causes of unexplained losses in fish hatcheries. Although the ammonia molecule is a nutrient required for life, excess ammonia may accumulate in the organism and cause alteration of metabolism or increases in body pH. Different species of fish can tolerate different levels of ammonia but in any event, less is better. Rainbow trout fry can tolerate up to about 0.2 mg/l while hybrid striped bass can handle 1.2 mg/l.

Fish may suffer a loss of equilibrium, hyperexcitability, increased respiratory activity and oxygen uptake, and increased heart rate. At extreme ammonia levels, fish may experience convulsions, coma, and death. Experiments have shown that the lethal concentration for a variety of fish species ranges from 0.2 to 2.0 mg/l. Trout appear to be most susceptible of these fish and carp the least susceptible.

pH

pH is one of the most common water quality tests performed. pH indicates the sample's acidity but is a measurement of the potential activity of hydrogen ions (H^+) in the sample. pH measurements run on a scale from 0 to 14, with 7.0 considered neutral. Solutions with a pH below 7.0 are considered acids. A change in the pH of water can alter the behaviour of other chemicals in the water which is detrimental to aquatic fauna and flora. The ideal pH level of drinking water should be between 6-8.5. Use the universal pH paper to get an exact pH measurement.

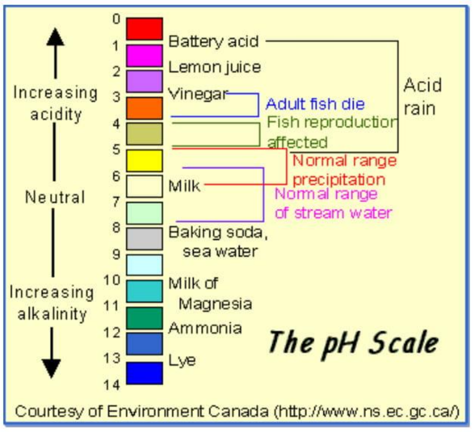


Image from: http://best-planet.com/blog/2012/02/25/water-quality-parameters-for-your-pond/

Unicellular aquatic organisms and the foldscope

Unicellular organisms belong to the Monera and the Protista kingdom. These organisms can be seen with a microscope and not with the naked eye. Use the field guide card from the foldscope microscope (2000X) to identify the variety of unicellular organisms in the water sample collected. Some of these organisms are disease causing, decreasing the quality of water. Use the field guide in the foldscope to identify a variety of organisms.

Extra information: https://www.msnucleus.org/watersheds/mission/plankton.pdf

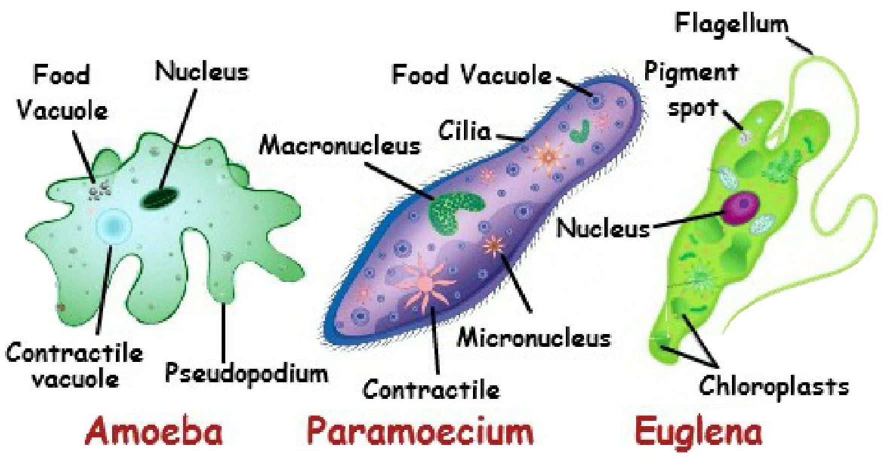


Image from: https://www.google.co.za/search?q=unicellular+organisms&safe=active&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjSoMaojLrZAhXIQ8AKHfk9CbYQ_AUICigB&biw=1366&bih=637#imgrc=nIiULCAhDCQloM:

5

TASK Instructions:

Exercise 1** – Research and collection of the water sample* ***[17]

1.1 ***Research*** the area you collected the water sample from, any information regarding the quality of the water. Write a short summary in the space below.

____

____

____

____

____

____

____

____

____ (5)

Apparatus and materials:

- Collecting jar for water collection (at least 300ml) – any glass jar/bottle may be used
- Universal pH indicator paper
- Pen, pencil, paper i.e. stationery
- Gloves
- Thermometer
- Permanent marker

Practical instructions for exercise 1:

Precautions:

- Before collecting ensure that the jar/bottle is clean.
- When collecting the water from the river, please use gloves or wash your hands after collection.
- Collect your water sample away from the edge and below the surface. Fill the jar/bottle completely underwater and put the lid on before bringing the bottle to the surface

1.2 Decide on an area to collect water from i.e. Hartbeespoort Dam or Botanical Gardens.

My water location: ____

1.3 Ask your parents/guardian to take you to the water source.

1.4 Collect 200ml of water from the water source (see precautions).

1.5 Close the lid to bring it to school. Using a permanent marker, mark your jar with your name and the location of the water source.

1.6 Using a thermometer, record the temperature of the water source from the river/dam and write it in the table below.

1.7 Using the universal pH indicator record the pH of the water source from the river/dam and write it in the table below.

1.8 **Take photographs** of the location where you collected the water sample from. Print these photos and paste them in the practical write up below where indicated. You need to appear in at least one photograph.

1.9 Complete the observation table below.

Heading:____

____

Water source	**Colour of the water**	**Temperature ( ) of the water**	**pH of the water**	**Other i.e. presence of any organisms, plants, any other observations**

(8)

Paste the photographs below:

7

<u>Exercise 2</u> - Practical instructions and write-up for laboratory exercise (in class). [33]

2.1 Write a ***hypothesis*** for your investigation.

____

____

____ (3)

Experimental procedure:

2.2 Write an ***aim*** for this investigation.

____

____

____ (2)

Apparatus and materials:

- Universal pH indicator paper
- Marking pen, Pen, pencil, paper i.e. stationery
- Foldscope
- Watch glass
- 3 test tubes and test tube rack
- Pipette
- Measuring cylinder
- Gloves
- Dissolved oxygen kit
- Thermometer
- Glad wrap
- 2x Syringe - 2ml and 1ml (showing calibrations for 0.5ml)

Precautions:

- Ensure all the apparatus is clean before use.
- Correct use of apparatus – see Biological Skills booklet on ITSI.

Method: Testing dissolved oxygen, pH and viewing unicellular organisms using the foldscope.

- Using a marking pen, label the test tubes A, B and C respectively.
- Using the measuring cylinder, add 10ml of the collected water sample into test tube A and B.

Temperature:

- Using a thermometer, in test tube A, take the temperature reading, and record in the table below.
- Compare to the original temperature reading done at the site of water collection.

pH:

- In test tube B, using the universal pH paper, take the pH reading by dipping the paper into the test tube.
- Compare with the colour code chart.
- Record in the table below.

Dissolved oxygen:

- Add 5 ml of collected water sample
- Drop one dissolved oxygen tablet into test tube C.
- Cover the test tube with glad wrap and gently swirl mixing the tablet in order for it to dissolve – 4 minutes.
- Leave for another 5 minutes.
- Compare with the colour code chart.
- Record in the table below.

2.3Heading:____

____(5)

Beaker	**Temperature ( )**	**pH**	**Ammonia test ( )**
A			
B			
C			
Original recording from the water source			

Foldscope:

- Follow the instructions to build the foldscope.
- Using the foldscope, view the water samples to identify any organisms.

2.4 Heading: <u>Organisms identified from the water sample using the foldscope field guide</u>.

List the organisms you identified from the water sample:

(3)

2.5 Reflect on your experience of **<u>folding</u>** the foldscope microscope? I.e. was it difficult, easy, explain your answer.

(2)

2.6 Reflect on your experience **using** the foldscope microscope to identify organisms in comparison to the light/compound microscope? I.e. was it difficult, easy, explain your answer.

(2)

2.7 Write a ***summary of the results*** for the investigation and make reference to the quality of water from the sample you collected.

12

(6)

2.8 Write a ***conclusion*** for the investigation.

(2)

2.9 What variables did you keep constant i.e. ***controlled variables***? (list 3)

(3)

2.10 When measuring the volume of the water, what steps did you follow to ensure your measurement was as accurate as possible?

(1)

2.11 What two changes would you make to the above experiment to improve the validity and the reliability of the findings?
(Discuss ***limitations and recommendations***).

Validity:

(1)

Reliability:

(1)

2.12 Write a ***reflection*** to explain your ***overall experience*** completing this practical, specifically referring to the foldscope.

Is it valuable to use the foldscope as part of your investigation?

Explain how the foldscope enhanced your understanding of this topic - water quality in Ecology and Biodiversity.

____

____

____(2)

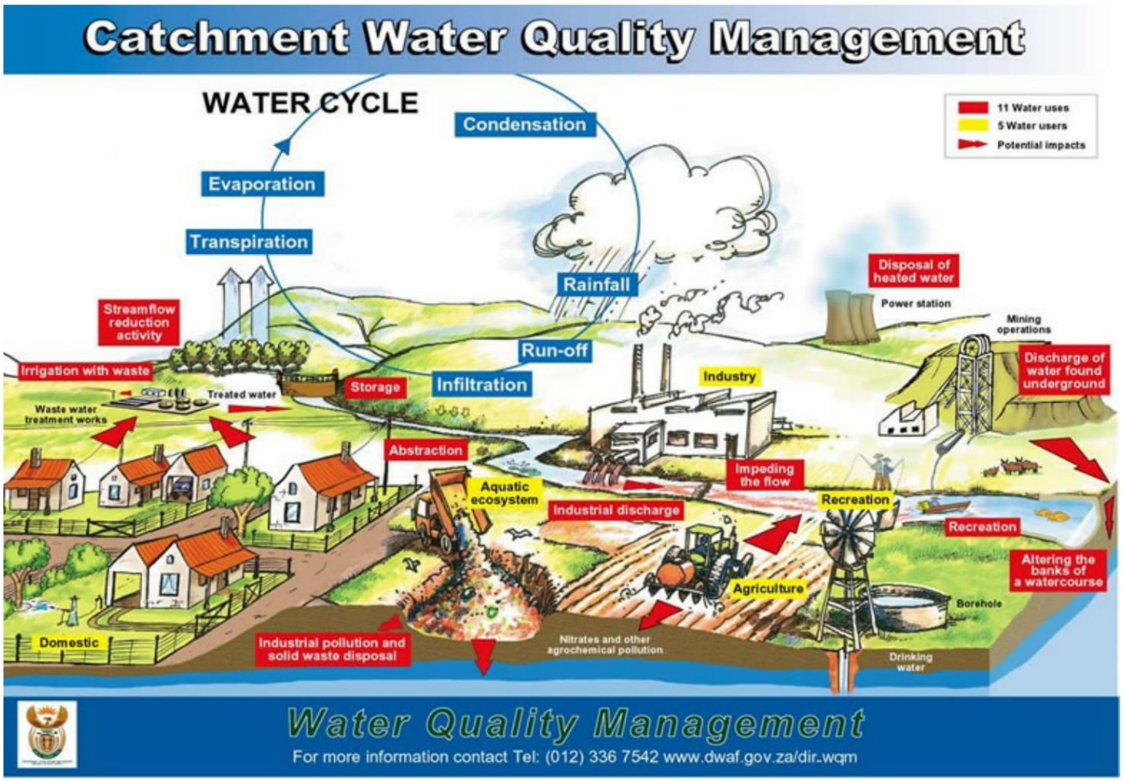


Image from: http://www.dwaf.gov.za/Dir_WQM/postBig12.htm

Thank you to the North West University (Prof Josef de Beer) and the Fuchs Foundation for the donation of the foldscopes.

NORTH-WEST UNIVERSITY
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SELF-DIRECTED LEARNING

THE CARL & EMILY FUCHS FOUNDATION

15

APPENDIX S: RUBRIC FOR CODING OF PARTICIPANTS' RESPONSES TO THE VNOIK INSTRUMENT

(Cronje *et al.*, 2015: 329)

Table 3. Rubric for coding of participants' responses to the VNOIK instrument

Question	Informed view (I)	Partially informed view (PI)	Uninformed view (UI)
1	Mentions at least four of the anticipated answers or other tenets of indigenous knowledge	Mentions at least two of the anticipated answers or other tenets of indigenous knowledge	Mentions one or none of the anticipated answers or other tenets of indigenous knowledge
2	Answers yes, with an acceptable reason or example	Answers yes without explanation or with reason that is not acceptable Answers no with acceptable explanation	Answers no or not sure
3	Can include supernatural to explain causes. Gives examples of possible unnatural causes	Can include supernatural to explain causes. Does not give examples of possible unnatural causes or gives irrelevant explanation	Answers no just natural causes
4	Answers yes and no or yes, but, and explains the resilience of indigenous knowledge but that indigenous knowledge can be modified as needs of society changes	Answers just yes with correct explanation of why it stays the same or no with correct explanation of why it changes	Answers yes or not sure without any explanation
5	Comprehensive suitable explanation including at least two examples relating to everyday life needs or trial and error methods	Short suitable explanation including at least one example relating to everyday life needs or trial and error methods	Not sure or unsuitable explanation
6	Yes with suitable explanation/ example	Yes with no explanation or unsuitable explanation	Not sure or no
7	Provides one holistic method including physical and spiritual systems and treatment including medicinal plants or rituals	Provides either method or treatment suggested in column one of question 7 in this table	Not sure or unsuitable explanation
8	Answers yes with explanation or example	Answers yes without suitable explanation or example	Not sure or unsuitable explanation
9	Yes it reflects social and cultural values plus explanation/ example. Believe it is universal/ transferrable/partially transferrable with suitable explanation/example	Yes it reflects social and cultural values plus explanation/ example. Does not believe it can be transferred with no explanation	No to both questions or unsuitable explanations
10	Yes it can change with suitable explanation or it can be modified with explanation and/or example	Yes or partially but explanation is not suitable	Not sure or no

Table 4. Examples of coded results on the VNOIK questionnaire

Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Overall score
001	I	PI	I	PI	I	I	I	I	I	PI	
Weighting	2	1	2	1	2	2	2	2	2	1	2 (1.7)
002	UI	UI	PI	PI	I	I	I	PI	I	UI	
Weighting	0	0	1	1	2	2	2	1	2	0	1 (1.1)

Q = Question; N/A = not answered; UI = uninformed view (0) ; PI = partially informed view (1); I = informed view (2).

APPENDIX T: ETHICAL CLEARANCE CERTIFICATES OBTIANED FOR THIS RESEARCH

NORTH-WEST UNIVERSITY ®
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NOORDWES-UNIVERSITEIT
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T: 018 299 4656
F: 086 661 8589
http://www.nwu.ac.za

10 September 2018

To Whom It May Concern

I hereby confirm that the ethics application, as stated below, was approved on the Edu-REC meeting of 26 July 2018.

Ethics number: NWU-00357-18-A2

Project head: Prof JJJ de Beer

Project team: C Jackson, Dr L White

Title: Teachers' affective development during an indigenous knowledge professional development intervention

Period: 26 July 2018 – 26 July 2019.

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

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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:

N	W	U	-	0	0	2	7	1	-	1	6	-	A	2
Institution				Study Number						Year			Status	

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: N/A

Commencement date: 2016-06-24 **Expiry date**: 2018-12-24 **Risk:** **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 Erna.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)

APPENDIX U: LANGUAGE EDITING CERTIFICATE

WORD for WORD
Academic Editing and Writing Support

Xenia Kyriacou (PhD Science Education)
+27614252802
xeniaxsk7@gmail.com

Confirmation of editing

This letter serves to confirm that the dissertation/thesis below has been language and style edited:

Title: Natural and Life Sciences teachers' affective development during an indigenous knowledge professional development intervention

Author: Cherine Jackson

Kind Regards
Xenia Kyriacou

10 November 2018