The integration of Indian Indigenous Knowledge into the SA Life Science curriculum

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Thesis submitted in fulfilment of the requirements for the degree Doctor of Philosophy in Natural Science Education at the North-West University

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Graduation:	May 2019
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DECLARATION

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

Signature

Date: 15 November 2018

ACKNOWLEDGEMENTS

I offer sincere and heartfelt thanks to the following people who helped me to complete this study:

1. My incredible promoter, Prof Josef de Beer, for being patient with me, for giving me his sage advice, inspiration, and guidance; and for steering me along the right path in this long journey in academia. I am thankful to him for giving me several remarkable opportunities and for supporting me in so many ways during the course of this study.
2. My co-promoter, Dr Neal Petersen, for his support, valuable advice, and encouragement throughout my study.
3. The Sol Plaatje Foundation, the Fuchs Foundation, and the NRF, for their generous funding that made this study possible.
4. The Vaidyaratnam Ayurvedic Foundation in Kerala, India, for graciously accommodating Prof De Beer and myself and teaching us the fundamentals of Ayurveda.
5. The SDL-IK community of practice, for their support, motivation, sharing of resources and their exceptional camaraderie.
6. The school teachers and principals who participated in this study.
7. My language editor, Dr Xenia Kyriacou, for her help in fine-tuning my document.
8. My loving husband and son, Navin and Dashaylan Reddy, for their understanding, assistance, and encouragement to complete this study.
9. My beloved parents, Bala and Saroj Reddy, for always instilling in my siblings and me the love for reading, and for their aspirations for us to be life-long learners.

Above all, I offer deep and humble gratitude to the Almighty for granting me the ability and perseverance to complete this study.

DEDICATION

This study is dedicated to my late paternal and maternal grandparents – the second generation of Indians in South Africa – who, under difficult conditions, were steadfast in their determination to perpetuate Indian culture while placing supreme importance on the education of their children.

ABSTRACT

This study considered the integration of Indian indigenous knowledge (Ayurveda) into the South African Life Sciences curriculum and was undertaken at a time when university students were embroiled in the #FeesMustFall campaign for free tertiary education, and for a decolonised curriculum (Le Grange, 2016). Against this background, emerged the urgent need to integrate more indigenous knowledge into the South African school curricula. Although the national CAPS curriculum policy document (DBE, 2011) stipulates this integration, it is silent on how it should be achieved.

Current textbooks make exclusive reference to African indigenous knowledge while excluding the indigenous knowledge of minority groups such as Indians, who make up South Africa's rainbow nation. This study used Ayurveda (a type of Indian indigenous knowledge) as a basis to contribute towards the pedagogy of indigenous knowledge integration using inquiry-based teaching strategies at short-learning programmes (SLPs) for Life Sciences teachers. An extensive literature study examined the theoretical and conceptual framework of this study. Social constructivism, and Vygotsky's (1978) zone of proximal development (ZPD), forms the theoretical framework. Concepts such as pedagogical content knowledge (PCK); the nature of science (NOS); the nature of indigenous knowledge (NOIK); conceptual change; self-directed learning (SDL); and Ayurveda itself formed the conceptual framework. Links between the basic principles of Ayurveda with specific topics in the Life Sciences curriculum further justified its inclusion.

This qualitative study was situated within a larger research project for SDL, which used design-based research (DBR) as a research methodology. My study was informed by the design flaws from Cycle 1, and formed part of Cycle 2. The design flaws identified in my study were subsequently refined and served to inform Cycle 3. Purposive sampling was used, and only Life Sciences teachers were selected to attend the SLP. Data was gathered using questionnaires, portfolios, interviews, and lesson observations, to examine the integration of inquiry-based techniques and Indian indigenous knowledge learnt at the SLPs. These multiple data sources afforded a 'thick description' (Geertz, 1973) and contributed to research rigour.

Data was subjected to a coding method recommended by Saldana (2009). In-depth analysis using the CHAT lens examined the tensions that arose.

Provisional themes emerged and were distilled into the main findings of the study, one of which suggested that despite the SLP being well-received by the teachers, actual implementation during lessons of what was learnt fell short, and teachers reverted to traditional transmission modes of teaching. A contradiction of control showing this dissonance emerged by juxtaposing two CHAT activity systems. Tensions were ascribed to systemic pressures and an under-developed PCK for indigenous knowledge. Teachers complained about a lack of time and an over-loaded curriculum. Contributions included the integration of Ayurveda into the Life Sciences curriculum; providing design principles to inform the next cycle of DBR; and motivating teachers to become self-directed learners and reflective practitioners.

Limitations included the small number of participants; poor submission rate of portfolios; and the unwillingness of many teachers to have their lessons observed. Future studies could be done on teachers engaging in classroom action research; more nuanced views of the tenets of indigenous knowledge; possible revision of the Life Sciences curriculum; and pre-service teacher education to include inquiry-based activities using Indian indigenous knowledge.

KEY WORDS: Indigenous knowledge, Ayurveda, teacher development, design-based research, CHAT, contradiction of control

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LIST OF ACRONYMS USED IN THIS STUDY

AYUSH	Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy
CAPS	Curriculum and Assessment Policy Statement
CAR	Classroom action research
CHAT	Cultural-historical activity theory
DBR	Design-based research
ESDC	Embodied, situated and distributed cognition
FET	Further Education and Training
GDE	Gauteng Department of Education
IK	Indigenous knowledge
IKS	Indigenous knowledge system
ISTE	Institute for Science and Technology Education
IWOK	Indigenous ways of knowing
KZN	KwaZulu Natal
NCS	National Curriculum Statement
NOIK	Nature of indigenous knowledge
NOS	Nature of Science
NWU	North-West University
OBE	Outcomes-based education
PCK	Pedagogical content knowledge
RTOP	Reformed Teaching Observation Protocol
SA	South Africa
SAARMSTE	Southern African Association for Research in Mathematics, Science and Technology Education
SDL	Self-directed learning
SLP	Short-learning programme
TIMSS	Trends in Mathematics and Science Study
VNOIK	Views of the nature of indigenous knowledge
VNOS	Views of the nature of science
ZPD	Zone of proximal development
ZPTD	Zone of proximal teacher development

LIST OF SANSKRIT TERMS AND ENGLISH EQUIVALENTS

Agni	optimal digestive fire
Asanas	posture in yoga
atma	soul/spirit
Ayurveda	knowledge or science of life
dhatus	normal functioning body tissues
dinacharya	daily rituals/regime
doshas	Humours
indriya	Senses
malas	waste products
Mana	Mind
panchakarma	five-pronged approach to cleansing the body as part of holistic Ayurvedic treatment
panchamahabhuta	five basic elements
tejas, jal, prithvi, vayu, akasa	heat, viscosity/cohesion (water), mass (earth), motion (wind), space (ether) - five basic elements
ritucharya	seasonal rituals/ regime
sloka	Couplet
vatta, pitta, kapha	basic humours (no English equivalent)

CHAPTER ONE – OVERVIEW OF THE STUDY

1.1 INTRODUCTION

This study set out to explore the integration of Indian indigenous knowledge into the South African Life Sciences curriculum. The aim of the study was to contribute to the field of indigenous knowledge in schools, especially Ayurveda as a form of Indian indigenous knowledge. Although there have been studies on indigenous knowledge, both locally and internationally, the integration of Ayurveda in the Life Sciences curriculum is completely absent from South African literature. Since Indians constitute a significant part of the South African demographic, a need exists to fill this gap.

Currently in South Africa, the school curriculum is known as the Curriculum and Assessment Policy Statement (CAPS), and it makes specific reference to the inclusion of indigenous knowledge into lessons as indicated by Specific Aim 3, "which relates to understanding the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the *relationship between indigenous knowledge and science*" [italics added for emphasis] (DBE, 2011:13). Although this is a commendable inclusion in the policy document, there are no guidelines as to how this Specific Aim is to be achieved, nor how to enable "such epistemological border-crossing in the science classroom" (De Beer, 2018:1). My study, therefore, set out to contribute towards the pedagogy of indigenous knowledge integration using inquiry-based teaching strategies during short-learning programmes (SLPs) for teachers; as well as to provide teachers with resources for the infusion of indigenous knowledge into their lessons.

The transfer of knowledge and skills from the SLP to actual practice in the classroom was also examined in my study. To this end, lesson observations, interviews and portfolios were used. Cultural-historical activity theory (CHAT) was used as a research lens to scrutinise any tensions that arose, and to provide a theoretical perspective for the analysis of the integration of Indian indigenous knowledge into the Life Sciences curriculum.

1.2 BACKGROUND TO THE PROBLEM

From 1995 to 2015, South Africa participated five times in the Trends in Mathematics and Science Study (TIMSS) assessment. Compared to nearly 70 other countries, South Africa (SA) produced consistently dismal results in mathematics and science. The most recent assessment took place in 2015 when "science achievement scores had improved from 'very low' to a 'low' national average" (Parliamentary Monitoring Group, 2017:1). The Grade 8 science results for SA ranked in the bottom-three positions amongst all the countries that took part, and for all questions. The percentage of South African learners who answered questions correctly was far below international averages (TIMSS, 2015). According to the same publication, "an understanding of mathematics and basic scientific concepts" contributes to an improvement on an individual, national, and global level by enabling the development of "knowledgeable and functioning" citizens (TIMSS, 2015:3).

These sub-standard results indicate that such an improvement is not easily attainable, thus leading to negative repercussions on each of these levels. In addition, the abysmal Grade 8 results also lead to poor mathematics and science results in Grade 12, which in turn leads to a weak foundation for tertiary studies, especially for those learners who pursue STEM (Science, Technology, Engineering and Mathematics) courses (TIMSS, 2015:3). The South African education system has undergone several curriculum changes since 1994 when apartheid was dismantled, to the present curriculum. The present curriculum was first implemented in 2012, and is called the National Curriculum Statement Grades R-12 or CAPS (DoE, 2011:3).

One of the general aims of the present curriculum is that it "promotes knowledge in local contexts, while being sensitive to global imperatives" (DBE, 2011:4); and one of the principles of the NCS Grades R-12 states that Indigenous Knowledge Systems (IKS) should be valued by "acknowledging the rich history and heritage of this country as important contributors to nurturing the values contained in the Constitution" (DBE, 2011:5). Despite these explicit references to indigenous knowledge, not enough information or guidance is included in the Life Sciences curriculum to realise this aim and principle. However, it is probably this lack of prescription in the curriculum document that made it possible to consider the integration of Indian indigenous knowledge into the curriculum, as I have done in this study.

This is unfortunate, as the incorporation of indigenous knowledge could make science education more relevant to learners; and a stronger focus on the affective domain might, in the long run, improve learners' performances in mathematics and science.

The deficiency of indigenous knowledge in school curricula also has consequences for learners who continue into tertiary education. This is highlighted by Odora-Hoppers (2005) who states that the value of including indigenous knowledge in university curricula is to prompt Africa "to find its voice, heal itself, and reassess its true contributions to global cultural and knowledge heritage". Much of the need for Africa to "heal itself" comes from the colonialism that Africa has been subjected to over the centuries. Odora-Hoppers (2005:17) refers to this as "knowledge apartheid" where the victors are the colonialists and the victims are the indigenous people of Africa. She describes this concept of knowledge apartheid as an emphasis on the knowledge of the victors, while that of the victims is overlooked, ignored and "condemned as unscientific" (id). Indigenous people have a vast trove of knowledge with traditional remedies, cultural practices and environmental conservation. Their indigenous knowledge was side-lined entirely in favour of Western knowledge – to the extent that indigenous people were not even allowed into schools or "into the public domain of policy or academic life" (Odora-Hoppers, 2005:22).

These practices by the colonialists served to compromise and severely truncate the development of indigenous people (id) whilst allowing only the colonialists to advance their knowledge. This absence of indigenous knowledge in science curricula may have led to the poor performance of children in the fields of science and mathematics "because they experience conflict between their existing knowledge and the knowledge of the various science curricula" resulting in them "withdrawing … from science classes" (Kibirige & Van Rooyen, 2006:236). If indigenous knowledge is included in the science curriculum, it could make the curriculum relevant to their lives, as stated in Specific Aim 3 of CAPS (DBE, 2011:13).

The effective inclusion of indigenous knowledge into teaching and learning is dependent on whether teachers receive adequate guidance and preparation during their teacher-training courses. Kibirige and Van Rooyen (2006:237) state that "it is the

responsibility of higher educational institutions to prepare teachers for the implementation of indigenous knowledge in the science classroom".

1.3 INDIGENOUS KNOWLEDGE AS DEFINED IN MY STUDY

It is necessary at this point to define what is meant by indigenous knowledge and what it entails. Indigenous knowledge has been defined in many different ways by various writers. For example, it is "local knowledge derived from interactions between people and their environment" and it is "a form of traditional wisdom". Herbal medicine is a good example of indigenous knowledge (ibid). De Beer and Whitlock (2009:210) define it as "the sum 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". Odora-Hoppers (2005:2) shares a similar definition and adds that it is the "totality of all knowledges and practices, whether explicit or implicit, used in the management of socioeconomic, spiritual and ecological facets of life".

These definitions show that indigenous knowledge is a holistic form of knowledge that integrates various aspects of life into a common knowledge, and that it is largely dependent on the ecology of the area that a group of people have occupied for many generations. In addition, the same author explains that learning about indigenous knowledge is "discipline-based" and entails a great deal of work in many aspects of life in order to obtain a "holistic, interdisciplinary frame of reference" (Odora-Hoppers, 2005:8). The impact of various Western influences, such as "colonialism, capitalism, and science [that] actively promotes individualism", forced upon many indigenous cultures, has subjugated these holistic traditional knowledge forms and created "cultural racism" (Odora-Hoppers, 2005:8).

The possible result of this 'cultural racism' has been, as mentioned earlier, poor mathematics and science results that are perpetuated throughout schooling. The integration of indigenous knowledge into the curriculum ought, therefore, to alleviate this poor performance. Although my study does not delve into learner performance, it considers instead the role of teachers in integrating indigenous knowledge into their lessons.

1.4 THE 'GAP' ADDRESSED BY MY STUDY

South Africa is a multi-cultural society made up of several different ethnic groups, including European, Afrikaner, Indian, Coloured, and various African ethnic groups. Each of these cultures has traditional knowledge, some of which is unique to them and the area they inhabit, and some of which is shared across many cultural groups. The Life Sciences CAPS document states that the examples of indigenous knowledge chosen "for study should, as far as possible, reflect different South African cultural groups" (DBE, 2011:17).

Having taught Life Sciences according to many of the previous curricula, as well as the CAPS, and having used many textbooks over the years, it is my experience that this requirement is not implemented. Instead the curricula and textbooks contain examples of indigenous knowledge that are mainly representative of the African and Khoi-San cultures including herbal remedies such as the ghaap (*Hoodia gordonii*), the African potato (*Hypoxis hemerocallidea*); the cancer bush (*Sutherlandia frutescens*); and 'duiwelsklou' (Devil's Claw) (*Harpagophytum procumbens*). Specific instances of the traditional knowledge of minority cultures, such as Indians, are neither mentioned in the curriculum guideline documents nor are they covered in the text books.

My Masters study investigated the Hindu perspective on evolution in the South African Life Sciences curriculum, and this made me curious to explore Indian indigenous knowledge further, specifically how it could be included in the Life Sciences curriculum. This would be relevant since Indian people make up a significant portion of the SA population. In 2011, Indians constituted almost 2.7% of the SA population (Statistics, SA). Recorded history shows that between 1860 and 1911, the British colonialists brought almost 152 000 Indians as indentured labourers to SA (Bradlow, 1998). Gradually more Indians followed as teachers, traders, and shop-keepers until an Indian community was established, especially in KwaZulu Natal (Gopal *et al*., 2014:31). Today, one of the largest diaspora of Indians outside India is actually in South Africa (Lal, 1998).

The South African Indian culture has roots in ancient India, bringing with them traditional knowledge such as Ayurveda and Yoga, among others.

It therefore, seemed appropriate to conduct a study that investigated the integration of Indian indigenous knowledge into the present Life Sciences CAPS curriculum, thus filling the gap that exists in the South African literature.

1.5 A brief literature study to the problem

The preliminary literature review revealed several international studies on the inclusion of indigenous knowledge of the First Nations people in North America and Canada; Fiji; India; and some African countries (e.g. Aikenhead, 1997; Battiste, 2005; Bartlett *et al*., 2007; Snively & Corsiglia, 2000; Madden, 2013; 2014 and 2015; Yishak & Gumbo, 2012; Uzochukwu & Ekwugha, 2015). There were also numerous studies on indigenous knowledge in Southern Africa (e.g. Le Grange, 2007; Botha, 2010; Naidoo & Vithal, 2014; De Beer & Van Wyk, 2011; De Beer & Whitlock, 2009; Odora-Hoppers, 2005; Ogunniyi, 2007). However, none of these studies looked at including Indian indigenous knowledge into the South African Life Sciences curriculum.

1.6 THEORETICAL FRAMEWORK – SOCIAL CONSTRUCTIVISM

The theoretical framework used in my study is that of social constructivism, with particular reference to the models devised by Vygotsky (1978) and Piaget (1964). Vygotsky looked at the social construction of knowledge; while Piaget focused on individual cognitive development to construct knowledge. These provided a suitable framework as indigenous knowledge is a social construct that is amassed from the experience and practice of many generations of people.

Piaget (1964) explained that active learning in individuals takes place through the processes of assimilation, accommodation and equilibration. These Piagetian concepts are explained succinctly in Siegler (1995:1): Assimilation occurs when new knowledge forms as new information is actively assimilated into the existing knowledge of an individual, such as when scientific knowledge has to be assimilated into indigenous knowledge. Accommodation refers to the means by which people adapt their ways of thinking to new experiences, such as when teachers have to adapt their own thinking to accommodate scientific knowledge, or when their own indigenous knowledge clashes with the indigenous knowledge of other cultures. Equilibration is the process that epitomises active and meaningful learning and occurs when both assimilation and accommodation allow an interaction between new information and

existing ways of thinking. It was necessary to include Piaget's notion of constructivism in my literature study to provide some background into how individuals learn, and how the relatively new concept of Indian indigenous knowledge could become part of the curriculum.

Vygotsky's zone of proximal development (ZPD) made up a more substantial part of the theoretical framework for my study because it examines how a person learns with help from a more knowledgeable other. Of particular relevance to my study was Warford's (2011) zone of proximal teacher development (ZPTD), a modification of Vygotsky's ZPD, where teacher development is scaffolded from 'actual' to 'potential development' using four stages: self-assistance → expert other assistance → internalisation → recursion (De Beer & Kriek, 2018?). This provides a theoretical basis for the teacher intervention programme or short-learning programme (SLP) that supplied part of the data for my study.

Vygotsky's work on the ZPD also gave rise to activity theory where 'tools' form an important part of the help received during learning. This eventually led to the third-generation activity theory or CHAT as devised by Engeström (1987), which was used as a research lens for data analysis. Cultural-historical activity theory indicates six nodes that are all inter-linked to show the dynamic interplay between them. This became known as the CHAT model by Engeström (1987:78) and is shown in Figure 1.1. This model shows the interaction between the individual on the top half and links this with his/her social interaction to the bottom half (Hardman, 2008). The double-headed arrows indicate that there is a dynamic interaction between each of the six nodes, which shows that it is not static, but constantly changing, a necessary feature for effective learning (Foot, 2001).

These dynamics also point to tensions that may exist in the classroom activity system, and will provide useful indicators of tension for the integration of indigenous knowledge into the Life Sciences curriculum.

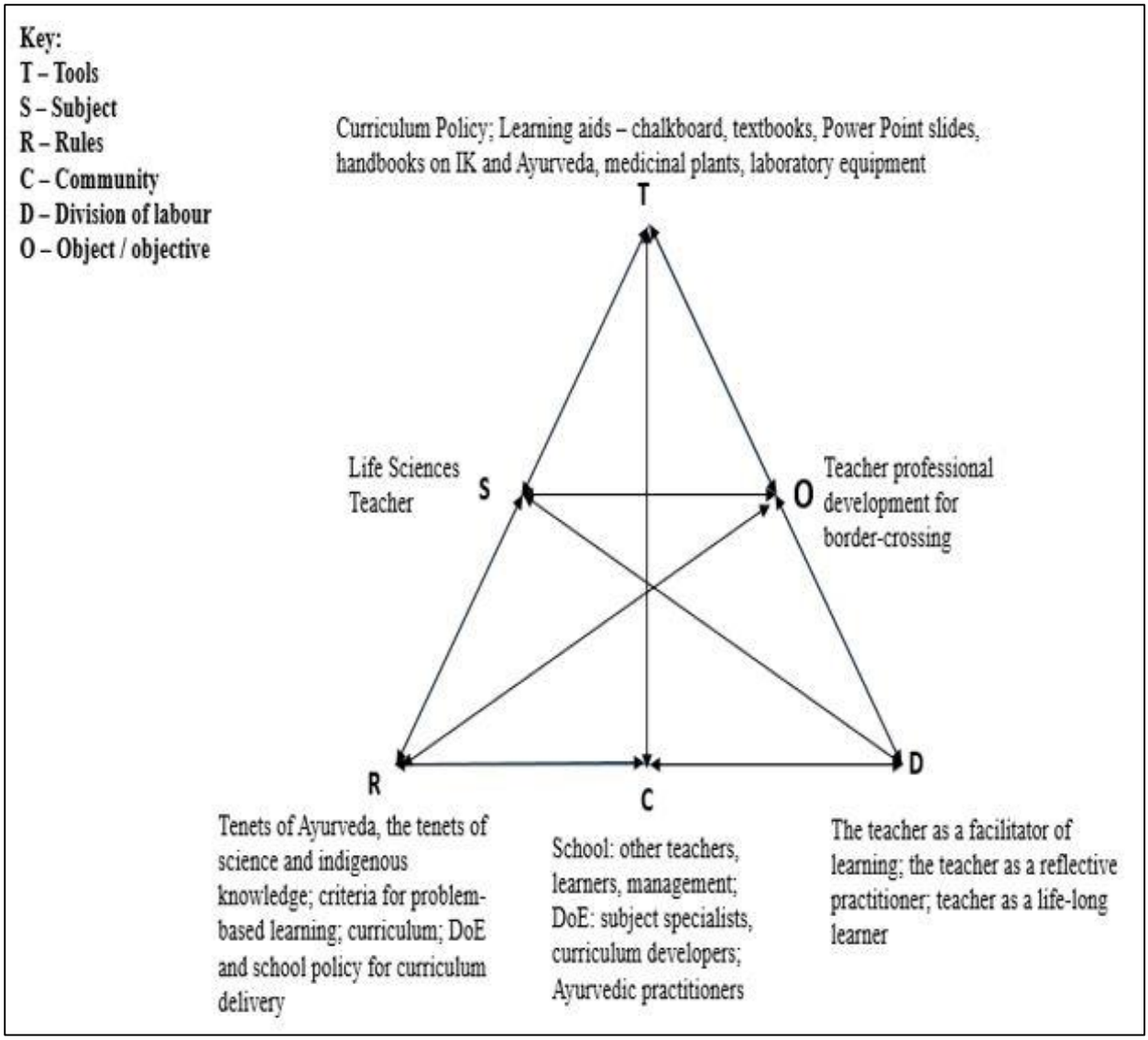


Figure 1.1: Third-generation activity model devised by Engeström (1987) and used as a research lens in my study

1.7 CONCEPTUAL FRAMEWORK

Several intermediate concepts formed part of the conceptual framework of my study, thus providing multiple dimensions to various aspects in this research. Whilst CHAT is used as a research lens, the intermediate concepts act as 'filters' to provide a more nuanced view of the data obtained.

These concepts included self-directed learning (SDL); embodied situated and distributed cognition (ESDC); conceptual change; pedagogical content knowledge (PCK); the nature of science (NOS); indigenous knowledge (IK); and the nature of indigenous knowledge (NOIK).

Included in the discussion are the basic principles of Ayurveda as a knowledge system, a brief history of the Indians in South Africa, as well as some background to indigenous knowledge in other parts of the world.

1.7.1 Self-directed learning

According to Knowles (1975:19), self-directed learning (SDL) refers to an individual recognising and taking charge of their own need to learn with or without help. De Beer and Mentz (2016) claim that the holders of indigenous knowledge are self-directed learners because they engage in knowledge construction based on need and using trial-and-error methods to find a solution.

My study was part of a larger project funded by the National Research Foundation (NRF) on the affordances of indigenous knowledge for self-directed learning, within the Research Focus Area: Self-Directed Learning, at North-West University. The project specifically investigates the affordances of indigenous knowledge for self-directed learning. As such it involved Life Sciences teachers' ability to improve their teaching strategies by using inquiry-based methods to integrate indigenous knowledge into Life Sciences lessons. This was especially important after the SLP when teachers were expected to become self-directed learners to find out more about indigenous knowledge and Ayurveda for integration into future lessons.

1.7.2 Embodied, situated and distributed cognition

In this study, I argue for the inclusion of indigenous knowledge from an embodied, situated and distributed cognition (ESDC) perspective. This refers to a paradigm of learning where the cognition process is deeply embedded within a person's mind (embodied), but also depends on the interactions with artefacts around them (situated), as well as social interactions with other people (distributed) (Hardy-Vallee & Payette, 2008).

The "overarching tenet of ESDC" is "that cognition is physiologically embodied, socio-culturally situated, and ostensibly distributed among individuals" (Chahine, 2016:54). The reference to socio-cultural context places this paradigm within the over-arching CHAT framework, justifying its inclusion as an intermediate theory in my study. The use of the ESDC paradigm in my study helps to show that teachers need to consider

the prior knowledge that their learners bring into the classroom in order to improve the learner understanding of scientific concepts. The teacher can then play the role of the more knowledgeable other, guiding the learner from their existing knowledge to the scientific knowledge that the curriculum requires.

The integration of indigenous knowledge into the curriculum will depend to a large extent on the principles of the ESDC paradigm since indigenous knowledge is regarded as knowledge accumulated over many generations from social interactions within cultures as well as with various traditional remedies (artefacts). This role of society in indigenous knowledge is emphasised by writers such as De Beer and Whitlock (2009:209); Onwu and Mosimege (2004); Ogunniyi (2007); and Odora-Hoppers (2005).

1.7.3 Conceptual change

This area of research arises from the notion of 'worldviews' which originated in German philosophy (Schilders *et al*., 2009). Learning is a social event and indigenous knowledge is a social practice, thus implying that the latter can be used to enhance learning. This relates to learning that stimulates interest among learners (i.e. their affective domain) which will engage and motivate them, since experiences with an emotional connection are embedded in our memories (Dubinsky *et al*., 2013).

This emotional connection is aligned with Pintrich, Marx and Boyle's (1993) concept of 'hot lenses' when viewing conceptual change. The notion of 'hot lenses' refers to a framework of beliefs and ideas through which a person interprets the world and interacts with it, thus allowing them to develop a complete picture that is used to make sense of new experiences and phenomena around them (id). Cavallo and McCall (2008:523) hold the opinion that an individual's learning is based on their worldview.

If this idea is applied to teachers, then many of them who were trained during the apartheid years may have a worldview that is in conflict with their traditional beliefs. This means that since Western Christian knowledge was the paradigm for the South African education system during the apartheid regime, many of the non-White teachers had to disregard their own traditional knowledge in favour of colonial, Eurocentric knowledge. This experience would have been similar for many indigenous

people around the world who were subjected to colonialism (Odora-Hoppers, n.d; Sanford *et al*., 2012; Madden, 2014). By using cultural-historical activity theory in this study, I was able to identify tensions that arose when indigenous knowledge conflicted with teachers' worldviews.

Since 2015, debates have been raging in South Africa around the decolonisation of the curriculum (Le Grange, 2015). This issue is of particular relevance with regard to conceptual change, since the integration of indigenous knowledge into curricula could help to address the current colonialist slant. This would then mean a shift in people's thinking towards being more accepting of indigenous knowledge, and more tolerant of the indigenous knowledge held by minority groups such as Indians in South Africa.

1.7.4 Pedagogical content knowledge

Pedagogical content knowledge (PCK) is a term that was coined by Shulman (1986). It refers to the subject matter knowledge, as well as the skill of how to teach it (pedagogy) for maximum learner understanding. This intermediate concept lends itself to the notion of self-directed learning (SDL) because the teacher has to set their own individual learning goals in order to develop their PCK for specific topics.

If teachers are not motivated to take responsibility for their own learning (to enhance their teaching skills, content knowledge and use of resources), then teaching and learning will not be effective and learners will not be interested in what is being taught (Sanford *et al*., 2012:19). The main focus during the SLPs was to assist Life Sciences teachers in developing their PCK in order to infuse indigenous knowledge into their teaching of the CAPS Life Sciences curriculum and, hopefully, to ultimately improve their learners' performance in Life Sciences.

1.7.5 Nature of science

A scientifically literate citizenry means that people are well informed about the environment, their health, and technological developments around them (Vhurumuku, 2011). This could be possible if learners are taught the tenets of the nature of science (NOS) at school. There are seven tenets of the NOS that are directly relevant to school science. These include: science is empirically-based; there is no single scientific method; there is a difference between a law and a theory, and between observation

and inference; scientific knowledge is tentative yet durable; it is theory-laden but partly subjective; it is socially and culturally embedded (Vhurumuku, 2011; Ledermann, 1999; Khishfe & Lederman, 2006; Cronje *et al*., 2015).

An understanding of these tenets should, in turn, lead to an understanding of scientific literacy. According to Abd-El-Khalick *et al*., (2004), if students are taught science using the inquiry method, they will have a better understanding of the scientific process, which should make understanding of topics such as indigenous knowledge easier to grasp and accept. The SLPs showed teachers several inquiry-based strategies that they could use in their own teaching. The Kirby-Bauer technique, for example, used simple laboratory skills that could be repeated in the classroom using everyday materials; while problem-based techniques, such as De Bono's thinking hats, encouraged teachers to delve into the tenets of the NOS by encouraging a reflection "on the moral principles that underpin science" (De Beer & Whitlock, 2009:215)

1.7.6 Nature of indigenous knowledge

In order for indigenous knowledge to be accepted and integrated successfully into the curriculum it needs to have basic scientific principles. According to Le Grange (2007:577) "universalists…argue that modern Western science is superior to indigenous perspectives on the natural world", a notion that needs to be dispelled by elevating indigenous knowledge to be viewed on the same footing as Western science. This would facilitate integration into the curriculum.

Cronje *et al*. (2015:322) have summarised the following as the tenets of the nature of indigenous knowledge (NOIK): indigenous knowledge is empirical and metaphysical in nature; resilient yet tentative; inferential yet intuitive; creative and mythical; subjective; social, collaborative and cultural; wisdom in action; has a functional application and a holistic approach. These researchers have aligned the tenets of the NOIK with those of the NOS while maintaining the uniqueness of each knowledge system (id). An understanding of both the NOS and the NOIK are needed in order to successfully integrate indigenous knowledge into the Life Sciences curriculum.

1.7.7 Indigenous knowledge in other parts of the world

Indigenous knowledge has been studied in other countries such as North America, Canada, Australia, and in many African Countries such as Ghana and Kenya (Naidoo & Vithal, 2014:253). Several researchers have contributed extensively to the global discussion on the value of integrating indigenous knowledge into school curricula, particularly with regard to decolonising the curriculum and giving prominence to the way local people take care of the land. Some of these researchers include Odora-Hoppers, Madden, Bartlett, Snively, Corsiglia, Battiste, Onwu, and Kwanya. Their work is dealt with in Chapter 2.

1.7.8 Indian indigenous knowledge – Ayurveda

Ayurveda derives from Sanskrit terminology translating into the 'Knowledge or Science of Life'. The closest equivalent in English is Life Sciences or Biology. Ayurveda is a holistic science that has been described as the "interaction between the body, senses, mind and atma (soul/spirit)" (Dwarakanath, 2003:6). One of my promoters and I attended a ten-day course in Kerala, India, where we learnt the fundamentals of this ancient science.

Ayurveda originated in ancient India nearly 5000 years ago from the ' doctrine of signature' (Pandita, Pandita & Pandita, 2016), that is also common to African indigenous knowledge. It links the appearance of certain plants with their benefit to corresponding organs in the body, for example, walnuts resemble the brain and scientists claim that walnuts help in developing over three dozen neurotransmitters within the brain, enhancing the signalling and encouraging new messaging links between neurons. Walnuts are known to help in preventing the onset of dementia, while also extracting and breaking down the protein-based plaques associated with Alzheimer's diseases (Bjerklie, 2003).

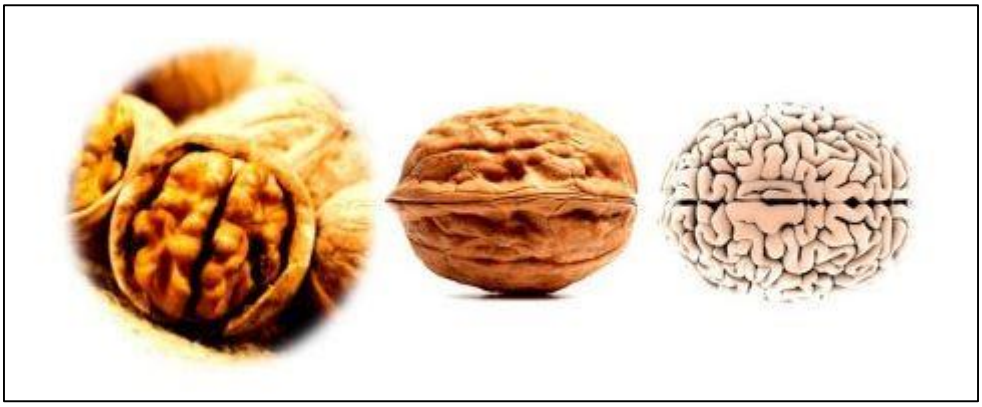


Figure 1.2: Walnuts resembling the brain – an example of the doctrine of signature

Ayurveda is based on five basic principles that can each be linked to different parts of the South African Life Sciences curriculum. The first principle is that of the panchamahabhuta (five basic elements) which make up all living organisms; a belief also held by the ancient Greeks. These five elements combine in different proportions to form the three biological humours, known as the three doshas – vatta, pitta and kapha (no English equivalent), and give rise to the second principle, that of the tridosha theory. Perfect health is achieved when these three doshas are completely balanced in a person.

The third principle is that of the Sapta Dhatus or seven biological tissues – plasma, marrow, fat, muscle, blood, bone, and reproductive tissues – each of which is under the control of a dosha. The fourth principle refers to the waste products of the body and, according to Ayurveda, there are three main waste products, i.e., sweat, urine, and faeces – thus giving rise to the trimalas principle. The fifth basic principle of Ayurveda is that of Agni or digestive fire. Ayurveda places great importance on food – how it tastes, its digestion, its elimination from the body, and its various effects on the body.

Ayurveda also prescribes specific habits that people should follow based on the time of the day and season in order to maintain good health and prevent illness. There are many herbal remedies for various conditions in Ayurveda. All of these aspects are relevant to the curriculum, and can be integrated into lessons under many different topics.

1.7.9 Indians in South Africa

Since my study examined the integration of Indian indigenous knowledge into the South African Life Sciences curriculum, it was necessary to understand the circumstances surrounding the Indian's arrival in South Africa, and how they managed to establish themselves as part of the demographics of this country. This sheds light on the rationale for considering Indian indigenous knowledge in the South African Life Sciences curriculum.

According to the High Level Committee Indian Diaspora Report (2001), Indians were imported to South Africa from 1860 as indentured labourers. They brought with them their own indigenous knowledge, traditions and religions that perpetuated in their new home over many generations. Much of the habits and herbal remedies among the Indian community have their roots in Ayurveda. This includes the use of turmeric and garlic as antiseptics and immune-enhancers. Indian people in South Africa were oppressed under apartheid rule and faced discrimination to limit their economic success and enterprise by the colonialists (id). It was only after much struggle that, almost a hundred years after the arrival of the first group of indentured labourers in South Africa, Indians were granted permanent residency status, giving them South African citizenship in 1961 (Gopal *et al*., 2014:31).

The inclusion of Indian indigenous knowledge would, therefore, contribute towards nation-building, an increased tolerance towards other people, and a renewed sense of pride for Indian people in particular.

1.8 AIM OF THE STUDY AND RESEARCH QUESTIONS

My study aimed to examine the integration of Indian indigenous knowledge into the South African Life Sciences curriculum. This aim gave rise to the main research question:

What are the affordances of including Indian indigenous knowledge into the SA Life Sciences school curriculum and what are the implications for teacher education?

In order to unpack this rather broad question, the following sub-research questions were derived:

1. How can Indian indigenous knowledge systems be integrated into the SA school Life Sciences curriculum?
2. How does the Indian indigenous knowledge system of Ayurveda and Yoga concur with the tenets of the nature of science and the nature of indigenous knowledge?
3. What are Life Sciences teachers' views about the nature of science and the nature of indigenous knowledge?
4. What transfer of Indian indigenous knowledge takes place in schools after the short-learning programme?
5. What are some of the tensions, if any, that arise when Indian indigenous knowledge is integrated into the SA Life Sciences curriculum?
6. What are Life Sciences teachers' lived experiences of participating in the short-learning programme (SLP), and teaching indigenous knowledge in the classroom?
7. What is the role of such an SLP in providing teachers with more nuanced understandings of Ayurveda as an indigenous knowledge system?

The objectives for my study based on these research sub-questions were as follows:

1. To investigate ways in which Indian indigenous knowledge (IK) systems can be integrated into the SA school Life Sciences curriculum.
2. To examine whether the Indian IK system of Ayurveda and Yoga concur with the tenets of the nature of science and the nature of indigenous knowledge.
3. To look at Life Sciences teachers' views about the nature of science and the nature of indigenous knowledge.
4. To examine whether the transfer of Indian indigenous knowledge takes place in schools after the short-learning programme?
5. To identify some of the tensions, if any, that may arise when Indian indigenous knowledge is integrated into the SA Life Sciences curriculum.
6. To delve into Life Sciences teachers' lived experiences of participating in the SLP, and the teaching of indigenous knowledge in the classroom?
7. To investigate the role of such an SLP in providing teachers with more nuanced understandings of Ayurveda as an indigenous knowledge system.

The aim, main research question, research sub-questions and objectives were all considered in order to devise the research design and methodology used in my study.

1.9 RESEARCH DESIGN

The overarching theoretical framework for my study was that of social constructivism, thereby necessitating the use of a qualitative research design. This enabled an in-depth view of teachers' response to indigenous knowledge and Ayurveda, as well as their views of the SLP. Qualitative research deals with "understanding the processes and the social and cultural contexts which underlie various behavioural patterns" (Maree, 2007:51).

1.9.1 Methodology and data collection

My study used a generic qualitative research methodology with elements of ethnography and phenomenology, framed within design-based research (DBR). Wang and Hannafin (2005:6-7) describe DBR as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories".

As indicated earlier, my study was situated within a larger research project for SDL which used DBR as a research methodology. My study was part of Cycle 2 in this larger study, having been informed by the design flaws in Cycle 1. The modification of these design flaws led to several design principles that contributed towards the development of the SLP for my study. The shortcomings from my study were refined and served to inform the SLP in Cycle 3.

Purposive sampling was used to include Life Sciences teachers in the SLP, and a total of 18 teachers eventually attended. Data gathering methods in my study included questionnaires, focus group and unstructured interviews, the SLP, portfolios from participants, and lesson observations. Each of these was coded, using the method described by Saldana (2009), to extract provisional themes. Eventually, the provisional themes gave rise to the major themes of my study.

Different data sources (structured interviews, lesson observations, artefacts such as lesson plans and policy documents, information obtained from attending a short course on Ayurveda in India, and response sheets from teachers) afforded a 'thick description' (Geertz, 1973) to enhance my study.

1.9.2 Research rigour

Validity and reliability are the two main concepts that contribute to research rigour. In qualitative research, reliability, in the form of credibility and dependability, is based on three main strategies: methodological coherence; researcher responsiveness; and audit trails (Miller, 2008:753). These were achieved through appropriate and thorough data collection strategies in which several sources of data contributed towards the thoroughness of the information received. The Methodology used was transparent and clearly explained.

Different types of validity were ensured in my study, including: construct validity; internal validity; external validity; reliability; and conceptual validity. Triangulation and crystallisation of data was also achieved by using multiple sources of data over a prolonged period of time. Triangulation of data also assisted to ensure the trustworthiness of this research.

1.10 ETHICAL CONSIDERATIONS

The larger SDL project had ethical clearance (NWU-00271-16-A2), although I also applied and was granted ethical clearance from the NWU Ethics Committee for my study (NWU-00358-18-A2). Written permission was obtained from the Department of Education. Participating schools and teachers volunteered their involvement. Their written consent was also obtained at the start of the SLP.

As the researcher, I maintained and respected the participants' privacy, confidentiality, and anonymity at all times during the study. All portfolios and journals submitted by the participants were returned after completion of the study, to ensure that these artefacts are not accessible to unauthorised persons. Participants were not harmed in any way during the course of the study, and they were not required to engage in any risky physical behaviour. They were also not expected to ingest any pharmaceutical products.

In their written informed consent, the participants were advised that their participation was purely voluntary and that they could withdraw at any time from the research without prejudice. Their wellness was protected throughout the study and appropriate feedback was given on the outcomes of the investigation after the culmination of the study. Lesson observations were not compulsory and teachers volunteered for researcher visits to their school.

1.11 CONTRIBUTIONS OF MY STUDY

1. To integrate Indian indigenous knowledge into the SA Life Sciences curriculum – this was the gap in the knowledge area identified, since almost all the studies on indigenous knowledge in SA involved African indigenous knowledge. Indians make up a sizeable percentage of the SA population, even though they are regarded as a minority group. Since their indigenous knowledge stems from the ancient source of Ayurveda and Yoga, it is appropriate to also consider indigenous knowledge from this population group. This study will, therefore, add to the body of knowledge on indigenous knowledge.

2. As much as possible, to document the indigenous knowledge and traditional remedies of the South African Indian people, as brought out by their forefathers (the indentured labourers from India in the 1800's), before it is lost forever.

3. To use the integration of Ayurveda in the Life Sciences curriculum as a means of educating people of all cultures on the holistic maintenance of good health of the body, mind, spirit, and the natural world of which we are all a part of. In this way, environmental health and sustainability can also be enabled – a necessary requirement for the continued survival of life on Earth.

4. To serve as a stimulus for Life Sciences teachers to pursue their own research into Indian indigenous knowledge, thereby contributing to the self-directed learning research area; and to encourage teachers to become lifelong learners.

5. From a methodological perspective, my study used CHAT in a unique manner where two activity systems were juxtaposed to show the contradiction of control between the SLP and actual implementation in the classroom by the teachers.

6. My study provided tools and resources for teacher professional development during the SLP. In an era of the ‘decolonisation of the curriculum’, and what Gibbons (2000) calls ‘Mode 2 knowledge production’, this study will contribute to our understanding of how to better contextualise school science.

1.12 OVERVIEW OF CHAPTERS

Chapter One

Chapter one provides an overview of my study, including some background on the topic as well as the motivation for undertaking this study. Also included are a brief literature review, research questions, and aims of the research. Some information is also provided on the research design, research rigour, and ethics of the study. The contributions of this study to the body of knowledge are discussed in the final sections.

Chapter Two

This chapter provides a comprehensive literature review of the theoretical and conceptual frameworks of my study. It contains a substantial discussion on the theoretical framework of social constructivism which gave rise to CHAT, the research lens for my study. Various concepts such as the NOS, NOIK, PCK and conceptual change are also explored. Indian indigenous knowledge, as well as indigenous knowledge locally and internationally, is explained in significant detail. The chapter also provides some history of the first Indian people who arrived in South Africa from India.

Chapter Three

A detailed account of the research design, methodology, data sources, sample selection, and coding methods is provided in this chapter. Research rigour and ethical considerations are discussed at length.

Chapter Four

This chapter presents the data gathered and the data analysis. An in-depth critical discussion for each data set and the provisional themes is presented with reference to the theoretical and conceptual frameworks used.

The major themes that arose from the data analysis are discussed with reference to how they address the research questions.

Chapter Five

The final chapter contains the conclusions, recommendations, contributions, limitations of the study, and suggestions for future research. It also contains my reflections as a researcher and Life Sciences teacher.

CHAPTER TWO LITERATURE REVIEW

2.1 INTRODUCTION

The aim of this study was to ascertain how Indian indigenous knowledge could be infused into the South African Life Sciences curriculum in order to enhance the teaching and learning of Life Sciences. Considering the current discourse on the 'decolonisation of the curriculum' or 'Africanisation of the curriculum', care should be taken not to marginalise certain cultural groups in the country. The departure point for this study is that all cultural groups represented in South Africa (African, Khoi-San, European and Indian) hold indigenous knowledge that can be utilised in the Life Sciences in order to enrich teaching and learning in multi-cultural classrooms. The focus of this study is on Indian indigenous knowledge, as captured in Ayurveda philosophy.

This chapter attempts to provide an in-depth literature analysis of the theoretical and conceptual frameworks that underpin my study. Social constructivism (Ernest, 2005.; Watts 1991), and Vygotsky's (1978) notion of the zone of proximal development (ZPD), form the theoretical framework of my study. Cultural-historical activity theory (CHAT) serves as a research lens in the study. Originally proposed by Vygotsky (1978), and further developed by Engeström (1987), CHAT has its roots in the 'grand theory' of social constructivism, and is used as a research lens through which to view the various dynamics in the activity system of Indian indigenous knowledge in the Life Sciences classroom.

According to Engeström (1987), a notable authority on CHAT, intermediate theories are necessary to enhance and provide a context for the interpretation of data gathered. These intermediate theories can be described as conceptual frameworks, which present lower hierarchical constructs within the social constructivist theoretical framework. The intermediate theories that have relevance to my study, and that will be examined in this chapter, include self-directed learning (SDL); embodied situated and distributed cognition (ESDC); controversial conceptual change (CCC); teachers' pedagogical content knowledge (PCK); the nature of science (NOS); and the nature

of indigenous knowledge (NOIK); as well as the tenets or basic theories of Ayurveda as an Indian indigenous knowledge system.

A short historical overview on the presence of Indians in South Africa is necessary to give my study context. Indians form a significant minority in the country since their arrival as indentured labourers more than 150 years ago, when they brought their rich culture and indigenous knowledge with them. A brief comparison will be made between Indian and African indigenous knowledge to show commonalities between the two. In addition, indigenous knowledge studies from other parts of the world, including Africa, will be dealt with in some detail.

Self-directed Learning (SDL) is an essential construct in my study since the short-learning programmes (SLPs) for the incorporation of indigenous knowledge into the Life Sciences aim to develop teachers into life-long learners. During the SLPs teachers were required to identify learning goals for their own professional development. Embodied, situated and distributed cognition (ESDC) is also an important construct, especially when looking at indigenous knowledge, as it is based on the knowledge that children develop as they grow up in a certain culture. During the SLPs, the importance of a contextualised curriculum was highlighted from an ESDC perspective.

Controversial conceptual change is discussed as it looks at the difficulty in reconciling existing worldviews with scientific views, which is necessary when looking at indigenous knowledge in the Life Sciences curriculum where people are often unaware that many indigenous knowledge practises have a scientific basis. This was dealt with during the SLPs when the tenets of the nature of science were compared with the tenets of the nature of indigenous knowledge, enabling teachers to include aspects of IK without fear of ridicule or scepticism from parents and the rest of the school. One of the goals of the SLPs is to assist teachers in such epistemological border-crossing between indigenous knowledge and ‘Western science’.

The focus of my study will be on Indian Life Sciences teachers and their pedagogical content knowledge that will determine the ease or difficulty with which Indian indigenous knowledge may be infused into the curriculum. Since my study involves the integration of Indian indigenous knowledge into the Life Sciences curriculum, the

key features of this vast field of indigenous knowledge will also be considered, starting with its origins in India. An important body knowledge and literature to be considered are the basic tenets of Ayurveda. For this reason, my promoter and I attended an intensive two week course at the Vaidyaratnam Ayurveda Foundation in Thrissur, Kerala, India, where we studied some of the classical treatises of Ayurveda, notably the *Charaka Samhita* and the *Sushruta Samhita*, under mentorship of expert Ayurvedic medical doctors. Both my promoter and I received certification in the principles of Ayurveda (see Appendix A).

The various intermediate theories mentioned above will be discussed separately in this chapter. However they have considerable overlaps with each other, which will be highlighted as the discussion proceeds. Since this is a rather lengthy chapter, a navigational tool in the form of a diagram is used to summarise the different sections and their relationship to each other (see Figure 2.1).

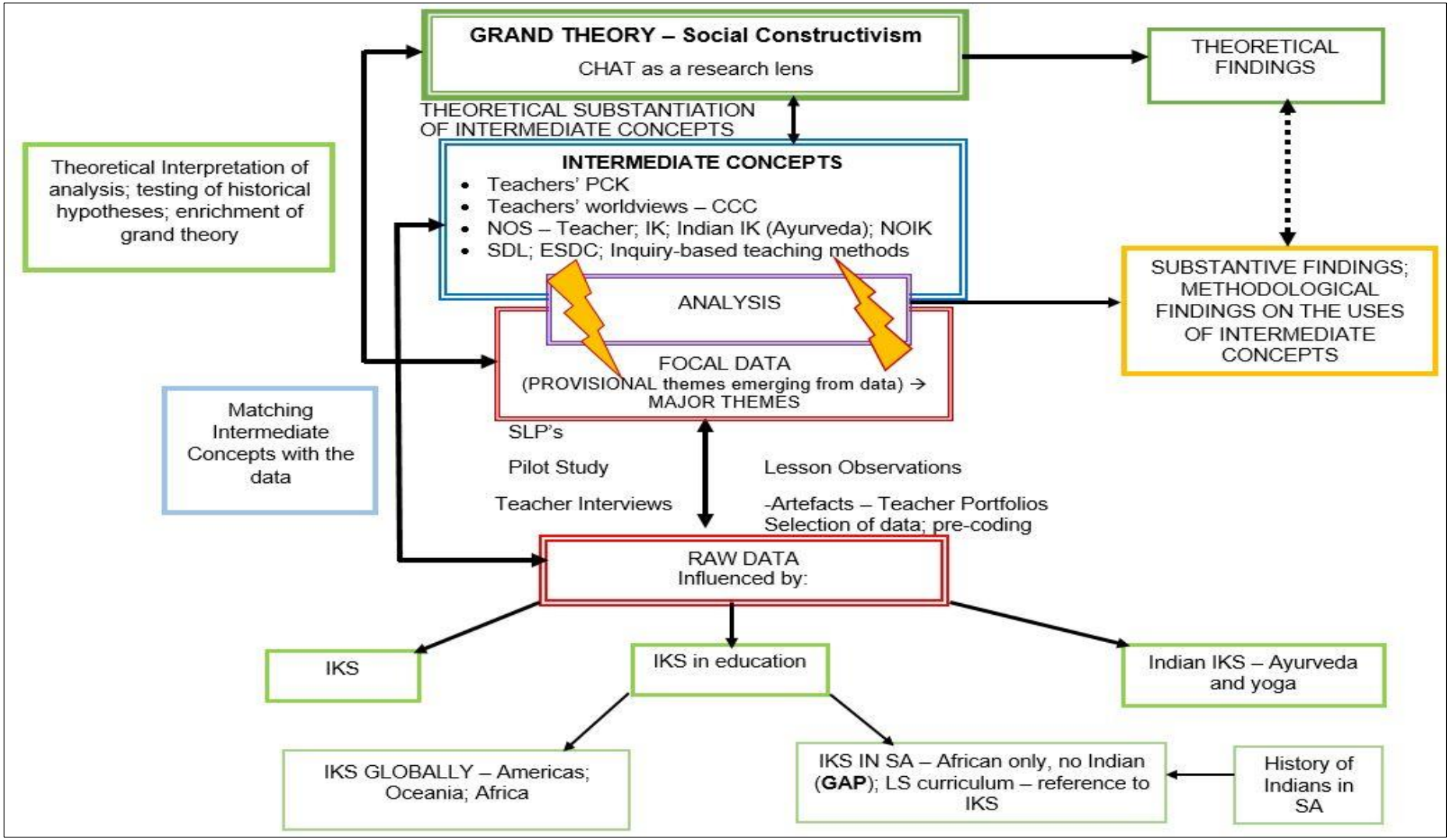


Figure 2.1: Navigational tool to position intermediate theories in relation to the contextual framework of cultural-historical activity theory (CHAT)

2.2 THEORETICAL AND CONCEPTUAL FRAMEWORKS

A theoretical framework is at a "higher level of conceptual organisation" than a conceptual framework (Jansen, 2008:1) and it uses a "grand theory…to explain a particular set of events". Sinclair (2007:39) writes that it "can be thought of as a map or travel plan". A conceptual framework on the other hand consists of one or more concepts linked together "to explain a particular event" (Jansen, 2008:1) while Jabareen (2009:51) defines it "as a network...of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena". In my study, the grand theory that is used is that of social constructivism with a focus on Piaget's theory of how learning takes place, and how to scaffold Life Sciences teachers' learning across the 'zone of proximal teacher development' (Warford, 2011). According to Piaget (1964) knowledge construction is an active process that makes learning and understanding active.

Social constructivism was chosen as an appropriate theoretical framework to guide this study on how learning in South African schools may be enhanced with the infusion of Indian indigenous knowledge into the Life Sciences curriculum. Indigenous knowledge itself is a social construct since it developed from a specific community of people and was passed on from one person to another in this community, as explained by Odora-Hoppers (2005:2): "Most of this knowledge and these skills have been passed down from earlier generations".

Social constructivism prompted another notable constructivist – Lev Vygotsky (1978) – to develop activity theory, which will be explained in greater detail later. In this chapter, I explain how learning should be scaffolded across the zone of proximal development, and specifically Warford's (2011) adaptation of this well-known Vygotskian construct. During the SLPs for teachers, their professional development was mediated. Cultural-historical activity theory (CHAT) was used as a lens to study the SLPs as an activity system. CHAT is made up of different elements such as an acting subject (the Life Sciences teacher); an object of activity (e.g. their professional development); tools and signs used in mediating the activity (e.g. problem-based learning activities); rules for the system (e.g. the CAPS curriculum, and the tenets of the nature of science and of indigenous knowledge); the community in the system (all the stakeholders); and a division of labour (roles of all stakeholders in the activity

system) with special emphasis on the roles of the teacher as a facilitator of learning, a life-long learner, and a critical reflective practitioner. A CHAT analysis enables unique insight into the multiple dynamics between the elements, which, in turn, serve to coordinate data received to construct meaning.

Although Piaget and Vygotsky were both constructivists, they had different views on how learning takes place. Piaget believed that learning starts with the individual and is determined by the physical development of their brain, which then leads to social development. Vygotsky believed that learning starts on a social level which then influences physical or internal development. Both these theorists are discussed further in this chapter.

The conceptual frameworks used in my study consist of the various concepts or constructs used to explain, interpret, describe and analyse the data received relative to the research questions. Extending the metaphor used by Sinclair (2007), who describes a theoretical framework as a road map, I look at the constructs of the conceptual frameworks as the rest-stops along the journey, which prompt the researcher to pause and examine data from different perspectives. As mentioned, these constructs include self-directed learning (SDL), pedagogical content knowledge (PCK), controversial conceptual change (CCC), the nature of science (NOS) and the nature of indigenous knowledge (NOIK) with an emphasis on Indian indigenous knowledge. The latter refers to the five basic principles or tenets of Ayurveda, as explained later in this chapter. According to Liehr and Smith (1999) these concepts form a route map for this study (as illustrated in Figure 2.1). The theoretical and conceptual frameworks are discussed separately.

2.3 THE THEORETICAL FRAMEWORK

2.3.1 Social constructivism

Constructivism is a theory of knowledge acquisition suggesting that reality depends on an individual's own constructs or perceptions. This is in contrast to the realism theory of knowledge that suggests the existence of an independent reality waiting to be discovered, rather than being subject to the individual's perceptions. Jean Piaget, one of the leading constructivists, stated that "the essential functions of the mind

consist in understanding and in inventing, in other words, in building up structures by structuring reality" (Piaget, 1971:27).

Piaget was interested in the cognitive development of children and he theorised that children develop intelligence through a series of four developmental stages from birth to adulthood (Von Glasersfeld, n.d; Cohen & Younghee, 1999). Piaget (1964:168) believed that "learning is subordinated to development", which means that the physiological development of the brain, and other parts of the nervous system, determine how and when learning will take place in a child. As a result, Piaget linked his four stage cognitive development to the physical development of children. Piaget, therefore, looked at the development of cognition in people based on their individual physiological growth, rather than on the influence of other people in their environment (Ginsburg, 1985).

Piaget's theory of constructivism, based on individual cognitive development, was in contrast to the behaviourist theories of psychology and cognition at the time. The behaviourists perceived knowledge to be a 'static entity' (Von Glasersfeld, n.d) waiting to be discovered, whereas Piaget, a constructivist, believed that individuals were actively responsible for their own construction of knowledge. Watts and Bentley (1991) take this idea further by explaining that knowledge is limited by what individual cognition can produce. Thus, knowledge generation is an active process that an individual is responsible for; and one of the ways in which active learning and in-depth learning can occur is if content is rediscovered by the individual (Ginsburg, 1985). According to Piaget (1964), this active learning occurs due to three important processes: assimilation, accommodation and equilibration.

Assimilation is when "people transform incoming information so that it fits within their existing way of thinking" (Siegler, 1995:1). This means that they do not change their thinking but try to fit new information into what they already know. This is usually the case where scientific information clashes with a person's world view forcing them "to abandon… his or her life-world concepts and reconstruct in their place new (scientific) ways of conceptualizing" (Aikenhead & Jegede, 1999:274). Such type of knowledge acquisition is also explained by Ausubel (1985:6) in the following way: "New information is linked to relevant, pre-existing aspects of cognitive structure and both

the newly acquired information and the pre-existing structure are modified in the process".

Therefore, new knowledge forms when new information is actively assimilated into their existing knowledge frameworks. In the context of my study, indigenous knowledge may be regarded as existing knowledge for many people who have grown up exposed to it. Scientific knowledge learned in the classroom can be regarded as new knowledge and, in order to make meaning out of this new knowledge, people need to actively integrate it into what they already know, in this case, indigenous knowledge, and more specifically, Ayurveda.

Accommodation refers to the ways in which people adapt their ways of thinking to new experiences" (Siegler, 1995:1), or as explained by Von Glasersfeld (n.d): "Accommodation occurs when experiences are assimilated but they do not fit with the existing knowledge framework". This then creates a 'perturbation' that must then change those new experiences. The process of accommodation occurs when teachers experience a conflict between their own indigenous knowledge and that of other cultures. Alternatively, they may experience conflict between what they know about indigenous knowledge and the scientific knowledge they studied. In both of these cases, the teachers in conflict may have to either change their existing knowledge framework to accommodate the new knowledge; or they can accept the new knowledge into their minds where it must then be accommodated.

Equilibration is the "overall keystone of developmental change within Piaget's system" (Siegler, 1995:2), and forms the hallmark of active and meaningful learning. It includes both processes of assimilation and accommodation, which leads to an interaction occurring between new information and existing ways of thinking. For equilibration to occur during the integration of indigenous knowledge into the Life Sciences curriculum, teachers should make sense of new (Indian indigenous) knowledge by using their existing ways of thinking about science; or by thinking about it using their own indigenous knowledge as a framework to understand it.

From the discussion above, it seems that equilibration is an ideal process to enable active and meaningful learning. However equilibration is not always smoothly achieved

due to the clash between prevailing worldviews and scientific knowledge. According to Hardy and Taylor (1997), this difficulty is due to accommodation depending, most often, on the profound influence of society and culture on people. Piaget's theory of constructivism in its pure form is, however, not ideal for my study as it tends to overlook the socio-cultural influences that indigenous knowledge is rooted in.

This particular criticism of Piaget's theory on how children learn is discussed in a paper by O'Loughlin (1992). According to this author, Piaget believed that children learn objectively through gradual "decentration" until they can construct "an abstract representation of reality" (O'Loughlin (1992:799). This conservative notion of Piaget is criticised because many other theorists, such as Vygotsky (1978:163) argue that learning first takes place on "the social plane, and then on the psychological plane." These detractors view intellectual development as a process of critically analysing the present reality with the intention of building current critical or other pictures of reality in order to enable people to "envisage and enact social transformation". The integration of indigenous knowledge into the school curriculum aims to transform learners so that they may relate more easily to scientific knowledge, thus enhancing their understanding and interest and thereby improving their performance in Life Sciences. The critical pictures of reality are, therefore, subjective ones rather than the objective views that Piaget proposed, where the social and cultural environment of children were disregarded.

Having pointed out this criticism, it is however important to mention that, even though Piaget regarded cognitive development as starting at an individual level, he credited society for advancing this development later on (Rogoff, 1990; Ginsburg, 1985). Von Glasersfeld (n.d) stated that Piaget did not ignore the role of social interaction, but gave it due recognition in accordance with one's physical development. Piaget was able to distinguish between the types of knowledge needing individual attention, which gave rise ultimately to those that depended on social guidance.

Piaget's theory of how objective learning takes place within the individual is in contrast to the theory put forward by Vygotsky who theorised that learning takes place by using social guidance to enable internalisation, which in turn allows individual cognitive growth (Rogoff, 1990).

This disparity between the two constructivists of how learning occurs is summed up concisely by Rogoff (1990:144): “For Piaget, development moves from the individual to the social, and for Vygotsky, development moves from the social to the individual”. This difference between Piaget and Vygotsky is clarified by Howe (1996) who explains that cognitive development, according to Piaget, is based on the individual’s internal level of maturation, while for Vygotsky this development is based on the external social world of the individual. Further discussion on Vygotsky’s ideas follows in the next section.

The grand theory of social constructivism, therefore, forms the theoretical framework of my study so that more sense can be made of how learning occurs when teachers are faced with new information (Indian indigenous knowledge) that may conflict with their existing (scientific) knowledge or their own indigenous knowledge. The converse may also occur when (new) school science knowledge may conflict with teachers’ existing indigenous knowledge. The process of meaningful learning depends both on the individual and on society, thus necessitating the use of both Piagetian and Vygotskian theories to direct my study. Piaget’s theory was already discussed in the preceding section. The next part of this chapter will focus on Vygotsky and the influence of society on learning.

2.3.2 Vygotsky’s ‘zone of proximal development’ and cultural-historical activity theory

Vygotsky is celebrated for his idea of the zone of proximal development (ZPD) which he defines as:

> The distance between the actual developmental level as determined by the individual problem solving and the level of potential development as determined through problem solving under expert guidance or in collaboration with more capable peers.
>
> (Vygotsky, 1978:86)

This definition can be represented diagrammatically as shown in Figure 2.2.

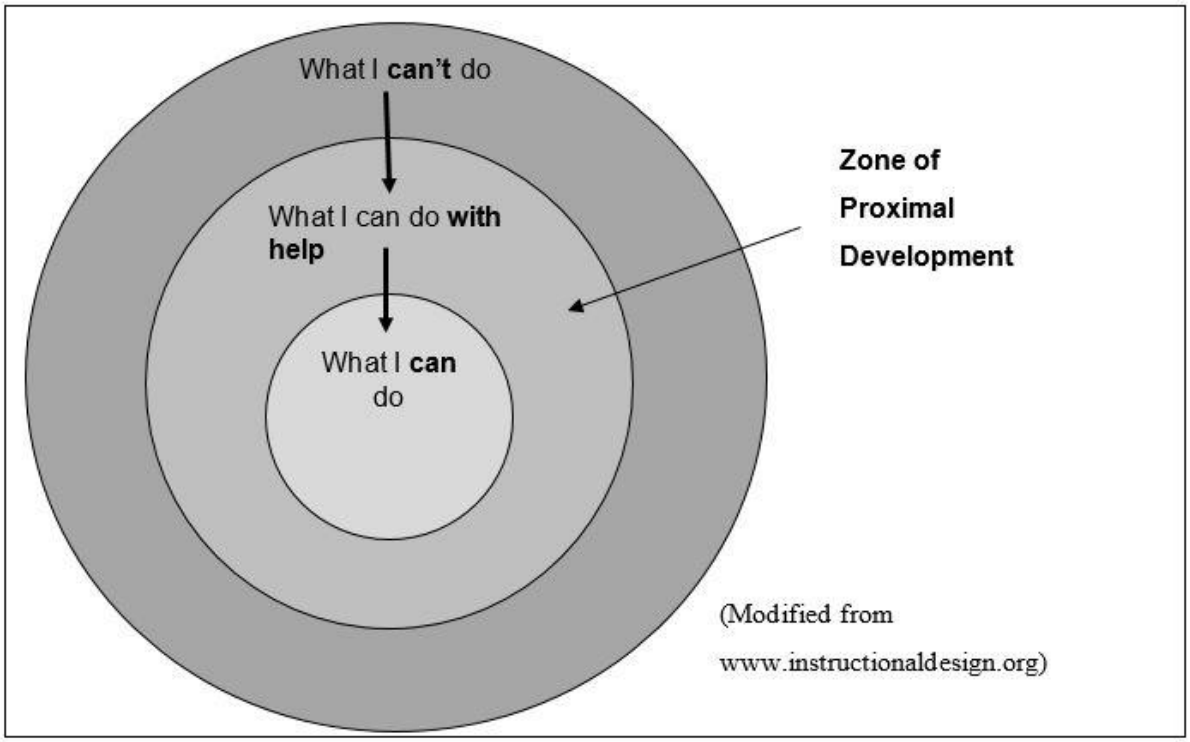


Figure 2.2: Diagrammatic representation of Vygotsky's ZPD

In my study it is necessary to look at the Vygotsky's notion of the ZPD because Life Sciences teachers participated in SLPs where they received expert guidance from more capable peers (course facilitators) to help them understand how to integrate Indian indigenous knowledge (Ayurveda) into the curriculum. Since these teachers received guidance from others, their training takes place on both a social or collaborative level, as well as an individual level. The teachers in turn were expected to use their new knowledge and skills in the classroom where they would act as the more capable adult and guide their learners from what they cannot do to what they can do with help.

This approach shows that Vygotsky (1978) draws from Piaget by acknowledging the importance of learning within the individual, while receiving help from others in society. Vygotsky regards this as the development of culture and it occurs on two levels: "First it appears on the social plane, and then on the psychological plane" (Vygotsky, 1978:163). He refers to the former as inter-psychological and to the latter as intra-psychological. This process of the social becoming the psychological is referred to as **internalisation** (Tharpe & Gallimore, 1991:2).

For Rogoff (1990), Vygotsky's main principle was that the internalisation of higher mental functions occurs from social interaction. In my study, Life Sciences teachers ought to have internalised these higher mental functions during their interaction with other teachers attending the course, and with the course facilitators, so that these functions could be applied in the classroom when integrating Indian indigenous knowledge into any part of the Life Sciences curriculum. The value of socio-cultural forces in intellectual development is also discussed by Hardman (2005:259) who states that Vygotsky attributes the "prior existence of complex cognitive structures as existing in the child's culture rather than in the individual child".

Vygotsky (1996) maintained that people's interaction with society creates a culture, which is then responsible for the generation of world views in those people. These world views are difficult to replace with other knowledge, and this makes the processes of accommodation, assimilation and equilibration more difficult. Furthermore, Vygotsky regarded social interaction as indispensable to individual cognitive function and to the "functions of assimilation" (Howe, 1996:43), further illustrating how Piagetian ideas were integrated into Vygotsky's socio-cultural theory.

Hardman (2008:66) uses the term "mediation" to describe the assistance that allows more learning to take place with assistance from more experienced others. According to her, mediation occurs on a social and cultural level. Life Sciences teachers, therefore, need to be well-trained and knowledgeable in order to effectively mediate the integration of Indian indigenous knowledge into their lessons. Of further relevance to my study, indigenous knowledge is usually passed on by means of mediation between older people who know, and younger people who are still learning, about their cultural practises. Thus the concept of mediation is of two-fold importance to my study.

I will specifically use Warford's (2011) application of the ZPD, namely the zone of proximal teacher development (ZPTD), as the short-learning programme for teachers was based on the four stages identified by Warford (see Table 2.1).

Table 1 Table 2.1: Scaffolding teachers' professional development during the short-learning programmes (based on Warford, 2011)

ZPTD (Warford, 2011): Stages in scaffolding learning	Sample of interventions/activities during the short-learning programme
Self-assistance	Prior knowledge and experiences of teachers teaching IK (and Ayurveda) in Life Sciences; World Café activity; teachers reflecting on their prior knowledge.
Expert-other assistance	Teachers were introduced to the principles of Ayurveda, and they engaged in a Kirby-Bauer technique to test the anti-microbial properties of Ayurvedic plants. Experimented with cooperative learning methods. Learning scaffolded by course presenters.
Internalization (automatization)	Journaling - teachers kept journals, in which they reflected on their own professional development. Teacher reflection - teachers needed to include reflections on their lessons in their evidence-based portfolios. After the SLP, teachers presented lessons on Ayurveda in their classrooms. Feedback provided by researchers.
Recursion (De-automatization)	Journaling by teachers; best practices shared on E-fundi (online forum); teachers assist each other and share best practices; class visits and portfolio submission.

Cultural-historical activity theory (CHAT) originated in the work of the Russian psychologist, Lev Vygotsky (Blunden, 2011; Stetsenko & Arievitch, 2004) and emerged from this work on the ZPD. In the scaffolding of learning, tools play an important role. This is further explained by Hardman (2005:259) who states that "every experience the child has is mediated by cultural tools". Vygotsky also believed that "artefacts mediate all human action"; that this mediation exists between the subject and object of action; and that this subject is usually an individual (Beatty & Feldman, 2009). An action for Vygotsky consists of three parts: a subject, an object, and mediational tools which humans use "to change the world and are themselves transformed through tool use" (Hardman, 2005:259). This Vygotskian stance shows learning to be transformative rather than only transmitted from teacher to learnerThe use of tools or mediating artefacts such as indigenous knowledge handbooks,

medicinal plants, and charts can be modified and improved through their use in the classroom while being used to include indigenous knowledge in Life Sciences. The use of these tools, therefore, serves to transform the curriculum by making indigenous knowledge a part of it. The three components constituting an action as described in Foot (2001) are represented as Vygotsky's first-generation activity triangle, shown in Figure 2.3. To summarise, Vygotsky's first-generation activity theory has been used to understand individual behaviour by analysing how "a person's actions upon objects are culturally mediated" (Beatty & Feldman, 2009:4).

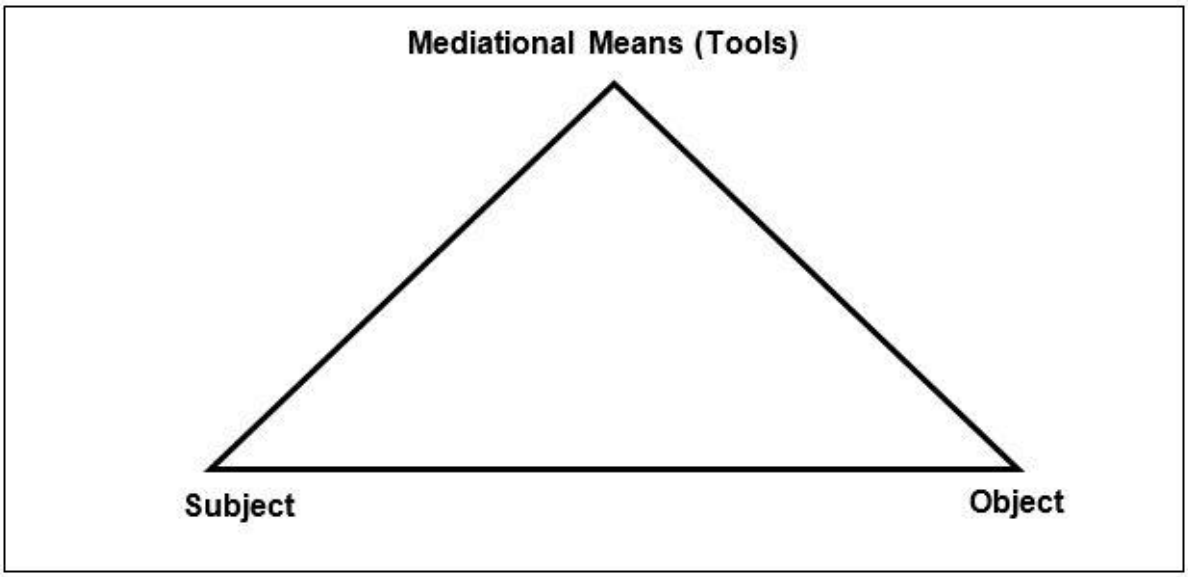


Figure 2.3: Vygotsky's first-generation activity theory (Engeström, 1987 in Beatty & Feldman, 2009)

This first-generation activity theory focuses on the influence of social and cultural tools on an individual's learning. Thus, the use of this activity theory enables an understanding of "learning as the complex result of tool mediated interactions" (Hardman, 2005:259) instead of regarding learning as an intangible activity that takes place in a learner's mind. However, it does not explain the response and contribution by the individual to the collective, collaborative activity of learning in society (Hardman 2005; 2008; Beatty and Feldman, 2009). This gap was then addressed by one of Vygotsky's students, Leontiev (1981) who developed the second-generation activity theory as illustrated in Figure 2.4.

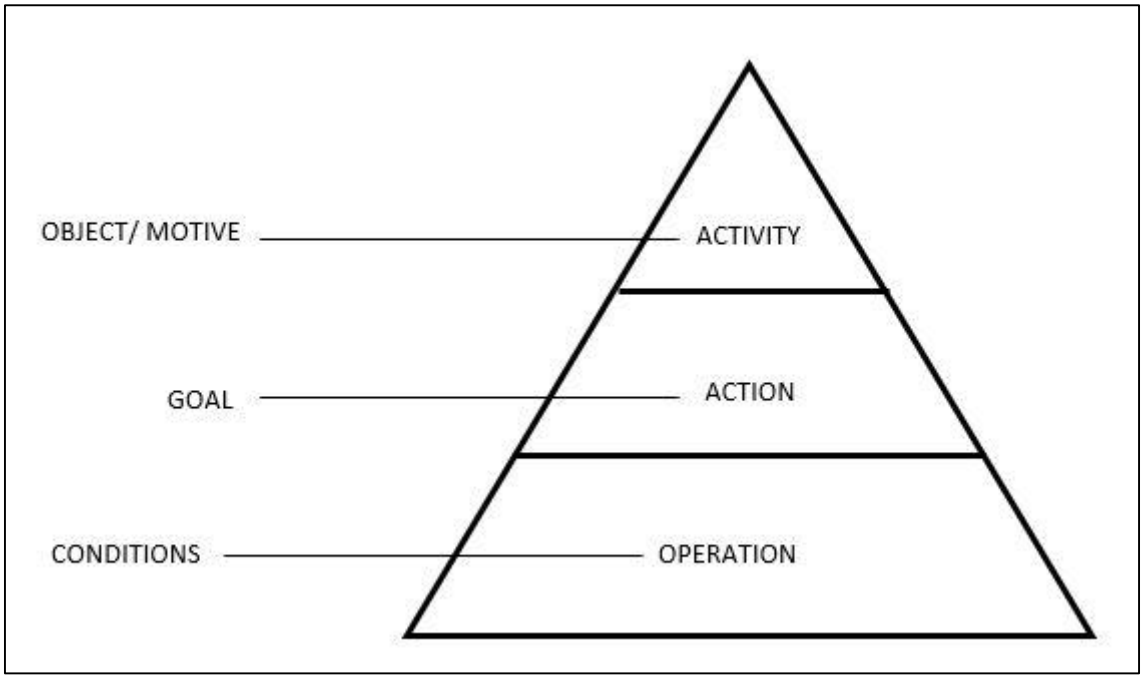


Figure 2.4: Leontiev's second-generation activity theory (Hardman, 2008)

According to Leontiev's model, "collective activity is object-oriented" and more enduring (Hardman, 2008:70; Engeström, 1987; Foot, 2001). However, he also believed that "an object is not an 'end'" (Foot, 2001:60) but uses the word 'horizon' to characterise it. This is a fitting analogy as it conveys the image of a horizon that can be seen but never reached; so to would an object be seen as the intended goal, but never be fully accomplished since it is re-defined and re-constructed constantly as the activity progresses.

The relation between the operation, action and activity of Leontiev's second-generation activity theory is aptly explained using an analogy suggested by Roth and Lee (2007:196). They compare these three facets to the inter-weaving of fibres into strands and eventually into thread – advancing from the microscopic to the macroscopic. Thread is tangible (macroscopic) just as an **activity** can be concretised through objects and motives such as lesson plans and curriculum implementation. However, strands are only noticeable upon closer inspection of the thread, just as the finer components of an activity system become apparent as concrete **actions** achieved through particular goals. On an even smaller scale are fibres, structures that can only be seen under a microscope, just as the concrete actions can only result from intangible **operations** arising from an unconscious level that cannot be easily seen.

To extend the analogy used in the previous paragraph: Just as fibres and strands are interwoven to form a collective thread, so too are the operations and actions inter-twined to result in a combined activity – once again highlighting the collective nature of an activity system (Roth, 2007). The relevance of a collective activity system to my study is evident on two levels: Firstly, Life Sciences teachers will benefit from collaboration with the facilitators during the short-learning programmes, who will guide them on how to integrate Indian indigenous knowledge into the curriculum. Secondly, the shared contribution of several generations of Indian people (and Ayurvedic texts such as the *Charaka Samhita* and *Sushruta Samhita*) forms the Indian indigenous knowledge base that provides the information used. Their shared perceptions and previous knowledge forms a background to the integration of Indian indigenous knowledge into the curriculum.

However, the second-generation activity theory of Leontiev does not completely account for this integrated, collective background that society brings to the activity system for individual learning. Instead, in his second-generation activity system, Leontiev added rules, a community and division of labour to the existing subject, object and tools from the first-generation activity model (Beatty & Feldman, 2009). Stetsenko and Arievitch (2004:489) clarify this notion of community by explaining that Leontiev's theory is based on the idea that individuals attain the "cultural norms and experiences of previous generations", which contribute to the collective nature of the activity system. This idea once again lends relevance to my topic on indigenous knowledge that is largely amassed from the "cultural norms and experiences of previous generations" (ibid).

The missing link from Leontiev's second-generation activity model was provided by Engeström (1987) in his third-generation activity theory. This is used most often and most effectively to show the development of an individual's actions in social collaboration with the aid of certain tools or artefacts (Hardman, 2008). According to Engeström, this social collaboration can only take place if there is division of labour among the community with rules to govern the actions of the subject towards an object (Engeström, 1987; Foot, 2001). Engeström places much importance on the object to give the system its permanency and states that "an activity system is built around its object" (Engeström, 1987:7). The third-generation activity theory is referred to as

CHAT by Engeström (Beatty & Feldman, 2009:4; Engeström, 1987:78) and it is characterised by the multi-directional two-way arrows showing the dynamic interplay between the six aspects mentioned above (rules, community, division of labour, subject, object, and tools). This activity model is illustrated in Figure 2.5.

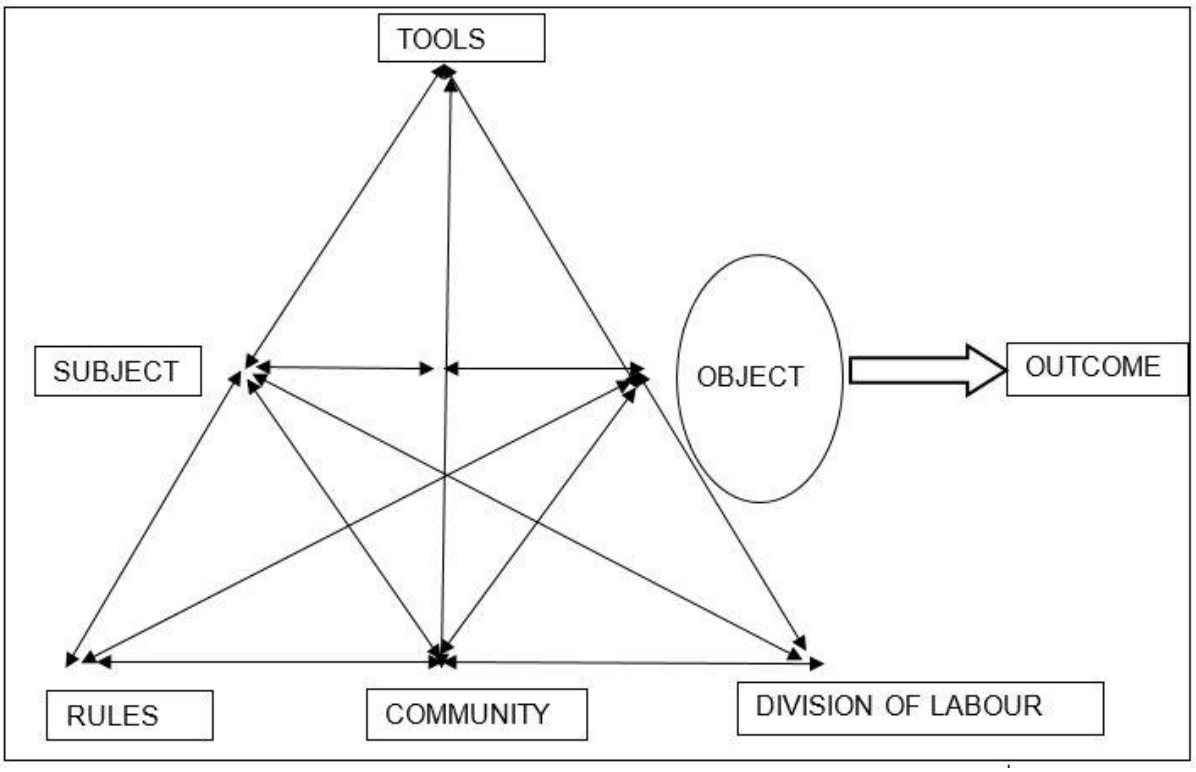


Figure 2.5: Engeström's third-generation activity theory (Engeström, 1987; Hardman, 2005; 2008:71)

This third-generation activity model shows a combination of the first- and second-generation activity models of Vygotsky and Leontiev, respectively. The merging of the two models shows the influence of the social on the individual as proposed by Vygotsky, who emphasised the role of society in the development of the individual. The upper part of the model in Figure 2.5 shows the action of the individual (subject) while the lower part shows the link between the individual's action with the collective, social aspect (Hardman, 2008:71) – almost as if the social aspect forms a foundation for individual development. Indigenous knowledge, therefore, forms a necessary part of a person's psyche because it originates and advances from a social level. The dynamic nature of this model is shown by the double-headed arrows, which indicate that this activity system is not static but constantly evolving.

In addition, the double-headed arrows also indicate the tensions or conflicts that are at play and contribute to the dynamic nature of this activity system. These tensions may be positive or negative and they strengthen the activity system. De Beer *et al*. (n.d) refer to these tensions as 'push' and 'pull' factors respectively. 'Push' factors are those that will encourage and enhance interaction in an activity system while 'pull' factors will restrict and prevent meaningful interaction in the activity system. According to Beatty and Feldman (2009) these tensions are one of the principles characterising CHAT, and they play a central role in motivating change and development in an activity system.

Foot (2001) emphasises that the conflicts in an activity system should not be regarded as signs of weakness to be overcome. Instead they should be regarded as allowing the development of an activity system by forming a link "between an activity system's present and its foreseeable future" (Foot, 2001:64) – thus functioning within the Vygotskian ZPD. The ability of an activity system to develop as a result of tensions is endorsed by Capper and Williams (2004:9), who regard disturbances in an activity system as "fundamental concepts" that act as "potential springboards for learning, innovation and development". In my study, which looked at the integration of Indian indigenous knowledge (as encapsulated by Ayurveda) into the Life Sciences curriculum, possible conflicts between various parts of the activity system are examined. This analysis is intended to contribute towards how and why Indian indigenous knowledge should be integrated into the Life Sciences curriculum.

The idea of social collaboration is examined in detail by Stetsenko (2008:480) where Vygotsky is cited frequently to confirm the importance of "social, collective activity" "at the centre of" human development. One of the key ideas of this article is that if humans work together collectively rather than in fragmented units, as they do currently, then the negative effects of humans on natural ecosystems may be alleviated.

Sustainable development, which will benefit all, should be practised rather than the selfish pursuit of self-gratification, as is the present trend. This idea is of great significance to both Life Sciences and to my research on indigenous knowledge: The Life Sciences curriculum looks at ecosystems and their conservation as a topic in schools, while one of the principles of indigenous knowledge involves humans existing

in harmony together and with the rest of the natural world, an ideal made possible through sustainable development, among other ways (which will be discussed later).

Stetsenko's view was also shared by Sir David Attenborough in a documentary *Planet Earth – The Future* (BBC, 2011) who said that "the one thing that can unite the people of the world is the common goal of nature conservation. It can allow us to move away from the gross materialism that is plaguing the world and towards spirituality and unity of people". Indigenous knowledge makes direct reference to this 'spirituality and unity of people' since it seeks to use natural resources sustainably so that "sensitive and caring values and attitudes are developed" (Osarome, 2011:1), thus fostering harmony among people and greater awareness of the spiritual rather than material world. This is also very true of Ayurveda since it states in the *Charaka Samhita* (*Sutra 1:46*) that the mind, body and spirit are "the tripod that constitutes man". Stetsenko (2008) concurs with the CHAT advocates that collaborative activity is what makes us human, thus emphasising the social nature of cognitive development as explained in Vygotsky's theory, i.e., that learning occurs from a social level to an individual level.

Jonassen and Rohrer-Murphy (1999) provide a few reasons why activity theory is used to study human actions as developmental processes both on a social and an individual level. They contend that activity theory regards learning as occurring due to activity or performance, rather than learning occurring as a precursor to activity as the idealists posit. These researchers also consider activity theory as a "powerful socio-cultural and socio-historical lens" used to examine most types of human activities within its particular context in society (Jonassen and Rohrer-Murphy, 1999: 62).

CHAT is also regarded as a realist theory used to methodically analyse social activity in context by emphasizing the most important factors affecting the activity and providing a language with which to analyse these factors (Cripps-Clark, 2014). Language has particular relevance to the continued existence of indigenous knowledge as indicated by Battiste (2002:17) who states that indigenous languages are structured by "their symbolic, verbal and unconscious orders". Battiste explains that indigenous children achieve academic success in communities where indigenous languages are "respected, supported and connected to elders and education"; and

that for a curriculum to be built on indigenous knowledge, the primary consideration "must be to respect Indigenous languages" (Battiste, 2002:18).

South African Indian people who were under the racially discriminating rule of apartheid were unable to impart their indigenous languages to their children in formal schooling systems; and were, therefore, expected to communicate almost exclusively in English, also foregoing much of their culture and tradition. This led to many Indian children losing their sense of identity as they adopted an increasingly Western lifestyle. An integration of Indian indigenous knowledge into school curricula would, therefore, contribute to teaching South African Indian children about their almost-forgotten culture.

Vygotsky was of the belief that "language and thought are interdependent in higher forms of mental activity such as learning high-school science" (Duran *et al*., 1998:314); and that language is able to mediate our thinking by arranging the ways in which we view reality, i.e., temporally, causally and spatially. According to these researchers, children obtain "both the conceptual meanings of scientific disciplines and the social power" (ibid) that goes with using an important cultural tool. This means that when children learn to talk, they acquire both the social nuances of language, as well as the meanings of the words they hear.

Odora-Hoppers (2005:6) recognises that "language plays a crucial function in that it contains the map of the land, the relationships to the energies and spirits of all living things". Indigenous people around the world have an intimate relationship between the language they speak and their culture, even holding the belief that "language is life" (Grayshield & Mihecoby, 2010:10). It is, therefore, important to realise the use of language as a necessary tool to study indigenous knowledge. Integrating indigenous knowledge into the curriculum will allow children to explore scientific thought by talking about it in their own cultural context.

Third-generation activity theory as conceived by Engeström (1987) regards the individual's actions as the central point of the activity system. The individual is in turn influenced by the many different facets of the activity system, viz., rules, division of labour, and the community itself. Hardman (2008) explains this interaction with great

clarity: The individual (subject) is able to operate on the object in order to achieve a specific outcome using certain tools. At the same time, the subject is directed by specific rules, the community of which they are a part of, and by a division of labour. The two-way arrows show the dynamic (active) nature of each item on the triangle, and how they are each able to influence the other – thus formulating the *activity* theory. The object is represented as a circle to show its fluid nature, and that it can be transformed in the activity system (Hardman, 2005). The object is, therefore, to be acted on such that its transformation moves the subject towards the outcome (Jonassen & Rohrer-Murphy, 1999).

As stated earlier, "an activity system is built around its object" (Engeström, 1987:7). Rogoff (1995) states that CHAT can be used on three planes, namely, the personal, the interpersonal, and the institutional or community plane. I will be using CHAT on the personal plane, by focusing on the teacher. An interpersonal plane perspective would look at the interaction between the teacher's facilitation, and students' learning. On an institutional plane, the subject is a system or a theory (Mentz & De Beer, 2017).

In my study I used CHAT in the conventional way, namely, on a personal plane with the 'object' being the integration of Indian indigenous knowledge into Life Sciences; acted on by the 'subject', which is the Life Sciences teacher; in order to achieve an 'outcome' of learning more about Indian indigenous knowledge (Ayurveda), as well as improved teachers' pedagogical content knowledge (PCK) on indigenous knowledge (e.g. the tenets of Ayurveda). For this to occur, certain 'tools' need to be used such as: teaching aids; textbooks; indigenous knowledge handbooks; Indian indigenous knowledge (Ayurveda and Yoga); laboratory equipment; and language. Teachers can neither achieve the outcome nor can they use the tools mentioned unless they are guided by a set of rules, the teaching community that they are a part of, and by a division of labour.

These various parts of the third-generation activity system specific to my study are depicted in Figure 2.6, and explained in greater detail thereafter.

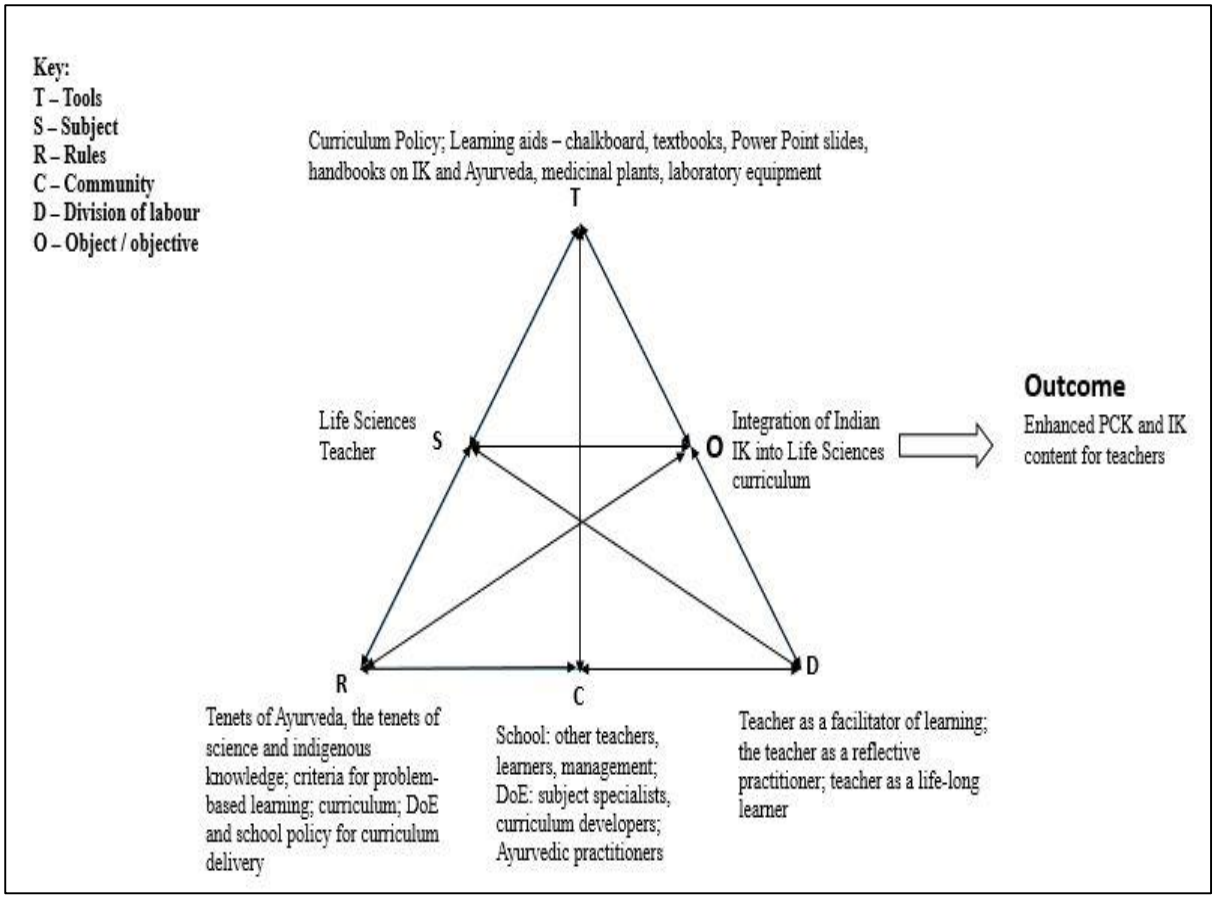


Figure 2.6: The integration of indigenous knowledge into the Life Sciences curriculum using the third-generation CHAT model to highlight tensions

As shown in Figure 2.6, the Life Sciences teacher is the 'subject' and is the focal point of the activity system. The subject needs to work on the infusion of Indian indigenous knowledge into the Life Sciences curriculum (object) so that their own pedagogical content knowledge and awareness of Indian indigenous knowledge systems can develop as the eventual outcome. Ultimately, this outcome ought to contribute to improved learner performance in the subject. However, teachers can only achieve this if they abide by the 'rules' laid down by various sectors such as the school, community, department of education (in the form of the curriculum documents), and Indian indigenous knowledge (such as Ayurveda and Yoga). Part of the rules would also be the tenets of the nature of science and of indigenous knowledge.

In the short-learning programmes, teachers were also exposed to cooperative learning and problem-based learning (PBL) strategies that could enhance self-directed learning. The basic principles of cooperative learning and criteria for PBL are,

therefore, also seen as rules in the activity system. These rules are not only for the 'subject' to follow, but they also apply to the 'community', which includes: other teachers; parents; elderly people learned in the traditional practises of Ayurveda and yoga; the learners themselves who enter the classroom with their own prior knowledge; the department of education officials; as well as the short-learning programme presenters.

Members of this community interact with each other as well as with the Life Sciences teachers such that 'division of labour' can occur, where teachers are responsible for imparting knowledge to the learners who, in turn, are responsible for internalising this knowledge and using it to advance their own understanding and worldview. Teachers also have the role of life-long learners since they attended short-learning courses where they learned how Indian indigenous knowledge (Ayurveda) could be added to the Life Sciences curriculum – with the desired result that these teachers are stimulated to continue learning about indigenous knowledge and its infusion into the curriculum. During the short-learning programmes there was also a strong focus on teachers' development as critical reflective practitioners. Teachers, therefore, have different roles to play as facilitators of learning, reflective practitioners, and as lifelong learners.

Department officials contribute to division of labour since they are required to facilitate curriculum delivery and implementation and, in doing so; they help teachers comply with the rules of the curriculum documents. One of the negative tensions arising from rules and the division of labour was encountered in a study conducted in the Eastern Cape by Letsekha *et al*. (2013:4580). These researchers found that teachers were 'fearful' about integrating indigenous knowledge into the curriculum as they felt they will be going against the education officials and the curriculum documents. Teachers had to be constantly assured that the integration was necessary and required as part of their curriculum delivery. The researchers felt that this fear impeded the robust inclusion of indigenous knowledge into the curriculum.

The 'tools' in this activity system were provided through various articles including: teaching and learning aids; laboratory equipment to test indigenous knowledge, for example, teachers engaged in an adapted Kirby-Bauer technique to test the

antimicrobial activity of *muthi* plants (and Ayurvedic plants that are available in South Africa) using inquiry learning approaches; textbooks; medicinal plants used in Ayurveda; handbooks on indigenous knowledge relevant to the curriculum; and the basic tool of language that teachers use to deliver their lessons and that learners use to internalise what they have learned.

There was also emphasis on cooperative learning and problem-based learning strategies. The quality of these tools and how effectively they were used by the teachers and other members of the community made a considerable impact on how successful this activity system was in achieving the intended outcome of enhanced teachers' PCK and their understanding of Indian indigenous knowledge.

In Chapters 4 and 5, I will be looking at the data through a cultural-historical activity theory lens. Engeström (2009:24) states that "in today's interconnected world, it is often useful to take two independent activity systems as the minimal unit of analysis". Such a stance would mean that two interdependent activity systems are juxtaposed (Mentz & De Beer, 2017). I will thus also be using CHAT by juxtaposing two activity systems: the short-learning programme as one activity system; and the teacher's classroom (where transfer needs to take place) as a second activity system. This will show what McNeil (2013) refers to as the 'contradiction of control'.

Social constructivism therefore forms the 'grand theory' or theoretical framework of my study. It forms a road map plotting the direction that my study takes since it examines how learning occurs, which is necessary when considering how teachers learn during the SLPs and how teachers mediate science concepts for their learners. The third-generation activity theory is derived from constructivism and is used as a theoretical lens with which to analyse the tensions, if any, that may develop in an activity system. In my study this would be the mechanism by which Indian indigenous knowledge can be integrated into the Life Sciences classroom. In my study, the theory of constructivism gives rise to several relevant intermediate concepts that form the conceptual framework. The conceptual framework is discussed in the next section.

2.4 THE CONCEPTUAL FRAMEWORK

2.4.1 Introduction

According to Lester (2005:460), “a conceptual research framework” is used to “highlight specific concepts and their interrelationships”. Whereas CHAT is my research lens, I see the conceptual framework (to continue the camera analogy) as the ‘filters’. There are several concepts in my study that look at how Indian indigenous knowledge may be integrated into the Life Sciences curriculum. In order to do this successfully, Life Sciences teachers received training on some methods of integration that can be used effectively in the classroom. It was anticipated that this would, in turn, result in teachers having enhanced teaching skills as well as knowledge of Indian indigenous knowledge. Ultimately, it was envisaged that this would lead to improved learner performance in Life Sciences.

These interrelationships involve several concepts, each of which will be discussed under the conceptual framework, and will also be viewed using the CHAT lens to show the tensions and interactions between them. These concepts include that of self-directed learning; embodied, situated and distributed cognition; conceptual change; pedagogical content knowledge; the nature of science; indigenous knowledge and the nature of indigenous knowledge; and the basic principles of Ayurveda as a knowledge system including a brief history of the Indians in South Africa. Each of these will be discussed further in the ensuing sections.

2.4.2 Self-directed learning

One of the aims of having Life Sciences teachers attend short-learning programmes on the integration of Indian indigenous knowledge into the curriculum was that these programmes encourage them to become self-directed learners. Self-directed learning (SDL) should encourage teachers to actively seek out other techniques and indigenous knowledge sources to embellish the learning process for their learners; since short courses cannot provide an exhaustive catalogue of indigenous knowledge techniques and information. It was anticipated that these teachers would then take responsibility for their own future pedagogy and learning.

This intention was in line with Knowles (1975:19) description:

> In its broadest meaning SDL describes a continuous process by which individuals take the initiative, with or without the assistance of others, in diagnosing own learning needs; formulating own learning goals; identifying own resources for learning; choosing and implementing own learning strategies and evaluating own learning outcomes.

Applying this definition to teachers in the short-learning programmes, they were expected to take the initiative to plan goals for their own professional development (based on self-assessment, and identifying shortcomings in their own knowledge and skills). They were required to plan for professional development activities and identify resources that would scaffold their own learning. They also needed to plan ways of determining whether they had achieved their own professional development goals. Teachers then had to plan their lessons (using tools such as curriculum documents) to ensure that they also enhance self-directed learning among their learners; decide on what their learners should accomplish at the end of a lesson or topic; choose their own resources to enhance their lessons; determine which learning strategies to use and reflect on the effectiveness of these techniques. It was anticipated that these activities would contribute to the development of self-reflective teachers and learners. Ultimately, the actions of a self-directed teacher should stimulate their learners to have a greater interest in the subject, and consequently enhance performance.

The explanation of SDL in the preceding paragraph can be seen on two levels: Firstly, that the teachers' own learning would result in more accomplished teachers; and secondly, that their learners become self-directed learners taking control of their own learning. Teachers in this context need to design lessons that will enhance SDL amongst their learners. The short-learning programmes were, therefore, intended to cultivate this culture among the teachers who attended.

In addition to SDL being useful in the training of teachers during the short-learning programmes, it is also envisaged that the SDL skills learned by the teachers attending will be passed on to their learners. The expected benefit of this is to create active learners who take charge of their own learning and can use SDL skills to become life-long learners. This would help to boost science and technology knowledge in the country (De Beer, 2015).

Knowles (1975) further states that “SDL is a process by which learners manage their own learning process from beginning to end”. Williamson (2007:67), describes self-directed learners as being proactive and taking “the initiative in learning rather than passively waiting to be taught as reactive learners”. The process of SDL has also proven “to be a highly effective method to engage and train adult learners” (Boyer *et al*., 2013:20). Self-directed learning, therefore, seems appropriate for the short-learning programmes in order to ascertain how teachers learn to integrate indigenous knowledge into the curriculum. This point is corroborated by the view that educators are “to ensure that students acquire self-directed learning skills” that can then be transferred from education to their work environment (Williamson, 2007:67).

Some characteristics of self-directed learners, as listed by De Beer and Mentz (2016), include: being self-disciplined; self-confident; goal-orientated; taking control of own learning endeavours; being aware that meaningful learning is one’s own responsibility; being motivated, curious and independent; and being willing to try new things. These characteristics were expected to develop in teachers attending short-learning programmes on the integration of Indian indigenous knowledge into the Life Sciences curriculum.

These features were also hallmarks of the short-learning programmes developed for teachers on the infusion of Indian indigenous knowledge into the Life Sciences curriculum. The programmes were specific for the subject and details of what teachers are supposed to do were clearly indicated; the activities were all linked and relevant to the curriculum; the duration of the programme was three days over a six-month period; and the programme offered teachers the actual tasks to be used in the classroom. All of these features were intended to motivate teachers to become life-long learners, particularly in the field of Indian indigenous knowledge.

It has also been noted that self-directed learning is “more meaningful and purposeful, with greater motivation resulting in longer retention” (Williamson, 2007:66). These are valuable outcomes of SDL to enhance science learning. However, it has also been found that there are certain prerequisites a person should have in order to want to use SDL such as: motivation, an internal locus of control, support, and self-efficacy. For teachers to want to engage in SDL, they should be motivated more intrinsically than

extrinsically; they should have a higher locus of control – meaning that they feel more in control of situations rather than letting external factors control situations around them. Teachers can hone their intrinsic motivation by becoming reflective practitioners, which in turn enhances their ability to feel more in control over certain situations.

According to Boyer *et al*. (2013:22), successful adult learning highlights the importance of support from peers and leaders. This has a direct link to the CHAT activity system that looks at the division of labour among other role-players such as the subject advisors, principals, course facilitators, knowledgeable elders in the community (leaders), and other teachers (peers). Support can also be found in the form of the tools in the activity system – such as text-books, indigenous knowledge handbooks, medicinal plants, curriculum documents, etc. Self-efficacy refers to a person's belief in their own ability to handle a particular situation successfully. A teacher can be empowered to teach certain topics in the curriculum by attending the short-learning programmes, which will in turn lead to them having greater self-efficacy and be able to engage in SDL.

Eventually it was anticipated that by using SDL as the overall context in which to conduct short-learning courses on the integration of Indian indigenous knowledge, the teachers attending would developed sufficient skills and the confidence to impart them to their own learners, who could in turn become self-directed and lifelong learners specifically in the field of science.

2.4.3 Embodied, situated and distributed cognition

This paradigm is of particular significance in the study of indigenous knowledge since it looks at how people express their knowledge and make it a part of who they are. According to Chahine (2016:54), "the overarching tenet of ESDC" is "that cognition is physiologically embodied, socio-culturally situated, and ostensibly distributed among individuals". The reference to socio-cultural context places this paradigm within the over-arching CHAT framework, further justifying its inclusion as an intermediate theory in my study. According to researchers Uzochukwu and Ekwugha, (2015:2-3), each society has its own culture that is "embedded in the way of life of a people transmitted from generation to generation either through written form or words of mouth". This affirms the embodied, situated and distributed notion of the ESDC paradigm.

Chahine (2016:54) uses mathematics to show how indigenous people can use their environment to enhance the skills and knowledge "which people in a particular geographic area possess". She explains further that students can use "multiple modalities" to enhance their learning of different "knowledge systems inherent in indigenous contexts" (ibid). This notion links indigenous knowledge to scientific knowledge, a significant link for the classroom, thus making it a relevant intermediate theory for my study on the infusion of Indian indigenous knowledge into the Life Sciences curriculum. Furthermore, Chahine's study reveals that indigenous cultures have a complex variety of ways in which they deal with knowledge; and that they share these ways with other members in their community, thereby distributing this knowledge.

Various researchers cited in Ramnarain (2008:3) highlight three main reasons for needing to integrate indigenous knowledge with science in the curriculum: firstly, this would show "the wisdom and values" of past generations of Southern African people; secondly, to allow sustainable use of ecosystems for communities, especially in rural areas, thereby enhancing "the quality of life of all South Africans" (ibid); and, thirdly, to enable "successful and meaningful science learning" (ibid) by improving cognitive development and understanding of scientific concepts. Indigenous knowledge could assist in making science more relevant to learners.

The first reason mentioned above refers to acknowledging the contributions made by elders in the community over many generations, by adding to the body of indigenous knowledge. Much of this knowledge involves using traditional remedies from locally growing plants; and it is important to document these remedies before they are lost from the oral tradition of a particular group of indigenous people. An example is the turmeric root that, apart from it being a culinary spice, has a host of health benefits such as its anti-bacterial properties for combating infections in the body (Singh, 2005:96; Ravindran *et al*., 2009:495) – once documented, turmeric can provide a cheap, accessible remedy.

The second reason given in the preceding paragraph is one of the hallmarks of "indigenous and local people [who] have practiced conservation for hundreds of thousands of years" (Claus *et al*., 2010:262). Sustainable use of natural resources

could contribute significantly in relieving the current “ecological crises” – the result of “narrow economic interests, unfair international policies, [and] mindless consumption” – so that more people can benefit from the resources on Earth (Stetsenko, 2008:488).

The sustainable development of communities can also be realised when the “prior knowledge or IK” of learners is integrated into the curriculum at school. This allows them to “better connect to material taught and can become a major knowledge source for their community’s sustainable development” (Srikantaiah, 2005:3). The task of ensuring that learners can better connect to the curriculum, by invoking their prior knowledge, contributes to the third reason why indigenous knowledge should be integrated into the curriculum. Learners who find relevance in what they are learning have a greater tendency to retain information, and are less likely to form misconceptions – an unfortunate side-effect of teaching scientific concepts while assuming learners hold no prior knowledge, i.e., are “empty vessels” (ibid). In addition, learners are likely to be more motivated to learn scientific concepts because they “feel ownership of the information they learn” (ibid).

The view that learners understand scientific concepts better if their prior knowledge is considered, is shared by Ramnarain (2008:6) who states that “successful learner achievement in science” depends on “recognising the social context of learning and the effect of the learners’ socio-cultural background”. The ESDC paradigm verifies that cognition is “physiologically embodied, socio-culturally situated, and ostensibly distributed among individuals” (ibid). This means that the neural connections in the brain (physiological) allow cognition of concepts while being framed by the learner’s socio-cultural history or experiences (situated).

The learner’s living environment allows the learner to embody certain units of information because the environment is an extension of the learner. The society, culture and environment of children allow them to learn by internalising information on a physiological or cognitive level, and then distributing this information among other members of the community. This emphasis on the influence of society on an individual’s cognitive development echoes the Vygotskian notion that children interact with more knowledgeable adults in society to develop their own potential across their zone of proximal development (ZPD). The influence of society on cognition is also

explained by CHAT, which attributes the development of higher mental functions (logical and abstract thinking, reasoning, etc.) to the influence of culture and society on an individual. Lower mental functions, on the other hand, are “completely biological by their origin” (Veresov, 2010:83).

As mentioned earlier, indigenous languages play a substantial role in the establishment of learners’ living environments since rituals and ceremonies allow them to learn the relationships and values featured in language (Battiste, 2002:18). One of the pitfalls of a Eurocentric curriculum for indigenous children is that it treats reading and writing as mechanistic processes rather than as active constructivist activities. This results in a suspension of their creativity and critical thinking (Battiste, 2002:20). Since a more constructivist approach was introduced to indigenous children in classrooms, it revived the development of problem-solving techniques and an appreciation for their rich heritage, thereby embedding literacy in social contexts. The constructivist model further established that meaningful learning occurs by considering the important role played by different life experiences and cultural practices. The ESDC paradigm (part of my conceptual framework), therefore, has links to the theoretical framework of constructivism and most directly to CHAT.

The use of the ESDC paradigm in my study helps to show that teachers need to consider the prior knowledge that their learners bring into the classroom in order to improve their understanding of scientific concepts. The teacher can then play the role of the more knowledgeable other in guiding the learner from their existing knowledge to what the curriculum requires of them. My study focuses on the South African Indian context, thereby necessitating the investigation of Indian traditional knowledge in the Life Sciences curriculum; and also delving into South African Indian society and its influence on the embodied and situated cognition of Indian children.

2.4.4 Conceptual change

In order to understand how teachers can successfully integrate Indian indigenous knowledge into the Life Sciences curriculum, it is necessary to include some discussion on the theory of conceptual change, another of the intermediate theories that make up the conceptual framework of the study. Vosniadou (2008) considers conceptual change as describing how concepts change with learning and

development in specific knowledge domains, and focusses on explaining students' challenges in understanding more advanced and counterintuitive concepts in these domains.

Based on the discussion on ESDC, it is evident that learners come into the science classroom with some prior knowledge rather than as 'empty vessels' or as 'blank slates' (Shulman, 1986:10) ready to receive knowledge. According to Van Dijk (2009:259) high school teaching should aim to develop learners' prior knowledge or 'pre-scientific conceptions' into the 'scientific viewpoint'. Pre-scientific conceptions are referred to as 'everyday concepts' by Vygotsky and as 'spontaneous concepts' by Piaget (Howe, 1996:38). Vygotsky, a social constructivist, explained 'everyday concepts' as being formed from a child's personal experiences and independent thinking while he referred to Piaget's 'non-spontaneous concepts' as 'scientific concepts' learned at school (ibid).

Conceptual change, according to Vygotsky, takes place continually where children constantly incorporate their everyday concepts into a logical system of related scientific concepts by interacting with more competent others, i.e., the teacher. The existence of everyday versus scientific concepts also has reference to Vygotsky's use of language as a mediating tool discussed above under Section 2.1.2. However, this process of incorporation is not a smooth one, as shown by a study where many learners continued to embed scientific concepts "in the context in which they were encountered in everyday life" irrespective of how carefully they received classroom instruction on these science concepts (Howe, 1996:44). This study shows that learners appear to place more importance on what they learn at home compared to what they are taught at school.

The implication of this for the integration of indigenous knowledge into the Life Sciences curriculum is the expectation that when children come into the classroom with their everyday concepts it might be easier to provide the relevant, corresponding scientific concepts for them to internalise and remember. This view is affirmed by studies in Ghana by Ngman-Wara (2015:168), who indicates that this link between learners' prior knowledge and classroom knowledge results in more meaningful learning as learners try to understand what they are being taught in the context of what

they already know. An interesting observation by a Native American teacher is that indigenous children often experience problems at school because educators have traditionally “attempted to insert culture into education, instead of inserting education into culture” (Ladson-Billings, 1995:159).

Vygotsky provides the following explanation for this dependence on everyday experiences to develop scientific concepts by reasoning: Everyday concepts progress in a linear direction from concrete situations to abstract events while scientific concepts develop “through mediation of already acquired everyday concepts” (Howe, 1996:39). Once again, Vygotsky’s ZPD is seen to come into play where concrete, everyday concepts act as a scaffold in helping learners understand abstract, scientific concepts. In this learning process then, the known is used to help understand the unknown, and this is regarded as an inductive process (Rudolph & Stewart, 1998). The scientific process is also referred to as an inductive process (Lovely & Kondrick, 2008). Learning the scientific process is, therefore, an inductive process where learners’ everyday concepts can be used to facilitate their understanding of scientific concepts. This is especially significant when investigating the integration of indigenous knowledge into the Life Sciences curriculum, since the former will contain everyday concepts while the latter contains scientific concepts.

While scientific concept development may occur in a linear manner, as described in the previous paragraph, children also learn them by moving in a zig-zag or back-and-forth manner between their everyday experiences and the scientific concepts learned, “fitting them together, discarding some ideas and accepting others” (Howe, 1996:48). Thus children apply the often intangible scientific concepts they are taught to concrete events they have experienced. This, in turn, will allow them to assimilate and understand these concepts as they will be using the known to understand the unknown. Everyday concepts are therefore passed on to children by the adults in their society through mediation in such a way that these concepts become embodied in their mind. Likewise, the child also needs to incorporate his/her everyday concepts into the scientific concepts learned at school, thereby moving from the abstract to the concrete and ensuring that movement occurs in both directions. This two-way movement is illustrated in Figure 2.7.

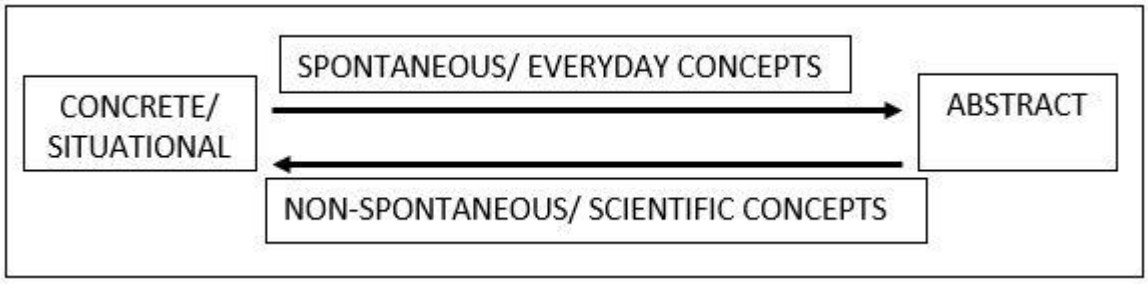


Figure 2.7: Schematic showing concrete to abstract development of everyday and scientific concepts in children (adapted from Howe, 1996)

Applying this to the integration of indigenous knowledge into the Life Sciences curriculum, it implies that, since many learners come into the classroom with everyday concepts, the teacher will need to mediate their understanding towards the scientific concepts. This process can add credibility to what is normally regarded as indigenous knowledge based on myth and superstition rather than on science. The role of the teacher is, therefore, one of a mediator who takes the learner from transforming their everyday indigenous knowledge into scientific knowledge.

This process of conceptual change is slightly different to what has been explained in Howe (1996:47) who describes the conceptual change model as follows: Learners have their own ideas about natural events, sometimes these are misconceptions. The teacher's role is to determine what these ideas are and then present learners with evidence to help them understand why their ideas are not scientifically correct. They can then better accept the scientific explanation by realising that their idea is not logical. Instead, in my study, the conceptual change model is where the teacher explains learners' experiences from home (indigenous knowledge) using scientific language and concepts, thereby attempting to integrate the two fields of knowledge. The misconception could be that learners regard their everyday experiences as not based in science, when in fact they could very well be!

In the past, socio-cultural factors were not considered in the learning process. This approach is called 'cold' conceptual change where, as postulated by Piaget, learning was considered to be an entirely objective and cognitive process (Vosniadou, 2008; De Beer & Henning, 2010). Vygotsky offered an opposing view with his "belief in the primacy of culture in shaping development" (Howe, 1996).

He, therefore, placed societal influence at the forefront of all cognitive development. His ideas took root and flourished such that, nowadays, the importance of socio-cultural, affective, and motivational factors are considered paramount in the learning process. This approach is called ‘hot’ or ‘warm’ conceptual change (Vosniadou, 2008; De Beer & Henning, 2010). Learning now becomes a subjective process with each child responding differently to what is taught, while also considering their emotions and interactions with their family and others in the community. As already discussed, the contribution of culture and society to the development of higher mental functions is emphasised by Veresov (2010) who also advocates the use of CHAT as a research tool.

This distinction between cold and warm conceptual change plays a crucial role in the integration of indigenous knowledge into the Life Sciences curriculum as children enter the classroom with the ‘warm’ everyday concepts influenced by culture and family, which will affect their learning of scientific concepts. Säther (2003, cited in Kyriacou, 2013) reinforces this view by stating that attitudes, social influences and perceived behavioural control are factors that influence the reasoning process, and bring about conceptual change. Like Vygotsky (Howe, 1996), Säther grounds conceptual change in “socio-cultural and social-cognitive interpretations and practical action”, which differs from the cold, objective, purely cognitive idea of conceptual change that existed in the past.

The notion of cold and warm conceptual change also includes the human constructs of emotion and motivation. Leontiev theorised that motive and emotion are fundamental to activity theory (Roth & Lee, 2007). They add that unmotivated learners are merely following different purposes from those laid out in CHAT, while motivated learners are those who comply with what teachers tell them to do, such that “the phenomenon becomes an internalization of the external locus of control” (Roth & Lee, 2007:214). This means that learners accept, by internalising, the teacher’s instructions that form the external locus of control. The concept of motivation and a higher locus of control were mentioned earlier where self-directed learning was discussed. Both teachers and learners can be affected by emotions and motivation, which are aspects of warm conceptual change that can promote learning.

According to these researchers, emotions “reflect relationships between motives (needs) and success”. They also acknowledge that emotion plays a focal role in scientific thought. They add that many CHAT adherents do not recognise the role that emotions play in the aims and objectives of learning. Indigenous knowledge is almost always associated with emotions since it has been amassed over generations, with deeply personal links to family, society, culture, and personal experience. It is, therefore, appropriate to include the affective domain in my study, since the emotions of Indian people, in particular, cannot be discounted or ignored when looking at how Indian indigenous knowledge can be infused into the curriculum.

This discussion on conceptual change has been twofold: firstly, I examined the notion of spontaneous and non-spontaneous concepts and how they influence each other through mediation to enable learning and cognitive development. Secondly, I looked at the idea of hot and cold conceptual change. In the approach known as hot conceptual change, cognitive development is considered most attainable when socio-cultural influences, together with emotions and motivation, are considered. Both aspects are relevant to my study, and are directly relevant to how teachers will deliver content that infuses Indian indigenous knowledge into the curriculum. The next part deals mainly with the aspect of content delivery by Life Sciences teachers.

2.4.5 Pedagogical content knowledge

My topic deals with how teachers integrate Indian indigenous knowledge (specifically Ayurveda) into the Life Sciences curriculum. Successful infusion of the two depends on the knowledge and skills that teachers acquire during their teacher training, and what they have developed since they graduated. Their level of knowledge and skill will impact the success of Ayurveda infusion into the CAPS curriculum and Life Sciences classroom, and how effectively such epistemological border-crossing will be facilitated. CHAT as a research lens (or a barometer for tension) will be able to identify positive or negative tensions in this regard (push-pull factors) as they arise in the activity system (De Beer *et al*., n.d). The previous sections deal with learning in general with some emphasis on how children learn, although the same principles can be applied to teachers.

Since pedagogy has a predominant role in this study, it is necessary to include pedagogical content knowledge (PCK) as an intermediate theory in this chapter, thereby contributing a further dimension to the conceptual framework of my investigation. Pedagogical content knowledge is a term that was coined by Shulman (1986) during his research into teacher education and the cognitive psychology of instruction. Of concern to Shulman was that teacher training did not include "how subject matter was transformed from the knowledge of the teacher into the content of instruction" (Shulman, 1986:6). There was a definite lack of attention to "the organization of content knowledge in the minds of teachers" and this he referred to as the "missing paradigm" (Shulman, 1986:6). A historical foray into teacher training reveals that, in the 1870's, the emphasis was on content knowledge. It was only in the 1980's that teachers were trained primarily in pedagogy. These days both content and pedagogy form part of a teacher-training programme.

Shulman (1986:8) asks how teachers "prepare to teach something never previously learned?" or "how does learning *for* teaching occur?" These are important and necessary questions for all teachers to address in the course of their training. The first question has relevance to my study since Indian indigenous knowledge has never been a part of the South African Life Sciences curriculum, and teachers have never been trained to teach it. The second question is more generic since it concerns teacher training in general for all subjects. Together with teaching something never before learned, Shulman (1986:8) also points out that teaching aids such as textbooks may further add to this shortcoming if they do not include full explanations or sufficient examples of those new topics. This is a known shortcoming of the inclusion of Indian indigenous knowledge into the curriculum since Life Sciences textbooks do not cover this area in any way, thereby adding a negative tension between 'tools', the 'subject' and the 'object' in the activity system described earlier. My study attempts to address this inadequacy by developing content that can supplement current textbooks, and assist teachers in integrating Indian indigenous knowledge into the Life Sciences curriculum.

Of further relevance to my study is Shulman's (1986) study on how teachers transform their understanding of a text into instruction that can be understood by their learners. Inevitably, a teacher's own culture, worldview, and beliefs will influence their

understanding of that text – which, in turn, will affect how the teacher views the inclusion of Indian indigenous knowledge into the curriculum, as it may differ from their own. This might contribute a negative tension in the activity system between 'subject' and 'object' as teachers might experience conflict between their own culture and what they have to teach. In an attempt to address these concerns, Shulman (1986) identified three types of content knowledge that teachers should have in teaching:

(a) Subject matter content knowledge
(b) Pedagogical content knowledge (PCK)
(c) Curricular knowledge

Subject Matter Content Knowledge is the structure of a subject and includes both the substantive and the syntactic structures. Substantive structures refer to the basic organisation of a subject into different topics so that the information is learnt in an orderly and logical manner. The Life Sciences curriculum (as per the latest CAPS document) in South Africa is divided into four strands, all of which are taught in Grades 10, 11 and 12. These four strands are: Life at the molecular, cellular and tissue level; Life processes in plants and animals; Environmental Studies; and Diversity, change and continuity. Topics within each of these strands is further organised such that they link onto each other and appear in progressively more detail in each grade. More about these strands will be discussed later in this chapter.

Syntactic structures on the other hand, refer to the set of rules that were used to amass information for a particular subject. In Life Sciences, like other sciences, the rules used are chiefly derived from scientific methods and the tenets of the nature of science. Teachers need to understand both types of structures in order to competently deliver well-informed lessons so that they "not only understand *that* something is so" but they also "further understand *why* it is so" (Shulman, 1986:9). An example to illustrate this point is that if teachers include the example of home-made cheese ('paneer' in Indian cuisine) to illustrate the effect of an acid on milk, they must also be able to explain why an acid such as lemon juice/vinegar is used to curdle the milk after it is boiled. It will not be enough to simply say to the class that an acid is used, they must also be able to explain why it is used, i.e., they require an understanding of the chemical reaction at the molecular level involving proteins and enzymes.

Pedagogical content knowledge (PCK) is explained by Shulman (1986:9) as "pedagogical knowledge which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge *for teaching*". This explanation encompasses the way in which a teacher is supposed to make learners understand what they are teaching, thus resulting in competent teachers. The article gives three aspects that teachers ought to know to be competent:

1. Typical difficulties that learners have when being taught certain topics, characteristic of their age and culture;
2. The preconceptions and misconceptions children have, also due to their culture and age; and
3. Customised approaches devised by teachers to ensure their lesson is understood well.

Having knowledge of these three aspects ought to encourage teachers to devise alternate techniques and strategies either from their own research or their own 'wisdom of practice'. Such teachers are self-directed learners taking responsibility for their own professional development. Barnett and Hodson (2001:430) also attribute teachers' ability to influence the curriculum by driving their own professional development and not depending on political forces that dictate the way in which a curriculum is to be implemented. Pedagogical content knowledge also includes the ability of teachers to detect any misconceptions that children may bring to the classroom, as well as methods of correcting these misconceptions, thereby acknowledging the conceptual change model where scientific and every day concepts may be in conflict. Content developed during my study intends to add to a collective body of knowledge that Life Sciences teachers can make reference to, thus reinforcing the view put forward by Barnett and Hodson (2001:433) that "individual teachers also draw on a store of *collective* teacher knowledge". This collective teacher knowledge is constituted mainly from the repertoire of more experienced teachers.

Barnett and Hodson (2001) highlight a few notable differences between these experienced or expert teachers and inexperienced or novice teachers. According to these researchers, the latter are more confident about their subject content and therefore use a content-laden approach to teaching in order to prepare their learners

for examinations. Expert teachers on the other hand are able to adapt their teaching methods to suit particular types of subject matter. In this way they develop their PCK. This is done by accessing four elements of context-specific PCK:

1. Knowledge of learners' existing understanding of concepts;
2. Knowledge of teaching/learning strategies, effective for particular subject matter;
3. Alternative ways of representing subject matter; and
4. Curricular saliency – that will allow a good teacher to determine what depth to teach the material in, and in what context to place it.

Other researchers who provide tangible differences between novice and expert teachers include Clandinin (1986, 1989); Johnston (1992); Carey (1986); Larkin (1983); Berliner (1994) and Schempp *et al*. (1998) (all cited by Barnett & Hodson, 2001:440). These researchers report that expert teachers have a wider, more accessible knowledge base because their information is organised more efficiently than novice teachers. Expert teachers can look at a problem or topic in depth since they have access to interrelated clusters of pertinent information and can use "more powerful overarching principles". Novices, however, access information superficially, in a fragmented manner, and use "means-end analysis". Experts are also able to operate at a more holistic, general and fundamental level compared to novices who look at issues individually and often do not see the bigger picture. Another important difference identified concerns the affective domain where expert teachers seem to be more responsible and emotionally connected to their decisions while novice teachers would rather abdicate responsibility for their decisions "citing precedent, student deficiency and regulation".

These insights into what differentiates expert from novice teachers offered my study a greater understanding of the teachers who attended the short-learning programmes, since they were at various levels of teaching experience. Novice teachers should be grouped with expert teachers to form communities of practice that enhance their professional development. It is expected that expert teachers will be in a better position to see the benefit of integrating Indian indigenous knowledge into the curriculum, as they have a global and more holistic view of the curriculum. They will be able to share their insights with the novice teachers, who may find it easier to accept the value of

indigenous knowledge when hearing it from their more experienced colleagues rather than from course facilitators.

The PCK of teachers involves both their cognitive and affective domains. Researchers such as Barnett and Hodson (2001) have ascertained that new ideas are incorporated into personal cognitive frameworks when the rationality of the idea, together with its impact on the affective domain, is considered. The idea must not just 'make logical sense', it also has to 'feel right' such that students have to be *comfortable* with it – comfortable in the sense that it meets their emotional needs and is 'culturally safe' (ibid). This means that a learner's 'social and cultural identity' have a significant impact on their learning. Research by Mavuru and Ramnarain (2017:8) showed that teachers who include their learners' indigenous knowledge into their lessons allow positive transformation of their PCK, and that teachers with knowledge of their learners' indigenous knowledge could then "support learners in trying to harmonise the conflict between learners' worldviews and science". This offers a justification for including Indian indigenous knowledge into the Life Sciences curriculum so that teachers can have some knowledge of the cultural beliefs and practices of Indian learners in their multi-cultural classrooms.

According to these researchers, "What is true for students is also true for their teachers", thus providing a reason for teachers themselves to recognise the influence of their affective domain when attending the short-learning programmes. They need to exercise emotional maturity and feel comfortable learning about different indigenous knowledge because "Knowledge that enables teachers to feel more comfortable in the classroom and to enhance their sense of self is likely to be embraced; knowledge that increases anxiety or makes teachers feel inadequate will almost certainly be resisted or rejected" (Barnett & Hodson, 2001:431). It is, therefore, imperative that the information provided on Indian indigenous knowledge makes teachers feel comfortable so that these new ideas may be welcomed and disseminated with the same sense of comfort and acceptance with which they were received.

The challenge of being unsure as to whose indigenous knowledge to include, including their own, faces many teachers when integrating indigenous knowledge into the curriculum in multi-cultural classrooms. A solution to this challenge is offered by North

American indigenous knowledge researcher Lowan (2012:77) who used his own indigenous background as a framework, then used other indigenous and Western sources to inform his knowledge base; thus respecting the other cultures in his research group while continuing to express his own perspective. This particular challenge, and suggested solution, illustrates that indigenous knowledge is not standardised, but instead is subjective and relative to an individual and their environment. The integration of indigenous knowledge is also, therefore, dependent on the researcher or teacher.

This affirms the need for teachers to have a sound knowledge of their own indigenous knowledge as well as that of their class, so that they are able to successfully integrate indigenous knowledge into their lessons both practically and theoretically. Battiste (2002:22) also points out that integrating indigenous knowledge with Western knowledge introduces the dilemma of whose knowledge is recognised in educational contexts. Her recommendation is that legislation should prescribe clear guidelines for the inclusion of indigenous knowledge into various aspects of advancing the success of a country, including the importance of respecting and protecting the rights of indigenous people. In Saskatchewan, Canada, indigenous leaders contributed at least one curriculum model of teaching to Grades 7 to 12 and, although not compulsory for schools to follow, this was a start to the integration of indigenous knowledge into the curriculum.

Curricular knowledge is the third group of content knowledge that teachers should have when teaching (Shulman, 1986). This author describes curricular knowledge as the range of materials available to deliver the curriculum, the curriculum itself, and the reasons to either use or avoid using some of these materials in delivering the curriculum. A good teacher is supposed to have knowledge of all aspects of the curriculum both horizontally and vertically. Horizontal or lateral curriculum knowledge entails the teacher knowing the relevance of topics being discussed in their subject, as well as in other subjects. This is known as cross-curricular links in South Africa. Using the example of indigenous knowledge as a topic in Life Sciences, a good teacher should know that there are also ways in which indigenous knowledge can be infused into other subjects such as mathematics, geography, history and technology. Vertical curriculum knowledge is knowledge of the same curriculum but at different

stages. A good Life Sciences teacher should be aware of what is taught in the subject across all the grades and not just the one they are currently teaching. This will enable the teacher to know what has been taught to form a foundation for the subject, and what will be taught in later years to stimulate learners' interest in wanting to pursue the subject in future years.

Shulman (1986) uses the analogy of a competent experienced doctor to illustrate what a teacher with good curricular knowledge should be like: Just as an experienced doctor will have a range of treatments for a patient, including alternative remedies in case the initial ones do not work; so too should a good teacher have a variety of techniques, methods and resources available to enable their learners' understanding of those topics. Such a teacher ought to have multiple ways or teaching styles to explain concepts in the classroom, and this will also cater for different learning styles that learners have. Teachers with strong curricular knowledge will also be in a better position to include information on indigenous knowledge from different cultures since they will have a range of teaching aids and strategies with which to convey this new information.

Whilst it is important to look at the theory behind PCK, it is also necessary to examine the basis of current teacher-training programmes, as these have a direct influence on the integration of indigenous knowledge into the curriculum. Currently in South Africa, there is a great deal of attention on decolonising the curriculum (Le Grange, 2015), so that the Western influence in the curriculum can be replaced by indigenous knowledge. Current teacher-training programmes, however, do not take this into account. Researchers Sanford *et al*. (2012) conducted studies into the integration of Canadian indigenous knowledge into teacher-training programmes and found that these followed a neo-liberalist or Euro-American way of teaching, which is not aligned to the integration of indigenous knowledge into the curriculum.

According to these researchers, this colonialist or neoliberalist method of teacher training considers the realism perspective of knowledge as existing to be learned, and then reproduced in different forms such as tests, projects and assignments. Students who have a better understanding of this knowledge, or who are able to remember it better, are then regarded as being superior to their counterparts who cannot, and will

score higher marks than them. Individual success becomes the goal of education and this pattern is perpetuated in the classroom with learners. The colonialist model of teacher training described has not evolved with the new generation of learners who live in a technologically advanced world with different challenges – challenges that the current education system does not prepare them for.

In order to cope with new situations in the current era, learners need to be taught by "teachers who are able to learn through adaptation and flexibility, [and] engage in meaningful experiences that connect to students' social lives" (Sanford *et al*., 2012:19). These new techniques that teachers ought to develop will allow the integration of indigenous knowledge to prevent "the repetitive neoliberal discourses that cut off students and their families through notions of individualism, power and mistrust" (ibid). According to these researchers, neoliberal teaching methods serve only to stunt the growth of all students including those of indigenous origin, while understanding methods of indigenous teaching may allow "educators to think about different ways of connecting with learners, valuing their knowledge, and helping them to move forward successfully into the world" (Sanford *et al*., 2012:21).

Sanford *et al*. (2012:21) draw an interesting comparison between neoliberal or colonialist ways of knowing with that of the more favoured indigenous or learner-centred ways of knowing. These differences show that the former will not facilitate the inclusion of indigenous knowledge into the curriculum because it is: "prescribed learning with pre-determined expected outcomes; teacher centred – teacher chooses what is to be learned; learning occurs silently in one location, the classroom; learners work independently and are monitored, corrected and evaluated by teachers; teaching and assessment are separate; focus is on a single discipline and culture is competitive and individualistic".

For indigenous knowledge to be made part of the curriculum, indigenous ways of knowing should be the model used in teacher-training programmes. According to Sanford *et al*. (2012:21), this model is in contrast to the neoliberal one because it has the following characteristics:

1. Learning is emergent;

2. Focus is on students and teacher interaction;
3. Learning happens in many locations in and out of school or the classroom;
4. Learning is noisy;
5. Students construct knowledge through gathering and synthesizing information;
6. Students work alone, in pairs or groups depending on the purpose of the activity;
7. Assessment is used in context to promote and diagnose learning;
8. Learners are guided to find their own solutions and answer their own questions;
9. Students evaluate their own learning, teachers also evaluate, teaching and assessing are intertwined;
10. Students have multiple opportunities for success and quiet recognition;
11. Students have some choices of learning activities and topics;
12. Approach is compatible with multi and interdisciplinary investigations; and
13. Culture is cooperative, collaborative and supportive.

These traits of the indigenous ways of knowing seem ideal for the inclusion of indigenous knowledge into the curriculum. However, in practice, this would be much more difficult to achieve since education systems in many parts of the world, including South Africa, are heavily prescribed and determined by policy. Therefore, in order to allow a smooth integration of indigenous knowledge into the curriculum, it will be more beneficial to institute a systemic overhaul of the current education system that is currently mired by neoliberalist tradition, such that indigenous education can be the means to understand “Eurocentrism as another form of knowing rather than *the* form of knowing” (Sanford *et al*., 2012:22).

Indigenous teachers are not inherently aware of the nuances, knowledge, language and relationships within indigenous knowledge. Instead they, like Western teachers, were also exposed to a Eurocentric education system both as learners and as teachers during their training (where indigenous knowledge was excluded). Indigenous language was, therefore, analysed and learnt according to Western linguistic structural models rather than according to the epistemological foundations of the indigenous language itself (Battiste, 2002:25). It is, therefore, important for the finer points of indigenous language and indigenous knowledge to be taught using indigenous pedagogies from “elders, knowledge keepers, and workers” in a society rather than from Western philosophies. In terms of PCK, this is a necessary

consideration, since it allows indigenous teachers to receive authentic training for them to be more effective in the classroom when integrating indigenous knowledge into their lessons.

In conclusion, PCK is an important component of the conceptual framework of my study since it involves teacher training in the different types of content knowledge that teachers ought to have to be effective and develop themselves professionally. These different types of content knowledge are subject matter content knowledge, PCK, and curricular knowledge. Together they contribute to teachers becoming more versatile in delivering curriculum, while also transforming them from novice to expert teachers. Indigenous ways of knowing would also strengthen the integration of indigenous knowledge into the curriculum, as it is a more learner-centred approach that acknowledges the role of learners' culture and background.

2.4.6 Nature of science

One of the hallmarks of an expert Life Sciences teacher is to be able to understand the nature of science (NOS) and transform this understanding into practice during lessons to benefit the learners. Shulman (1986) confirms this by explaining that the NOS is part of the subject matter that teachers should understand. According to this author, teachers should have an understanding of subject matter, pedagogy, and should also be able to convert this understanding into their teaching practice.

However, a study by Lederman (1999:916) revealed that "teachers' conceptions of science do not necessarily influence classroom practice" whereas "teachers' level of expertise, intentions, and perceptions of students", in other words teachers' PCK, played a more critical role in influencing their pedagogy than their conceptions of science. Science teacher training programmes should, therefore, consider structured and deliberate activities that allow teachers to develop techniques for their increased understanding of science; and how to apply this understanding to their lessons (Lederman, 1999). In doing so, teacher education programmes should emphasise "teachers' understandings of the nature of science and ways to translate these understandings into classroom practice" (Lederman, 1999:927). These actions will then enhance teachers' PCK and in turn increase the understanding of the NOS for both teachers and learners.

The understanding of the NOS has been shown internationally to promote scientific literacy among people and enable them to make informed decisions when scientific claims are directed at them, rather than immediately believing these claims without thought. With this in mind, the NOS has been included “as an educational outcome in the United States since 1907” (Lederman, 1999:916). The NOS forms part of the conceptual framework of my study for this reason, as it allows learners to be more circumspect when faced with indigenous knowledge that they are not able to trust. They will also be able to understand “socio-scientific issues, participate in decision-making processes, and appreciate science as part of contemporary culture” (Hanuscin *et al*., 2010), thereby becoming more scientifically literate. The NOS, as an intermediate theory in my study, will allow a comparison to be drawn later in this chapter with the nature of indigenous knowledge.

While there is no agreed upon definition of the NOS among researchers, the following by Lederman is one that is frequently used: “The nature of science typically has been used to refer to the epistemology of science, science as a way of knowing, or the values and beliefs inherent in the development of scientific knowledge” and has been cited in various research papers (Bell *et al*., 2000:564; Lederman *et al*., 2002:498; Vhurumuku & Mokeleche, 2009:97). According to Vhurumuku (2011), the NOS was regarded as scientific knowledge in the 1960’s and understanding the latter (scientific knowledge) implied an understanding of the former (NOS). At around the same time, a notion arose that an understanding of the NOS also existed if scientific process skills could be understood and performed, i.e., observing → hypothesising → data gathering → analysis of data → reaching conclusions.

Presently, neither of these two perceptions of the NOS is considered to be relevant to the NOS. This is because a person with science process skills may know how to perform experiments or research by simply following a written procedure, much like following a recipe in the kitchen, without fully understanding why certain steps are carried out. Similarly, another person may know how biological processes occur without understanding the values, beliefs and assumptions of science concerning those processes. For example, a person may understand the process of photosynthesis, with all its biochemical pathways, without understanding the value of protecting natural vegetation in ecosystems.

As mentioned earlier in this section, an understanding of the NOS increases scientific literacy in the populace so that they may be more mindful about issues of direct concern to their lives involving science and technology. Vhurumuku (2011) elaborates on this reason by describing how scientifically literate people would be more capable of deciding, for example, on which toiletries to buy based on the chemical composition of these products. They would also know which foods to buy for their good health; how to avoid contracting certain diseases such as tuberculosis, malaria, HIV, etc. On a broader scale, scientific literacy should make people more environmentally conscious, so that they understand how their actions can harm the environment.

In addition, people who understand the NOS will also be more critical and less accepting of scientific research that may not benefit everyone. Governments around the world allocate hefty budgets for science and technology research, mostly for warfare, new medicines and space exploration (Vhurumuku, 2011) – aspects that may not benefit all citizens whose taxes are being used. Scientific literacy should, therefore, make taxpayers question the need to do this, thus serving as a watchdog for their governments who will no longer have free rein in spending money on such research. An understanding of the NOS as learnt at school, should therefore create a more discerning society with the ultimate aim of achieving healthier people and a healthier environment. Coupled with the understanding of the NOS, is the integration of Indian indigenous knowledge into the curriculum, for learners to follow a healthier lifestyle by observing particular habits.

2.4.6.1 *The tenets of the nature of science*

The NOS has the following seven tenets that are applicable to school science (Vhurumuku, 2011; Lederman, 1999; Bell *et al*., 2000):

1. Science is empirically based (derived from observations of the natural world);
2. Scientific knowledge is tentative (subject to change) yet durable;
3. There is a difference between observation and inference;
4. Scientific knowledge is theory-laden, yet partially subjective;
5. Imagination and creativity play a role in science, involving the invention of explanations;
6. There is no single scientific method; and

7. There is a difference between a law and theory.

Science is empirically based (derived from observations of natural world): This tenet implies that scientific claims should be substantiated by evidence obtained, either through observation or experiment. However, the availability of evidence does not make scientific claims irrefutably true and rigid. An example of this could be the geocentric model of the solar system that existed centuries ago because evidence suggested that the Earth was stationery while the sun and other heavenly bodies moved around it. This model had to change to the heliocentric model when astronomy revealed evidence to the contrary. The invention of the telescope allowed new evidence to be observed that eventually installed a new model in place. Thus, technological development and inventions offer greater opportunities for discovery or observation, causing initial claims to be modified, improved or completely refuted. This gives rise to the next tenet of the NOS, that science is tentative yet durable.

Scientific knowledge is tentative (subject to change) yet durable: This tenet considers that scientific claims that were once supported by significant amounts of data may change based on new evidence. This is in contrast to how many learners regard scientific knowledge, i.e., as undisputable truth devised by scientists that cannot be interfered with. Aflalo (2014:299) found that pre-service science teachers also shared the view that scientific knowledge is "objective and permanent, revealing the absolute truth and tending to flawed idealization of science". This tenet allows for the possibility of changing a scientific claim based on new evidence that may come to light, often as a result of other scientists' research or advancements in technology.

Vhurumuku (2011:31) explains that scientific claims are verified based on "the most accurate model…available at the time"; and are "not necessarily an exact representation of reality". The durable nature of scientific knowledge comes from the substantial amount of evidence amassed at the time for a particular claim, while the tentative nature is the possibility that it is not irrefutable. Alternatively, the tentative nature can be ascribed to the constructivist theory that posits the formation of knowledge based on an individual's perception of a phenomenon. Different scientists will, therefore, have their own account for a phenomenon for which they gather relevant evidence. This also implies that scientific knowledge is not a body of

knowledge waiting to be learned, as realists believe. The tentative nature of science is also applicable to indigenous knowledge, which is dynamic and changes over time, because knowledge itself is dynamic and constantly evolving as “new challenges” arise (Maila & Loubser, 2003:11).

There is a difference between observation and inference: According to Vhurumuku (2011) observations are made using the five senses while inferences are deductions or conclusions made to explain these observations and “are not directly accessible to the senses” (Lederman *et al*., 2002:500). Many different inferences can be made from one observation. Inferences are made based on the background knowledge, prior training, personal beliefs, social and cultural context, and experience that a scientist has. This point also shows that conceptual change in science is ‘warm’, rather than ‘cold’ and purely objective. According to Vhurumuku (2011:30), there is usually “a logical link between a scientist’s observations and the inferences they make”. This three-way interplay between observation, inference, and background knowledge is represented in Figure 2.8.

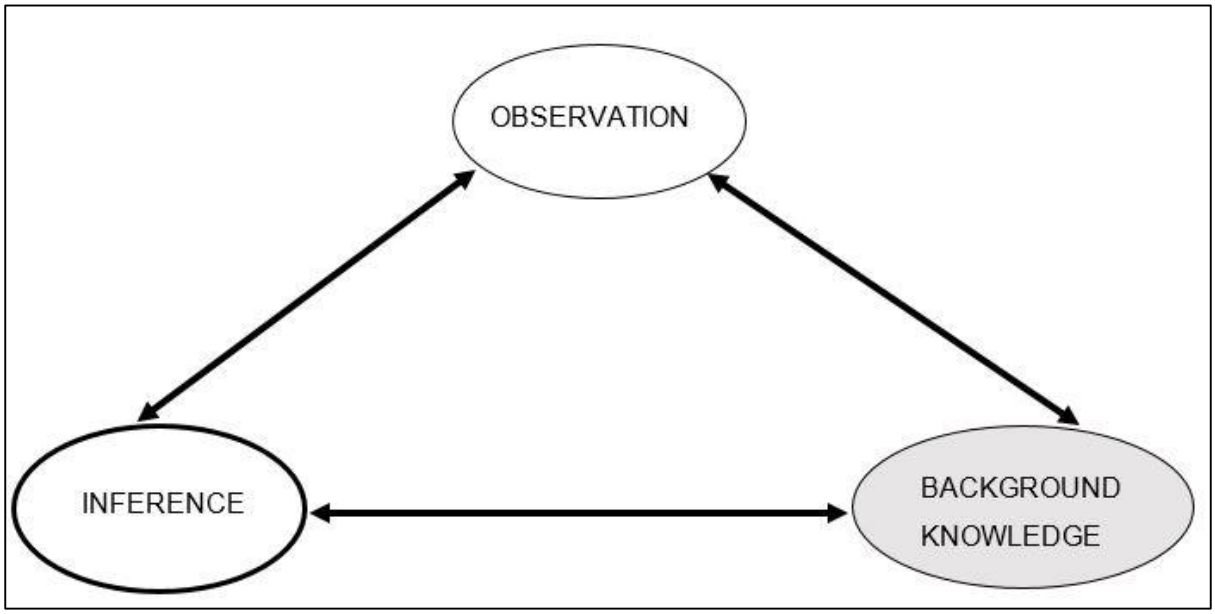


Figure 2.8: The relationships between observation, inference, and background knowledge (Vhurumuku, 2011:30)

Background knowledge is also socially and culturally dependent, thus establishing two of the NOS tenets (3 and 4) as relevant to indigenous knowledge, and providing justification for the inclusion of the NOS in my conceptual framework.

Scientific knowledge is theory-laden, yet partially subjective: Suppe (1977) defines scientific theories as well-established, highly substantiated, internally consistent systems of explanations, while the subjectivity in this tenet is the result of the background knowledge that a scientist has. Scientific theories cannot be tested directly as they are usually based on a set of assumptions that speculate "the existence of non-observable entities" (ibid). Further discussion on theory follows in Tenet 7.

Although theories serve to corroborate scientific knowledge, it is unavoidable for some bias to influence the explanation for particular claims, as these claims are influenced by the scientist's prior knowledge and experiences. These claims are also influenced by social and cultural background (Lederman *et al*., 2002), thus linking to my study on indigenous knowledge, which is also socially and culturally constructed. Once again, this personal dimension establishes the 'warm' conceptual change aspect of scientific knowledge construction. These influence what is observed since as Vhurumuku (2011:31) explains, "An observer…tend(s) to 'see what you want to see' and…concentrates less on what is not important". This subjectivity further supports the constructivist idea that knowledge is constructed by the individual who is influenced by their own experiences and perceptions.

Dagher (2014:205) compares the historical with the philosophical perspectives of science "to help students understand science as a human endeavour", thus also referring to the social and cultural evolution that broad scientific ideas undergo to become more easily accepted by the scientific community. This adds impetus to the above discussion on the subjective nature of scientific knowledge.

Imagination and creativity play a role in science; involves the invention of explanations: The tenets discussed so far show that the process of gathering scientific knowledge is not a 'cold' process, but dependant on the subjective inferences made by scientists following the constructivist pattern of knowledge formation. This

fifth tenet supports earlier tenets with regard to the 'warm' constructivist nature of knowledge formation, as it entails scientists using their imagination and creativity when drawing conclusions and arriving at explanations for their observations and experiments.

Scientist may even propose ideas that initially "appear to be absurd, fantasy, trances or dreams" Vhurumuku (2011:31). Lederman *et al*. (2002:500) confirms this view by stating that science is anything but "a lifeless, entirely rational, and orderly activity", but that most models and theories are actually conceptions that arise from scientists' creativity and imagination rather than being "faithful copies of reality" (id). The last quote echoes traits of realism, which is what science is not. The constructivist notion of scientific knowledge was confirmed in a study on pre-service secondary school science teachers conducted by Bell *et al*. (2000:570). These authors found that most of the teachers realised the value of their creativity and subjectivity in the construction of scientific ideas. Vhurumuku (2011) uses the following analogy: Just as an artist can use his/her imagination to create a piece of art, so too can scientists tap into their creativity and imagination to construct scientific theories and knowledge.

There is no single scientific method: Several science textbooks portray what is known as the scientific method as the only way that scientists conduct research. The scientific method is an inductive one that is represented as a linear sequence of specific steps that scientists follow as they would a recipe:

Observation of a phenomenon → formulate a problem/question → devise a hypothesis → design experiments to gather data → make relevant observations or measurements → interpret/analyse these observations or measurements → draw conclusions → report on findings (adapted from Vhurumuku, 2011).

However, this is a misconception, since although the steps can be followed they are not adhered to in a rigid sequence (Lederman, 2002:501). This author also states that "there is no single scientific method that would guarantee the development of infallible knowledge" (Lederman, 2002:501). Bell *et al*. (2000) asserts that scientists do not work as if they are following a recipe. Instead they work in a back-and-forth or 'zig-zag' fashion where they constantly try out new methods, ask different questions, re-

interpret results and sometimes even come across answers by sheer luck (Vhurumuku, 2011). This manner of formulating scientific knowledge is enhanced by the scientist's values, background knowledge, culture, previous experience, as well as their imagination and creativity, as described in Tenet 5.

There is a difference between a law and theory: Another misconception in science is that many people regard laws as widely held, established theories when theories and laws are actually separate types of knowledge (Vhurumuku, 2011; Bell *et al*., 2000). A rudimentary difference between a scientific law and a theory is that the former describes "what happens while the latter explains why and how things happen" (Vhurumuku, 2011:33). In other words, scientific theories can be regarded as explanations, and laws as observations of phenomena. This author suggests that many theories can be used to explain one observation since different researchers create their own theory informed by their values, beliefs and culture.

Bell *et al*. (2000) state that inference from certain types of evidence can be used to validate theories. This is in contrast to laws which, as mentioned, can be based on directly observable evidence and phenomena. In Life Sciences, Darwin's theory of evolution by natural selection offers an explanation for the biodiversity on Earth. However this cannot be proved directly but can be inferred by observing how organisms change over time using multiple strands of evidence such as palaeontology, molecular biology and biogeography. The Life Sciences CAPS document and many approved textbooks (such as Isaacs, *et al*., 2007) provides an alternative explanation for the biodiversity on Earth as Intelligent Design which credits an intelligent designer with creating complex life forms, and which also cannot be proved directly. Indian indigenous knowledge offers an explanation using Hindu scriptures (the Vedas) for the biodiversity on Earth – this has given rise to Avataric Evolution, a concept explained in considerable detail in Reddy (2012). Thus, the values, beliefs and culture of a group of people have been used to suggest how different life forms on Earth came to be.

2.4.6.2 *The Value of the NOS in Life Sciences*

At the start to this section on the NOS, two reasons were mentioned for the benefit of including the NOS in school curricula. The first of these was to create a more

scientifically literate populace who would be better informed in their daily lives concerning what foods to eat and what toiletries to buy. The second reason was to stimulate in people the need to critically question issues such as pharmaceutical testing, space travel, and warfare – since these are science-based and have a direct effect on them.

After considering the seven tenets just discussed, a further advantage of the NOS would be to offer people the liberty of making their own decisions after considering all possible evidence including their own values and cultural background. The pre-service science teachers in the study by Bell *et al*. (2000) provided the following additional benefits to why they believed the NOS should be included in school science curricula: They felt that the NOS would make the teaching and learning of science more interesting; that it is the means for critical thinking and problem solving; and that it is a more reliable method for understanding science and the construction of scientific knowledge. These teachers reiterated the first advantage mentioned in the previous paragraph – that the NOS promotes a scientifically literate society who will be better informed to make rational decisions. Aflalo (2014) adds that understanding the NOS would also make the learning of scientific subject matter easier.

Dagher (2014) uses her paper on Mendelian laws to motivate for teachers to understand the nature of biology. She explains that this would help them appreciate the growth of scientific knowledge that they can in turn convey to their learners. She suggests that teacher training should emphasise the use of "theories, laws and models as explanatory tools" (Dagher, 2014:215). Furthermore, frequent reference to these knowledge forms should stimulate discussion and achieve "metacognitive depth to learning" (Dagher, 2014:215) so that student teachers can think about the knowledge they will use to teach their learners. She explains that this will not mean including more theories, laws and models in the curriculum, but will rather enable understanding what these do and how they can be used to explain phenomena and predict outcomes (Dagher, 2014).

In teacher-training programmes, an understanding of the NOS provides "a guiding framework and a link to scientific knowledge and supports the understanding of scientific concepts" (Aflalo, 2014:301), thus advancing the PCK for new teachers who

would also develop more confidence about the content of what they have to teach. This researcher advises that science teacher training programmes should expose student teachers to teaching and learning about the NOS in order to bring about "perception change". However, Buaraphan (2012) contradicts this intended outcome in an investigation of what teachers actually do in the classroom once they qualify. It seems that teachers' views of the NOS are relatively impervious to change and even if views do change, it does not translate to teaching NOS in the classroom.

This outcome was seen in my study where teachers attended short-learning courses with elements of the NOS. However, since this was not explicitly dealt with, many of the teachers were unable to identify what the NOS is about. Some of the reasons given for not practising the NOS in lessons were time constraints; lack of resources for NOS teaching; and poor support from more experienced teachers leading to a build-up of tensions in the CHAT model. One of the ways that the pedagogy of NOS, as well as an understanding of science concepts, could be strengthened in the classroom is through the use of the inquiry methods of science teaching (Abd-El-Khalick *et al*., 2004).

2.4.6.3 *The inquiry method of science teaching*

The inquiry method of science teaching has a direct bearing on constructivism and advocates for critical thinking, problem-solving, development of a scientific attitude and the discovery method of learning, rather than mere rote learning of science content (Abd-El-Khalick *et al*., 2004). This method of science teaching can be used in two ways: Firstly, when inquiry is seen as a 'means' that intends to assist learners to develop an understanding of science content. In this case, the **content** acts as an end or outcome after instruction. Secondly, when the inquiry method is seen as an 'end', it looks at 'inquiry about science' where **inquiry** is the instructional outcome (Abd-El-Khalick *et al*., 2004:398).

Although both inquiry methods have their benefits, it is necessary to point out that merely using the inquiry method will not ensure that learners understand the NOS. Instead as Abd-El-Khalick *et al*. (2004) propose, it is more important for learners to understand *about* scientific inquiry rather than about how to *do* science. This implies

that using the scientific method is not as important as understanding how scientific inquiry works.

This has lead researchers to differentiate between explicit and implicit teaching about the NOS and scientific inquiry. Implicit teaching assumes that, by including inquiry activities in the science curriculum, students would absorb the NOS as a by-product of learning science. Explicit teaching, by contrast, advocates for the inclusion of actual aspects of the NOS as a learning outcome so that these aspects are directly (explicitly) addressed. Several studies presented in Khishfe and Lederman (2006) show consensus on the value of the explicit over the implicit teaching of the NOS. These researchers distinguish between integrated and non-integrated approaches to teaching the NOS, both of which fall into the explicit category of science teaching. The former is when NOS is taught as embedded into the science content; while the latter is when the tenets of the NOS are part of a relevant NOS activity without relating it to the science content.

When applied to teacher-training programmes, it was found that the explicit approach to the teaching of the NOS improved teachers' understanding irrespective of whether integrated or non-integrated methods were used (Khishfe & Lederman, 2006). Another study by Dekkers (2006) concurred that teachers' understanding of the NOS improved when they were trained using explicit learner-centred inquiry activities that probed tenets such as the role of creativity and imagination in scientific knowledge determination; and that in science there can be multiple valid answers.

In South Africa, the explicit teaching of the inquiry method was only formally introduced into the Grade 12 Life Sciences curriculum since 2008, together with the controversial topic of Evolution. This was the first time, in their final year of high school, that learners were exposed to the definitions of scientific theories, hypotheses and even minor ideas about science being a human construct. When the curriculum changed once again to the Curriculum Assessment Policy Statement (CAPS) in 2013, these aspects became integrated more explicitly into certain topics, with the human element interspersed throughout the curriculum. Since Grade 10, learners have been taught the scientific method with repeated emphasis on a School-Based Assessment (SBA) task called Hypothesis Testing using the flowchart shown in Figure 2.9.

Although this task provides a glimpse into the inquiry method of science knowledge construction, it regrettably serves to feed the misconception that all scientists follow a linear, sequential process when conducting research. The sixth NOS tenet 'There is no single scientific method' is consequently etched in learners' minds. Although part of the human element of science was included in the content, minimal consideration was given to the values, cultures, or beliefs that influence science. Furthermore, the tenets of the NOS are not taught explicitly in the CAPS Life Sciences curriculum.

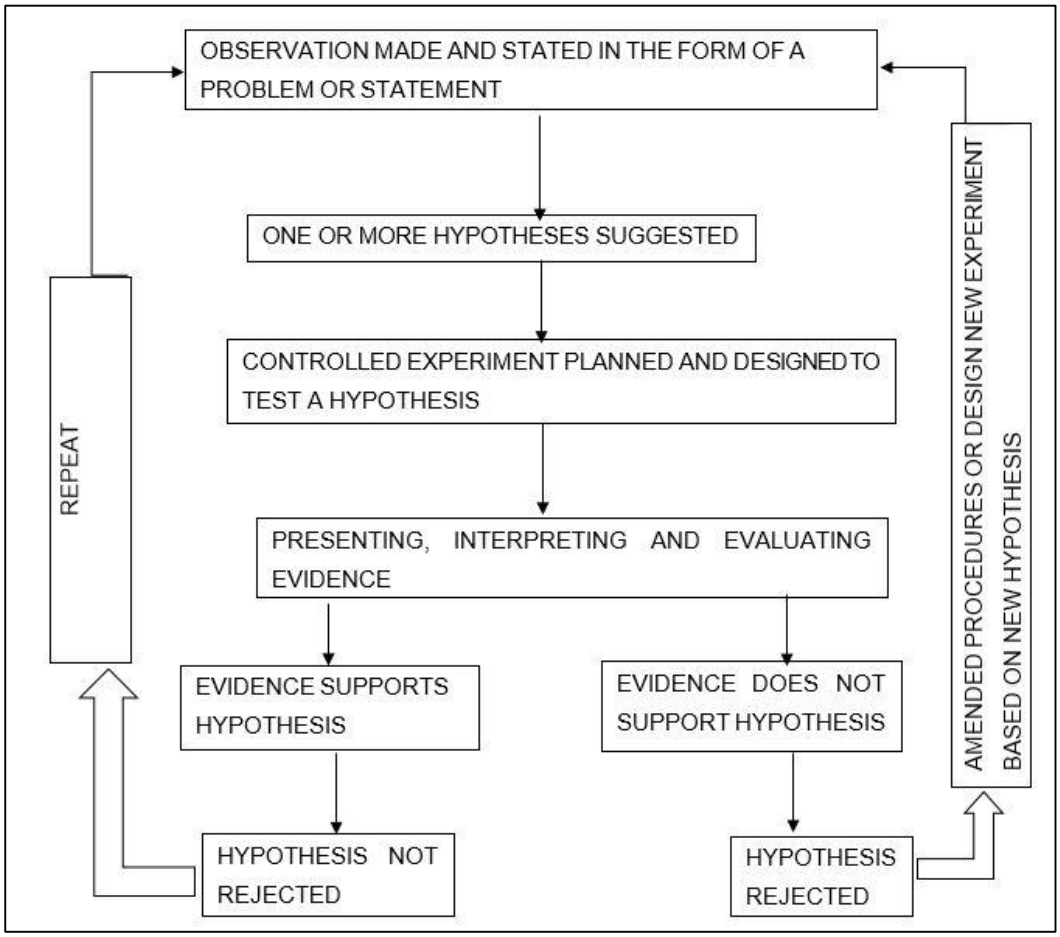


Figure 2.9: Schematic representation of controlled experiments (adapted from Isaacs *et al.*, 2007:xii)

According to research conducted in Taiwan, teachers feel constrained by a shortage of time and are under pressure to complete heavily laden syllabi crammed with science concepts and facts that are required for the purpose of summative assessment (Abd-El-Khalick *et al*., 2004). Taiwanese teachers also feel that spending time on inquiry-based lessons are an indictment on their efficiency as teachers hence they rather use

lecture-style teaching methods in order to complete as much content as possible in a shorter space of time. A similar position exists in South Africa, especially with the introduction of CAPS – a content-driven, teacher-centred curriculum. The Life Sciences curriculum is crowded with several topics and concepts that have to be taught within a certain time for summative assessment purposes – prescribed by a document known as a Pace-setter. Thus, even in South Africa, the time-consuming, albeit more beneficial inquiry method of teaching is relegated in favour of lecture-style teaching approaches. This shortcoming forms part of the tensions identified by the CHAT analysis, and will be discussed in Chapter 4.

Research on science teaching in Taiwan has additional significance in respect of my study on indigenous knowledge. According to the research conducted by Hsiao-Lin Tuan, Taiwan is influenced by both Eastern and Western cultures (Abd-El-Khalick *et al*., 2004:409). The Eastern influences are rooted in Taoism, which is characterised by holistic and mystical beliefs; while the Western influence is more objective, analytical and mechanical. The researcher notes that the Taiwanese "prefer conforming to nature and searching for harmony between humans and nature", i.e., their Eastern culture is preferred to the Western approach. The affinity to achieve harmony between man and nature is one of the core principles shared by many indigenous people around the world. This aspect, together with the indigenous knowledge that these people hold, is discussed at length in the next section, and forms part of my conceptual framework.

2.4.7 Indigenous knowledge and its tenets

There is an abundance of literature on indigenous knowledge but none of them agree on a common definition. They do, however, share many of the elements of indigenous knowledge systems as encapsulated in a statement from the Inter-Commission Task Force on Indigenous Peoples (cited in Onwu & Mosimege, 2004:2):

> Indigenous Knowledge Systems are local, community-based systems of knowledge which are unique to a given culture or society and have developed as that culture has evolved over many generations of inhabiting particular ecosystems. IKS is a general term which refers broadly to the collective knowledge of an Indigenous People about relationships between people, habitat and nature.

According to the African department of United Nations Environment Programme, indigenous knowledge is “unique to every culture and society and it is embedded in community practices, institutions, relationships and rituals” (Khatri & Choukhande, 2012:2). Kwanya (2015:1) defines indigenous knowledge as “the unique, traditional, local knowledge existing within and developed around the specific conditions of people indigenous to a particular geographic area”. Letsekha *et al*., (2013:4577) provide a definition of indigenous knowledge in the South African context as “a body of knowledge embedded in African philosophical thinking and social practices that have evolved over the years”.

Extensive studies have been conducted in Canada among the indigenous First Nations people regarding the pedagogy and epistemology of integrating indigenous knowledge into the school curriculum (Battiste, 2002; Battiste, n.d; Lowan, 2012; Haig-Brown, 2008; Madden *et al*., 2013; Bartlett *et al.,* 2007; Hatcher *et al*., 2009). According to Battiste (2002:2), indigenous knowledge is embedded in the collective teachings and experiences of indigenous people instead of being stored in written books. This researcher goes on to explain that indigenous people have their own way of teaching and gathering knowledge that does not follow Eurocentric approaches but “is a knowledge system in its own right with its own internal consistency and ways of knowing” with limits to the extent that it can be understood using a Eurocentric perspective.

The complexities of indigenous knowledge can, therefore, not always be fully comprehended using Western methods; and this is one of the arguments around decolonising the curriculum, a complex process in itself. Canadian studies indicate that this entails a multi-faceted approach that includes recognising the collective voice of Indigenous peoples; exposing the injustices in the colonial history of a country; critical examination of the past for the social, political, economic, and emotional reasons for silencing indigenous voices; authenticating the voices and experiences of indigenous people in the curriculum; acknowledging it as a dynamic context of knowledge; and knowing and communicating the emotional journey that such considerations will generate.

Although in much of the literature on this topic, indigenous knowledge and indigenous knowledge systems are used interchangeably, Vhurumuku and Mokeleche (2009) provide a distinction between the two terms. They regard **indigenous knowledge (IK)** as referring to the knowledge showing the dynamic interaction of people in their environment and how they can use their environment, culture and history to enhance their lives by putting this knowledge into practical use.

Indigenous knowledge systems (IKS) on the other hand, refers to a composite of different types of indigenous knowledge such as science (including elements of Western science), technology, religion, language and politics. They explain concisely that "What is called indigenous knowledge is embedded, enmeshed and interwoven into holistic cultural matrix called an "indigenous knowledge system". Indigenous knowledge is the knowledge itself and indigenous knowledge system is the cultural matrix in which it is enmeshed and stored" (Vhurumuku & Mokeleche, 2009:99).

Mosimege is perturbed by the narrow view that most people display when they equate IKS with traditional healing alone, when actually it is only a small part of this vast field (Onwu & Mosimege, 2004:4). Mosimege asserts that IKS includes biological resources and how these are managed, as well as "indigenous institutions, languages, mathematical knowledge, environmental resources, governance matters, etc." (Onwu & Mosimege, 2004:4). In my study both indigenous knowledge and indigenous knowledge system will be used depending on the context and intended meaning.

Since both these definitions mention the integral role culture plays in the development of indigenous knowledge, it is necessary to provide a description of culture for the purposes of my study. Aikenhead and Jegede (1999:272) adopt the cultural anthropological definition of **culture** as being "an ordered system of meanings and symbols, in terms of which social interaction takes place". The researchers find this definition relevant as it applies to the study of Western science. Culture is also regarded as the "norms, values, beliefs, expectations and conventional actions" of a group (cited in Aikenhead & Jegede, 1999:272). My study considers the South African Indian culture and how it evolved from the time the Indian forefathers arrived in KwaZulu-Natal from India in the 1800's as indentured labourers, bringing with them their own indigenous knowledge.

Vhurumuku and Mokeleche (2009:98) describe a phenomenon that occurs among indigenous communities as a result of human interaction over time, when some knowledge considered to be “indigenous” among certain people is passed on and embedded into the culture of other people “across geographical boundaries, countries and continents”. In 1860, when the initial consignment of indentured Indians first landed in KwaZulu-Natal, they faced a foreign environment, different from what they were accustomed to in India. However, they were able to adapt their indigenous knowledge to make use of indigenous plants that were being used by local African people to treat certain ailments, or for other uses such as food, thereby showing that indigenous knowledge can be shared among different communities. An anecdotal example of this is the Aloe plant that is indigenous to South Africa including to KwaZulu-Natal where the local people applied smoke to the dried leaves and pounded it into a powder to be used as tobacco. The Indian people then followed suit as there were no tobacco plants growing in KZN in the 1800’s. However, they were familiar with aloe plants that grew in India as well.

My study looks at the integration of Indian indigenous knowledge into the Life Sciences curriculum. A study examining the inclusion of indigenous knowledge into the curriculum was also conducted by De Beer and Whitlock (2009) and showed how traditional healing could be examined and subjected to experimental processes in American classrooms. Their study cited the Relevance of Science Education Study (ROSE), which indicated that the level of relevance of a curriculum for many students drops as a country becomes more developed. These researchers surmised that this could be as a result of the curricula in developed countries being based in “Western philosophies and scientific discoveries that might be alien to some students” (De Beer & Whitlock, 2009:209), a situation referred to by Odora-Hoppers (2005:2) as “cosmopolitan knowledge”. This is distinct from what she calls “knowledge apartheid” where Western knowledge is favoured over indigenous knowledge, and where the latter is often rejected by many teachers as “pseudoscience” (De Beer & Whitlock, 2009:209) resulting in many teachers not being confident about including indigenous knowledge in the classroom.

Conversely, an earlier study by Ogunniyi (2004:302) on the integration of indigenous knowledge into the curriculum by science teachers revealed that some teachers

“oscillate between a scientific and an indigenous worldview” and are willing to transform their pedagogy into one that is more constructivist. This transformation allowed them to acknowledge the role of culture in science learning, thus providing a suitable comparison with this study which looks at the successful integration of Indian indigenous knowledge into the science curriculum.

The researcher cites other studies that affirm these findings and suggest that when the indigenous knowledge of learners is given prominence in the curriculum, science teaching and learning is more effective and teachers are more confident about referring to indigenous knowledge in the classroom (Ogunniyi, 2004:303). Lelliott *et al*. (2009:56) confirm that when learners and teachers are allowed to co-design curricula with the incorporation of their everyday knowledge, it leads to increased and less inhibited learner participation, greater learner confidence and learners who can relate more strongly to the content. At the same time, learners who value their own indigenous knowledge have their “intellectual interests” kindled, unlike curricula that “cast aspersions and [a] disdainful gaze at learners’ traditional cultures” (Ogunniyi, 2004:303). Yishak and Gumbo (2012:185) conducted a study in Ethiopia which also affirms the assertion that a curriculum sensitive to learners’ context makes more pedagogic sense as it enhances their learning, motivation to learn and academic performance when the school curriculum is rooted in their own cultures, experiences and perspectives. This view is also supported by Ngman-Wara (2015:168) who regards contextual teaching and learning as making the curriculum relevant to learners, which in turn motivates learners to perform better.

Aikenhead and Jegede (1999:271) describe the “transition from a student’s life-world into a science classroom” as being “a cross-cultural experience” for most students, which they refer to as “cultural border crossings”. These authors echo Ogunniyi’s view that students need to negotiate school science to ensure success in science. Onwu and Mosimege, (2004:11) present additional benefits to incorporating IKS into the science curriculum, such as allowing more cooperative efforts rather than dialogue or rhetoric between teachers and learners. Instead teachers and learners can share their cultural experiences in lessons – as Maila and Loubser (2003:15) declare that it is only when “people acknowledge that they can learn from each other that they begin to

emancipate themselves as a people", thus hinting to the release from the shackles of a colonial past.

Onwu and Mosimege, (2004:11) add that indigenous knowledge inclusion should also acknowledge the contribution made by traditional knowledge towards science education in the classroom; strengthen the synergistic link between IKS and Western science by highlighting the similarities and differences between the two fields; and enable learners to see that both fields of knowledge can overlap and fortify each other, each possibly filling knowledge gaps in the other. These are generic benefits of the integration of indigenous knowledge into the school curriculum that can enhance learning and improve academic performance. My study intends to show how the integration of Indian indigenous knowledge into the Life Sciences curriculum can also achieve these intended outcomes, although specifically for Indian learners, but ultimately for all learners in the class.

2.4.7.1 *Indigenous knowledge and the Western notion of science*

Society often places indigenous knowledge on an inferior level as compared to Western knowledge. According to Maila and Loubser (2003:1), this is because indigenous knowledge "belongs to a particular racial or ethnic group which often, it is assumed, lacks the necessary cultural capital". The effects of colonialism further exacerbated the notion that indigenous people did not have any knowledge to contribute. Therefore, the indigenous knowledge of the places colonised were ridiculed or ignored altogether (Kibirige & Van Rooyen, 2006: 236). This view is also expressed by Ogunniyi (2004:290) who uses the term "ethno-science" to refer to the science within indigenous knowledge systems that was regarded by the West as being an inferior science.

Le Grange (2007:586) adds that although Western science and indigenous knowledge are incompatible "or that indigenous ways of knowing may be recognised as a particular way of understanding the world… they are not science". This author goes on to explain that if science is viewed as performance and not only representation, then the differences between western science and indigenous knowledge will be removed. Performance refers to "science as a human and social activity that is messy,

heterogeneous and situated" (Le Grange, 2007:587) while representation refers to "abstractions such as theories and laws" (ibid).

Batiste (2002:4-5) asserts that indigenous knowledge has always existed regardless of whether it was recognised by Western science or not, and that it has recently come to the fore "as an act of empowerment by indigenous people". Western opinion is that only Western people can progress while indigenous knowledge is grounded in the past and is incapable of moving into the future. There is a fallacy in the West that indigenous people are backward, passive recipients of Western knowledge. The systematic use of Western ideals, pedagogy and epistemology by indigenous scholars was not met with success and led to them questioning the power of Western thought. They then looked towards the "rich treasure ... of … the neglected ancient knowledge and teachings of the elders" for solutions that had previously established their unity and dignity over millennia (Batiste, 2002:5).

However, the UNESCO World Conference on Science for the 21st Century and its Declaration emphasises, amongst other aspects, that "all cultures can contribute scientific knowledge of universal value" and that "it is necessary to recognise the many ethical frameworks that exist in civilisations around the world" (Odora-Hoppers, 2005:33). This has allowed for indigenous knowledge to be included in schools and university curricula and for the discussion on indigenous knowledge to be dealt with more freely. In South Africa, the latest school Curriculum and Assessment Policy Statement (CAPS) calls for the explicit inclusion of indigenous knowledge into lessons, although the exact implementation thereof is not detailed. This curriculum statement "acknowledge(s) the rich history and heritage of this country" (DBE, 2011:5) and incorporates it into Specific Aim 3, a subject specific aim that comprises "…the relationship between indigenous knowledge and science" (DBE, 2011:13).

Even abroad, the integration of Western science and indigenous knowledge continues to be met with resistance. According to Simpson, a North American indigenous scholar, Western scientists appear to want to force indigenous knowledge systems to fit into their idea of what is right and because spiritual values do not conform to this idea, these are shunned (Lowan, 2012:74). While Western scientists may, on the one

hand, be receptive to the possible solutions provided by indigenous knowledge for environmental problems, on the other hand, they are less accommodating of the spiritual foundations, indigenous values and worldviews that inform these solutions.

Other differences that are seen between Western science and indigenous knowledge include the trust placed in inherited wisdom among indigenous people, in contrast to Western scepticism; and the indigenous belief in the link between the metaphysical and physical worlds, unlike Western science which focuses its understanding on the physical world only (Lowan, 2012:75). Aikenhead and Ogawa (2007:545) describe several characteristics of Western science, such as its primary objective of solving mysteries in nature by devising scientific descriptions and explanations such that "the need to know nature motivates scientific curiosity", whereas indigenous knowledge does not strive to know everything about nature and accepts that some phenomena have no explanation. Another feature is that scientific experiments are designed to be predictive. Western science is, therefore, based on predictive validity, endeavouring to explain and predict natural phenomena. This is unlike indigenous knowledge that is based on content validity which instead looks at "*what* the universe is" (Aikenhead & Ogawa, 2007:548).

These researchers also put forward the rectilinear notion of time that is regarded in Eurocentric science as "an absolute feature of reality" (Aikenhead & Ogawa, 2007:548), unlike the cyclical notion of time held by many indigenous cultures, including Indians, who believe in the *Kalachakra* (wheel of time) where time repeats itself in four Yugas (ages) totalling almost 4 billion years at a time (Reddy, 2012). Circular time coincides with the cycles in nature that indigenous people observe and use as their idea of time. Aikenhead and Ogawa (2007:549;556;560) describe the anthropocentric view of Eurocentric science that allows humans to dominate nature, as opposed to indigenous knowledge which places humans on the same level as nature so that there is harmony between both. In this way, indigenous people observe and listen to nature in order to learn from it. Eurocentric science is characterised by quantification which only looks at entities and events as scientific if they can be measured. Any non-quantifiable constructs such as spirituality, are ignored (Aikenhead & Ogawa, 2007:550).

Le Grange (2007:586) mentions that knowledge systems have different "epistemologies, methodologies, logics, cognitive structures…and socio-economic statuses", but they do share "their localness". This applies to indigenous knowledge as well, which arises from people living in a particular locality and using the resources available to them. Kibirige and Van Rooyen (2006:239) use an epistemological stance to compare indigenous knowledge and the Western idea of science. Their comparison is summarised in Table 2.2.

Table 2.2: Comparison of indigenous knowledge with Western science (adapted from Kibirige & Van Rooyen, 2006:239-240; and Ogunniyi, 2004:292-3)

INDIGENOUS KNOWLEDGE	WESTERN SCIENCE CONCEPTS	COMMON ELEMENT IN CLASSROOM PRACTICE
Passed on orally and experientially	Recorded in written form	Interaction between teacher and learners – communicative approach; case studies used
Learnt through practical experience	Taught in an abstract form	Relevant and active learning in class; use of empirical investigations
Represents a qualitative and intuitive thinking mode	Represents a quantitative and analytical thinking mode	
Tries to understand systems holistically	Looks at systems in parts (reductionist)	Inductive approach to classroom science; inquiry method used
Often depends on spiritual, cumulative, and collective knowledge that is continually reinterpreted	Depends on hypothesis testing, theories and laws	
Nature is real, partly observable and testable	Nature is real, observable and testable	Can use experiments to illustrate certain phenomena, e.g., antimicrobial properties of plants; problem-solving methods
Events have both natural and unnatural causes	All events have natural causes	

Language is important as a creative force in the workings of the natural and unnatural worlds	Language is not important to the workings of the natural world.	
Indigenous Knowledge is concerned with 'what,' 'what ought to be,' and 'why'	Science deals with 'what' and NOT 'what ought to be'	
Man is capable of understanding only part of nature	Man is capable of understanding nature	

Both indigenous knowledge and Western knowledge, therefore, can exist synergistically without conflicting with each other. This is also apparent when comparing traditional healing remedies with Western medicine. The authors cite a case study where sexually transmitted diseases (STD's) were more successfully treated by traditional healers than by doctors. The plants used by the *Sangomas* (African traditional healers) were tested and shown to have anti-microbial properties (Kibirige & Van Rooyen, 2006:241). Similarly, an Indian traditional remedy, that uses garlic and turmeric for skin irritations and throat infections, also has anti-microbial and antiseptic substances (Singh, 2005:81, 82, 96).

These examples show that traditional or indigenous knowledge can co-exist with Western medicine, with each supporting the other rather than being in opposition to each other. Similarities have also been identified between North American indigenous knowledge and Western science such as "the concept of a unified universe; personal qualities such as perseverance, curiosity and honesty; empirical observation of nature; and a desire to understand the behaviour and patterns of plants, animals and other natural phenomena" (Lowan, 2012:75).

This view of engaging both indigenous knowledge and Western knowledge is also applied widely to environmental education and is referred to as a 'two-worlds' approach by Kapyrka and Dockstator (2012:97). They believe that it "has the capacity to enlighten both educators and students and promote relationship-building between Indigenous and non-Indigenous peoples and their respective cultural understandings".

In so doing, the two-world approach can build relationships so that our “collective environmental challenges” may be addressed collaboratively. These and other possible links between indigenous and Western knowledge will also be addressed later in this chapter.

2.4.7.2 *The nature of indigenous knowledge*

The NOS and indigenous knowledge systems are regarded as “contentious constructs” by Vhurumuku and Mokeleche (2009:97) mainly since “each construct is described as convoluted, disparate, multifaceted, complex, dynamic and elusive”. Some of the complexities of the NOS were detailed with specific reference to its tenets in a previous section. Similarly, the nature of indigenous knowledge (NOIK) has been clarified by Cronje *et al*. (2015) using these tenets of the NOS as a guideline. They have classified the philosophical framework of the NOIK into four aspects: ontology; epistemology; methodology, and volition. However, they also caution that this is not in an attempt “to compare indigenous knowledge and Western science or to determine if one is superior to the other” (p.322). Cronje *et al*. (2015:321-322) offer the following ontological tenets of the NOS:

1. Science is empirical;
2. Scientific theories and laws are different;
3. Science is creative and theory-laden, but partly subjective;
4. Science is socially and culturally based;
5. Science is tentative;
6. There is no single scientific method; and
7. There is a difference between observation and inference.

These tenets of the NOS are then compared with these tenets of the NOIK that suggest that indigenous knowledge is:

1. Empirical and metaphysical in nature;
2. Resilient but tentative;
3. Inferential but intuitive;
4. Creative and mythical;

5. Subjective;
6. Social, collaborative, and cultural;
7. Wisdom in action;
8. Functionally applied; and
9. Holistic in approach.

The researchers state that these tenets of indigenous knowledge are not exhaustive but have been considered as relevant for a comparison with the NOS. The comparison of the tenets of both the NOS and the NOIK are summarised in Table 2.3.

Table 2.3: Comparison of the ontological tenets of the NOS with the tenets of the NOIK (adapted from Cronje *et al*., 2015:323-4)

NOIK	TENET	NOS
Empirical and metaphysical in nature	**1**	Science is empirical
Resilient but tentative	**2**	Science is tentative
Inferential but intuitive	**3**	Science is inferential
Creative and mythical	**4**	Science is creative
Subjective	**5**	Science is subjective but influenced by theory
Social, collaborative and cultural	**6**	Science is cultural and social – it is a human endeavour
Wisdom in action	**7**	Several methods used to generate scientific knowledge
Functionally applied	**8**	Theories and laws used to explain natural phenomena
Holistic in approach	**9**	Science is reductionist in its approach

Using Cronje (2015: 32-44) as the basis, each of these ontological tenets will now be explained further:

Tenet 1: Both the NOS and the NOIK are empirical as they are real, observable and testable. While the NOS suggests that the universe is orderly and predictable, the NOIK considers it to be partly predictable and also metaphysical.

Kwanya (2015:1) states that indigenous knowledge is indicative of “thousands of years of experimentation and innovation in all aspects of life in a particular context”, thus alluding to the empirical nature of indigenous knowledge.

Tenet 2: Both these knowledge systems are tentative as they are constantly changing and can be challenged by all. Indigenous knowledge contains traditions that are fluid, transformative and linked to people’s experiences.

Tenet 3: Both the NOS and the NOIK are based on natural causes. Unnatural causes are considered in indigenous knowledge, hence the importance of the metaphysical. Facts in both are tested and experimental observations made.

Tenet 4: Apart from observations and experiments adding to knowledge, both the NOS and the NOIK also depend on human creativity and imagination, with myths also playing a role in indigenous knowledge.

Tenet 5: Scientists endeavour to remain objective and culture-free but they are human beings influenced by their disciplinary and theoretical commitments, prior knowledge and beliefs thus making them subjective. The elders in a community are also influenced by their culture, spirituality, cosmology, prior ways of knowing, and beliefs.

Tenet 6: Scientists often work alone in specific locations but generalised scientific laws and theories have universal applications. They are also influenced by society and their culture. Indigenous knowledge is steeped in cultural tradition and within a particular historical-political context. It focuses on sharing information to a group of people rather than on an individual.

Tenet 7: Indigenous knowledge is devised through daily practical engagement by trial and error experiences to ensure survival. Likewise, science is not generated through a single recipe-like universal method. A variety of methods are used to test theories and solve problems, usually in laboratories.

Tenet 8: Indigenous knowledge is concerned with people’s daily lives instead of with facts, theories and laws. It considers what, why and what ought to happen in nature by emphasising practical or functional application and skills. Scientists, on the other

hand, use theories and laws to explain phenomena in nature because scientific laws describe WHAT happens while theories explain WHY and HOW they happen. Laws are therefore causal, rational and logical.

Tenet 9: Scientific methods are usually reductionist with a problem being broken up into smaller parts and analysed separately; while indigenous knowledge has a holistic approach looking at a composite of different aspects such as science, religion and psychology.

The epistemological tenets that Cronje (2015) highlights are that indigenous knowledge derives a way of knowing from the culture of a group of indigenous people in a certain area, while science is confined to subject matter knowledge. The latter includes procedural and conceptual knowledge (the NOS) while the former considers practical knowledge about daily living (the NOIK). Indigenous knowledge refers to pedagogical ways of knowing and relies on an oral mode of transmission; while the NOS requires PCK in order to be transmitted through texts.

In terms of methodology, indigenous knowledge is amassed through wisdom in action where facts are tested and experimented over many generations of use; ceremonies and repetition play an important role in adding new knowledge; discovery learning occurs through participatory research and inquiry and investigations. Contrary to naïve notions, indigenous knowledge is neither unchanging nor unchanged, but instead constantly re-created and regarded as “living knowledge” (Haig-Brown, 2008:13). Scientific knowledge is gathered using practical work, scientific inquiry and scientific investigations (Cronje, 2015).

The aspect of volition refers to the will to do and is connected to values, beliefs and attitudes of indigenous knowledge holders (Cronje *et al*., 2015:322). In science, this is characterised by healthy scepticism; respect for research of others; was initially a mechanistic and positivistic worldview, but is moving towards constructivist views.
With indigenous knowledge, on the other hand, volition also refers to a healthy scepticism, but respect for ALL things; is inseparably intertwined with ethics, spirituality, metaphysics, ceremony, and social order; and has an overall anthropomorphic worldview (Cronje, 2015).

From the discussion above, it is apparent that both the NOS and the NOIK are valuable aspects for the inclusion of indigenous knowledge into the school Life Sciences curriculum. There is also merit in comparing indigenous knowledge to Western science as it serves as a bridge between two cultures, thus facilitating the transition when integrating indigenous knowledge into the curriculum. Since this study focusses on Indian indigenous knowledge, the next section will shed some light on this vast area.

2.4.7.3 *Indian indigenous knowledge*

Indian indigenous knowledge revolves around medicine and health-care, although it also incorporates aspects of agriculture, astrology, astronomy, mathematics, and architecture. This study, however, emphasises those aspects linked to the South African school Life Sciences curriculum, i.e., Ayurveda as a traditional system of medical treatment (Ravindran, 2002).

As mentioned previously (Section 2.2.7), indigenous knowledge has several different definitions in various publications. One states that it "is unique to every culture and society [being] embedded in community practices, institutions, relationships and rituals" (Khatri and Choukhande, 2012:2). Indigenous people are described by Tripathi *et al*. (2000:321) as having a vast knowledge and ability for "developing innovative practices and products from their environment" while also serving as keepers of their land, "entrusted to care for these through successive generations". Indian people are, therefore, no exception to this practice and have their own rich history of indigenous knowledge unique, not only to them as Indians, but also to a myriad of distinct villages and geographical regions on the Indian sub-continent.

Like South Africa, India has also been subjected to colonialist rule, most recently by the British who ruled India for almost 200 years up to 1947. During the time of colonial rule, much of India's traditional knowledge systems were subjugated by Western medical practices (Islam, 2012:503). However, since the 1970's, the value of indigenous knowledge has seen a revival in India with a dedicated government department. The department – Indian Systems of Medicine and Homeopathy (ISM&H) – was set up to oversee all aspects of Indian traditional healing and medicines (Islam, 2012:509). In 2003, this institution was renamed as the Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha, and Homeopathy (AYUSH).

Alix and Dell (1997) provide a brief explanation of some of these fields, viz., Ayurveda tries to ensure harmony between the mind, body and spirit by using herbs, yoga and other techniques to prevent or treat illness. Ayurveda is an ancient medicinal knowledge system that originated in India, in which the central dogma is health and not disease (Singh, 2005). This qualitative science has principles that are supported by thousands of years of empirical evidence. It is a holistic, indigenous knowledge system that holds affordances for the Life Sciences classroom as it can be used to contextualise the topics in the CAPS curriculum, especially for Indian learners.

Martins (2011:500) draws a distinction between Western or conventional medicine and Eastern medicine. He explains that Western medicine regards the cause of most diseases as due either to external pathogens or to internal organ malfunction, while Eastern medicine asserts that these diseases are "due to an imbalance of the mind …. [and therefore] … the cure could be performed by the mind itself" rather than by external treatments prescribed by Western medicine. Martins (2011:500) refers to Eastern medicine as "mind-body medicine" and he cites the traditional Indian medicine, Ayurveda, as "one of these mind-body medicines" (Martins, 2011:504). This author also mentions meditation in Yoga as one of the techniques that can be used to achieve a healthy mind-body relationship (Martins, 2011:505).

Yoga is regarded as one of the oldest forms of health practice in the world and it attempts to unify distinct elements in the body using various postures and breathing techniques, which will be discussed later in this chapter. Naturopathy uses the body's inherent ability to heal and emphasises hydrotherapy, massage, nutrition and herbal treatments. Unani is a traditional form of treatment with Arabic or Islamic origins. Siddha refers to treatments using gemstones and minerals. Homeopathy is an alternative medicine system using minute quantities of substances to stimulate the body's immune system.

My study focuses on Ayurveda as a form of Indian indigenous knowledge to be included in the South African Life Sciences curriculum. This form of Indian indigenous knowledge, and possible ways in which they can be integrated into the school Life Sciences curriculum, is discussed in the following section.

2.4.7.3.1 Ayurveda

> Hita hitam sukham dukkha ayustasya hita hitam manam ca tacca yatroktam Ayurveda ca ucayate
>
> (Charaka Samhita)

The English translation for this Sanskrit sloka (couplet) is: “The science that describes what is appropriate and inappropriate, a happy or unhappy life, and describes the guidelines for what is essential and irrelevant for a long life, and everything about life, is called Ayurveda” (Vaidyaratnam Foundation, 2017:1). The term Ayurveda is derived from Sanskrit and is made up of two words: *Ayuh* and *Veda* which mean Life and Science/Knowledge (Ravindran, 2002). Putting these two root words together, Ayurveda means the Knowledge or Science of Life, and the closest equivalent in English is Life Sciences or Biology (Dwarakanath, 2003:6) – hence it has direct relevance to my study, which looks at integrating Indian indigenous knowledge, particularly Ayurveda, into the Life Sciences curriculum.

Ayurveda is a holistic science that has been described as the “interaction between the body, senses, mind, and *atma* (soul/spirit)” (ibid.). It regards “the psyche and body …as inseparable” with healing focusing on “herbal medicine, detoxification or dietary changes and massage therapy to restore balance” Bhagwan (2012:239). This notion of unity between the body and mind in Ayurveda is also described by Angeletti (2015:7) who states that Ayurveda associates “mental, emotional and energetic states with the physical state of the body” and that “the mind and body are a reciprocal informed entity, rather than two separate systems of functioning and expressing” (Angeletti, 2015:8). This reciprocal nature between the mind and body implies that the health of the one determines the health of the other, and *vice versa*. Ravindran (2002) states that Ayurveda centres around three aspects, namely: (a) Rogaprathirodha (preventive medicine); (b) Rogaprathishedha (curative medicine); and (c) Rasayana Chikitsa (rejuvenative medicine).

All terminology used below, to describe or explain Ayurveda, will be in Sanskrit with the closest English equivalent included where available.

A. Origin of Ayurveda

Before delving into the essence of Ayurveda and its relevance to the Life Sciences curriculum, it is necessary to look at a brief history of this vast field, focussing especially on its origins and development into the science it is today. Khatri and Choukhande (2012:3) state that the earliest documented writings on medical practice in India were found dating back to the Vedic period (1500-1000 BCE); and they claim that Ayurveda dates back to more than 5000 years ago when it was compiled as part of the four main books of spirituality known as the Vedas. These books contain information on topics including health, astrology, poetry, armies, and human behaviour.

According to Kumar (2014:11), “Healing is the basic, evolutionary necessity of an organism to survive” implying that “the history of health care can be traced back to the beginning of life on earth” (ibid.). This author proposes that all living organisms have an inherent tendency to survive and to escape discomfort – to illustrate; he cites examples of plants growing towards the light and the simple unicellular *Amoeba* using its *pseudopodia* to move away from harmful substances. The human body is no different in that it has complex mechanisms to expel foreign material that cause fever, vomiting, etc.

However, these natural mechanisms were often not sufficient to ensure good health, which prompted early humans to use articles from their natural environment to help cure or treat diseases. Primitive man used mainly plants and “often combined them with prayers, sacrifices, and other rituals to please Gods”, since it was believed that diseases were caused by displeasing the Gods and/or devils entering the body (Kumar, 2014:12; Palep, 2004:2). During these ancient times, medical treatment was based on a belief system as opposed to a scientific system. The latter uses evidence to explain cause and effect, while the former relies purely on belief. Gradually, Ayurvedic medical practices were recorded and, about 3000 years ago, Ayurveda emerged as “an independent scientific system” (Kumar, 2014:12) that attributed disease to internal imbalance caused by improper habits and exposure to the changing environment, i.e., seasons, climate, night and day.

Ayurveda, thus, offered a more logical means of explaining causes of, and treatments for, afflictions (Kumar (2014:23). There is also a mythological aspect to Ayurveda that is recorded in ancient Hindu scriptures (the Vedas) and sometimes Ayurvedic history is intermingled with mythology (Kumar, 2014:16; Dwarakanath, 2003:12). However, since my study intends to look at Ayurveda from a non-religious dimension, these mythological aspects will not be dealt with in any detail. The authenticity of Ayurveda has been confirmed through multiple strands of evidence thus add to its credibility as an ancient medical practice (Kumar, 2014:14). These include:

1. Literary evidence – Ayurvedic manuscripts and texts, as well as the non-Hindu scriptures of Buddhism and Jainism.
2. Archaeology – excavations of the ancient pre-Aryan, Indian cities of Mohenjo-Daro and Harappa.
3. Inscriptions about health and hygienic practices – specifically those from the historic period of the Indian King Asoka.
4. Travelogues – recorded by early Chinese, Greek, and other travellers.

Ayurveda is well-documented in comprehensive volumes of texts and manuscripts from India dating back to more than 3000 years. The authorship of these volumes is often shrouded in controversy, especially as many of the authors appear to share the same names. The three main Ayurvedic texts, known as the Brhat-Trayi, are the Charaka Samhita, Sushruta Samhita and the Ashtanga Hrdaya – written by Charaka, Sushruta, and Vagbhata, respectively.

There were also writers who shared a group name, e.g., ‘Charaka’ means ‘traveller’ in Sanskrit rather than the name of one person and since the Charaka Samhita is such a lengthy detailed volume, many modern scholars debate whether it could have been written by one person. There are also debates as to whether there are two Vagbhatas, since a separate text exists called Ashtanga Samgraha also written by a Vagbhata, (Dwarakanath, 2003:1-3). This last text is not included for discussion in this study. Nevertheless, Table 2.4 is an approximate timeline for the origin of these manuscripts with their possible authors (Kumar, 2014:17-18).

Table 2.4: Ayurvedic Texts – their authorship and timeline (adapted from Kumar, 2014:17-18; and Dwarakanath, 2003:2-3)

TEXT	AUTHOR and DESIGNATION	APPROXIMATE DATE	MAIN EVENTS
		Pre-Vedic Period: up to 1500 BCE	Primitive practices
		Vedic Period: 1500–1000 BCE	Early attempts to classify diseases and identify plant remedies, etc.
Kaya Chikitsa	Atreya – chief advisor of medical tradition	1000 BCE–600 BCE	Philosophy emerges in India
Charaka Samhita[+] Medicine and therapeutics	Agnivesa - chief author of medical tradition (taught by Atreya) Charaka – master of medical tradition	Samhita period: 500 BCE–600 CE	Buddhist monasteries used to explore anatomy, pathology, pharmaceutics and therapies
Shalya Tantra (Surgery) **Sushruta Samhita**[+]	Dhanvantari - chief advisor of surgical tradition Sushruta – father of surgery		
Bala Chikitsa	Kasyapa – master of Ayurvedic paediatrics		
Astanga Hrdaya[+] (8 types of Ayurvedic treatment)	Vagbhata – master of comprehensive medicine	200–300 BCE	Development of Ayurveda as a science; specialisation of various branches of Ayurveda – integration of specialties; King Asoka's influence
[+] Denotes the **Brhat-Trayi** (great trio) of Ayurvedic texts		Sangraha Period: 600 CE–1000 CE	Dark ages; interaction with Chinese medicine and culture; interaction with Unani medicine (Mughal Dynasty)
		Modern period – after 1800 CE	Allopathy dominates Ayurveda

There are eight limbs or branches of Ayurveda, the details of each are summarised in the Ashtanga Hrdaya as follows:

- Kaya Chikitsa = inner medicine (or general medicine, according to Ravindran, (2002)
- Bala Chikitsa = paediatrics
- Graha Chikitsa = psychiatry
- Urdhvanga Chikitsa (also known as Oordhwangachikitsa) = (above the collar bones) head and neck ailments
- Shalya Chikitsa = surgery
- Visha (Dhamstra) Chikitsa = toxicology
- Jara Chikitsa = rejuvenation or anti-ageing therapy (Geriatrics)
- Vrsha Chikitsa or Vajikarana = aphrodisiacs or reproductive/fertility health

Chikitsa refers to treatment. An Ashtavaidyan is a physician who has mastered all eight branches of Ayurveda (Dwarakanath, 2003:15; Vaidyaratnam Foundation, 2017:3) and is the equivalent of a medical doctor in the West.

B. Characteristics of Ayurveda as a form of complementary medicine

In the past, Western science rejected indigenous knowledge as they considered it to be "unreliable, non-quantitative, and unempirical" (Haron & Hamiz, 2014:1303). However, Ayurveda is different as it has particular features that make it a reliable and highly practical branch of alternative medicine. Kumar (2014:13) points out that Ayurveda is different from other types of alternative medicine in the following ways:

1. It has a firm, methodical theoretical basis;
2. It has a philosophical approach on life and life events;
3. It prefers to maintain homeostasis by following a certain lifestyle for disease prevention rather than treatment for diseases when they manifest;
4. It regards health to be part of wellness in physical, mental, social, and spiritual domains of human life; and
5. It considers nature as the primary source for the various resources used to prevent or treat particular health conditions.

These characteristics of Ayurveda further serve to entrench it as a reliable field of medical treatment and practice since it is grounded in definitive principles. The next section will deal with the theoretical basis of Ayurveda in considerable detail.

C. The premise of Ayurveda

> Samadosha Samagnishcha Samadhata Mala Kriya
> Prasanna Atma indriya manah swastha iti abhideyate
>
> (Sushruta Samhita)

This quote is a key sloka (verse) in Ayurveda and translates to: “Good health is due to a balance among all three vital humours (doshas), optimal digestive fire (Agni), normal functioning body tissues (dhatus), and elimination of waste products (malas), together with blissful harmony of mind, senses and consciousness (Mana, indriya, and atma)” (Vaidyaratnam Foundation, 2017:1-2). Sushruta places prime importance on the doshas, Dhatus and malas and regards them as the “roots of the body” (Singh, 2005:24).

In its 1948 constitution, the World Health Organisation (WHO) defined health as a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity – thus sharing the same idea for good health as that expounded in ancient Ayurvedic texts. The starting point for the purposes of this study in explaining the basis of Ayurveda is the belief that the whole universe and all living organisms consist of varying proportions of five basic elements, similar (but not equivalent) to those described by the ancient Greeks, viz., fire, water, earth, air, space/ether.

Ayurveda refers to these five primary elements as the panchamahabhuta – tejas, jal, prithvi, vayu and akasa, respectively (Dwarakanath, 2003:80; Vaidyaratnam Foundation, 2017:3; Singh, 2005:10-11). In Ayurveda, these five elements within living organisms, form the basis on which all physiological conditions as well as their subsequent treatment is performed (Singh, 2005:10). Akasa is described as the space in which matter can shine, manifest or vibrate; vayu is described as motion of all kinds; tejas is described as radiation or heat; jal is explained as being necessary to determine viscosity and cohesion; and prithvi is described as mass containing potential energy

(Dwarakanath, 2003:84). These descriptions of the panchamahabhuta show that they are not the direct counterparts of the elements put forward by the ancient Greeks, but the similarity is used in order for Western science to better conceptualise them.

The panchamahabhuta combine in different proportions to form the three biological humours, known as the three doshas – vatta, pitta, and kapha [no English equivalent]. The doshas can therefore be considered as the biological expression of the panchamahabhuta. The sloka at the start of this section states that one way to achieve good health is for these doshas to be balanced in their body; and Ayurvedic practices and treatments strive to attain a state of balanced doshas. The fundamental principle of Ayurveda rotates around these three doshas or tridoshas (Dwarakanath, 2003:16). Each dosha is made up of two of the five elements as follows:

1. Vatta = akasa + vayu (space/ether + air)
2. Pitta = tej + jal (fire + water)
3. Kapha = jal + prithvi (water + earth)

Most people are a combination of two doshas with one usually predominant over the other, e.g., a person may have a vatta-pitta constituency where the vatta dosha is more dominant and the effects of the kapha dosha are almost non-existent. It is also necessary to mention that each of the three doshas has five divisions depending on the sites and nature of activities (Ravindran, A., 2002). However, these are beyond the scope of my study and will, therefore, not be dealt with here.

Each dosha also has the capacity to *vitiate* or *be vitiated* by themselves or other factors such as the external or internal environment. In Ayurveda, the word ‘vitiate’ refers to becoming out of balance or being upset. In order for the concept of vitiation and doshas to be understood more clearly, the characteristics of each dosha will be dealt with in the ensuing paragraphs.

Vatta dosha

This is regarded as the main dosha as it regulates the functions of the other two doshas (Singh, 2005:20). Since the vatta dosha is made up of the vayu and akasa elements, it has qualities similar to air and space, viz., dryness (Rooksha), lightness

(Laghu), coldness (Seetha), roughness (Sookshma), minuteness, movement (Chala) (Vaghbata, n.d:5). Vatta is located below the umbilicus in the lower abdomen, specifically in the colon and bone tissue. During digestion of food, gases are produced in the large intestine; and in bone tissue there are numerous spaces assumed to be filled with air. Hence the vatta dosha is said to be housed mainly in these two parts of the body (Palep, 2004:68). The vatta dosha is divided into a further five types but these will not be discussed here.

The vatta dosha initiates, controls, regulates, and coordinates all types of movement in the body by using free space and the energy of air to drive the process (Singh, 2005:20). Examples of functions and processes in the body achieved through vatta dosha are: hearing and touch; functioning of mind and motor organs; control and regulation of all the physiological, biochemical, and psychological processes; normal functioning and renewal of cells and organs; respiration, breathing, heartbeat, regulation of all body urges; and all types of movements in the body including child birth in females and ejaculation in males. Vatta dosha acts on the mind to stimulate enthusiasm, imagination, creativity, and wakefulness in a person; it also regulates and supports intelligence (Palep, 2004:69).

People with vatta-predominant doshas are usually of small, lean body frame; dry rough skin, hair, and nails; scanty hair; small, rough protuberant eyes; loose unsteady joints that creak when moving; visible tendons and prominent veins. They have an irregular appetite; prefer sweet, salty and sour foods; have quick but short memory; scanty interrupted sleep; quick, light movements. They should avoid foods that are light, cold, dry, and rough, e.g., nuts and dried fruits, beef, apples, pears, cruciferous vegetables, oats, corn, and rye. Instead they should eat warm oily foods; all dairy products; rice, wheat, honey, sugar, cherries, grapes, avocados, and coconut; and spices such as ginger, clove, cinnamon, and mustard seeds (Singh, 2005:33-35).

The vatta dosha in a person may become vitiated when its qualities are exacerbated, e.g., people who are vatta-predominant should not expose themselves to cold dry conditions or eat cold dry foods because this is also the same quality as their dosha and can lead to dry skin. Instead, these people should keep warm, use oils on their skin and eat foods of a warm, oily nature (Palep, 2004:71). When vatta is increased in

the body, it can lead to harsh or stuttering speech, emaciation, body aches, constipation, and insomnia. This can happen when a vatta-predominant person engages in excessive physical exertion; fasting; eating dry or stale food; exposure to cold, wind and extreme temperatures; fear and grief (Palep, 2004:70). Vatta disorders can also affect the mind and these lead to “obsessions, anxieties, fears, agitation, and even bipolar or schizophrenic conditions” (Angeletti, 2015:5).

Pitta dosha

This dosha is regarded as the second basic unit of living organisms and is responsible for digestive and metabolic processes (Singh, 2005:18; Palep, 2004:77). The elements making it up are jal and tej (water + fire) with the fire element providing the energy to enable these two crucial biological processes for life to exist. The properties of pitta are therefore linked to those of fire and water, viz., hot (Ushna), sharp (Theekshna), fluid (Sasneha), sour (Visram) and oily. This dosha is located between the umbilicus and heart, including the liver, spleen, blood, sweat and lymph glands, with its primary location being in the small intestine. Just as vatta is chiefly responsible for movement in the body, pitta is responsible for functions of transformation in the body and include heat generation, vision, appetite, thirst, softness of the body, intelligence, power of understanding, and complexion (Singh, 2005:21). Palep (2004:77) adds suppleness, lucidity, courage, valour, radiance and lustre to the functions. There are also five types of pitta dosha, but these will not be covered in this study.

The main function of pitta dosha is digestion and assimilation, and since the main area of digestion in the body is in the small intestine (duodenum), it is logical for this dosha to be located here. Digestion transforms food into a form that can be used by the body hence the pitta dosha is associated with transformations. However, the process of digestion would not be possible if there was no movement (peristalsis) in the digestive tract, and the pitta dosha is therefore under the control of vatta. As indicated in the section above, vatta dosha is the main dosha among the three. Pitta dosha is also responsible for the red colour of blood and red blood cell synthesis with the formation of haemoglobin, which requires the absorption of iron from the duodenum, the formation of haem in the liver and eventually the breakdown of red blood cells in the spleen.

The main characteristics of pitta-predominant people, include: clear memory and quick to understand; medium-sized body; soft and moderately-strong; fair reddish-toned skin with freckles; tendency for premature grey hairs and baldness; sharp penetrating eyes with reddish-yellow sclera; flabby joints; fetid body odour with foul smell in armpits; moderate and sound sleeper; eyes become red easily due to anger or sun exposure.

According to Angeletti (2015:5), pitta imbalances can also lead to mental conditions such as “narcissistic, domineering or anti-social behaviour”. These people should avoid foods that are hot and sharp-tasting – pungent, salty and sour; as well as almond, sesame, mustard and corn oils; grapes, olives, peaches, any sour fruit, garlic, ginger, pepper, most dairy products; beef, seafood and egg yolks. They should instead eat: cold sweet foods; milk and butter; soya bean products; olive, sunflower and coconut oils; sweet fruit; leafy green vegetables; sprouts, radish, cinnamon and coriander (Singh, 2005:21-22, 31-35).

People can cause a vitiation of their pitta dosha by eating foods of the qualities mentioned above, i.e., hot, pungent, salty, and sour. Undue exposure to heat; summer; being outside at midday; repression of the natural urges of thirst and hunger; excessive grief, fear, anger and jealousy also vitiate this dosha. Symptoms of decreased pitta vitiation include poor digestion, cold clammy feet, loss of radiance and lustre in the complexion (Palep, 2004: 79-80). Increased pitta vitiation include symptoms such as increased yellow coloration of eyes, skin, urine, and faeces; excess hunger, thirst, and insomnia; bitter and sour taste develops in mouth; fainting; increased signs of inflammation in the body – pimples, putrefaction, pus and ulcer formation (Vagbhata, n.d: 171).

Kapha dosha

The third basic constituent of the body is the kapha dosha and this is made up of the prithvi and jal elements (earth + water) (Singh, 2005:18; Palep, 2004:83). Qualities of the kapha dosha are therefore similar to those of earth and water, such as: “heavy (Guru), slow (Manda), smooth (Slakshna), white, thick, soft, unctuous (oily), stable, viscous and sweet” (Singh, 2005:22). The presence of prithvi gives kapha its solid, firm structure while the presence of jal gives it a fluid nature that nourishes and lubricates the constituents of the body it is concerned with. The kapha dosha is located

above the heart and, just as vatta is responsible for movement and pitta for transformation, this third dosha is responsible mainly for protection.

Due to the thick viscous nature of the kapha dosha, it adheres and binds cells, tissues and organs together so that they may remain firmly intact thereby giving the body structure and shape. The liquid aspect of the kapha dosha provides the brain and joints with lubrication and nourishment for their proper functioning, while it also allows fortitude, forgiveness, and greediness on a mental level (Singh, 2005:22). In addition, this dosha can bring about heaviness or obesity; well-defined muscles; increased libido; good stamina for exercise; high resistance to disease and ability to heal; strong, stable, smooth joints as well as courage, zest, virility, knowledge, understanding, and good long term memory (Palep, 2004:84).

Kapha-predominant people are usually those who are have a pleasant disposition, are more tolerant, and have a stronger immune system with a longer life-span than people who are more vatta or pitta predominant (Palep, 2004:85). However, imbalances can also lead to mental afflictions such as “passive, dependent and depressive conditions with psychomotor retardation” (Angeletti, 2015:5). They usually prefer pungent, bitter or astringent tastes and enjoy a deep sleep that can sometimes be excessive.

Since kapha-predominant people have the tendency towards obesity, they need to avoid sugary or excessively sweet or salty foods; most oils; wheat, rice and oats; sweet fruits; excess whole milk and other dairy products; seafood, beef and pork. Instead, their diet can consist of warm, light, dry, slightly oily foods with a pungent, bitter or astringent taste. They can have low-fat milk, Basmati rice, corn, barley and rye; honey; pomegranates, apples, pears, cranberries; eggplant, broccoli; and all spices (Singh, 2005:33-35). Certain conditions cause kapha vitiation and these include cold substances and temperatures; laziness and not exercising; slimy, oily foods that are heavy to digest; sweet, sour or salty tasting foods; and the other foods mentioned above that are to be avoided. Normally kapha has a white, heavy, slimy, sweet nature but when it is vitiated, it turns salty (Palep, 2004:85). When kapha increases it may result in heartburn; excess salivation; cold clammy limbs; looseness of joints; wet cough and drowsiness (Palep, 2004:84).

Location of doshas

As the discussion on doshas above mentioned, the tridoshas are distributed throughout the body but each of the three doshas has a specific location in the body:

1. Vatta → lower abdomen, specifically the large intestine
2. Pitta → between the umbilicus and the heart
3. Kapha→ above the heart

Ayurveda also believes that the tridoshas govern our lives at specific times in the day, night, when we eat and even in our lifespan. According to Vagbhata (n.d:4), “in a person’s life, day and in night (separately), the first part is dominated by kapha, second part is dominated by pitta and third part is dominated by vatta. While eating and during digestion, the first, second and third part are dominated by kapha, pitta and vatta respectively.” The effects of this can be seen in our lifespan – babies and children are growing so they are under the influence of the kapha dosha where their musculoskeletal system is forming and growing; pitta dosha comes into effect in adolescence when teenagers are transforming into adults, hence they have healthy appetites due to the digestive fire being at its most potent and they may often be prone to skin inflammations like acne. Middle-age and old-age under the vatta dosha influence cause greater prevalence of grey hair, hair-fall, and osteoporosis.

During the day, the Tridosha effect is seen from the morning when we awake from sleep and the kapha dosha is dominant – this is when we need to brush our teeth, clean our mouth and remove white plaque and sticky mucus (qualities of kapha); by midday we are under the influence of pitta dosha hence this is when we get hungry and are ready to have lunch – our digestive fires are at their highest; towards the evening, vatta takes over, our energy levels drop and we are ready for bed. At night, our sleep cycle follows the same pattern.

Digestion of food is also under the influence of the tridoshas. At the start of the digestive cycle kapha predominates because it ensures secretion of the liquids needed for digestion and moistening the food in the stomach. Thereafter, pitta dosha takes over by supplying digestive power in the duodenum to transform the food into nutrients for assimilation and the last part of the digestive process involves vatta which moves the digesting food towards the colon where gases and faeces are eventually produced.

It is therefore important that at each stage mentioned, the governing dosha is not vitiated in any way thereby bringing about sickness or diseases. An example is when we are hungry at midday, we should not suppress the urge to eat as this will result in pitta being disturbed and can result in ulcers. Another example is when it is evening and we should be preparing for sleep, it is not advisable to engage in vigorous prolonged exercise as this vitiates vatta dosha and can lead to insomnia. Eating a heavy meal at bedtime will also cause a vitiation of the vatta dosha as our digestive fires (pitta) are at their lowest at night, resulting in indigestion.

The discussion thus far shows that although Ayurveda originated in ancient times, it is still relevant in the present. The basic principles on which Ayurveda is based has not changed, only the context in which these principles are to be applied may need to be modified. This adds weight to the scientific nature of Ayurvedic practice and that it can indeed be included as part of the Life Sciences curriculum without danger of being seen as inferior knowledge. A later section will show how certain practical daily and seasonal regimes laid down by this ancient science can also be followed in modern times to prevent sickness and disease.

Sapta dhatus (Seven biological tissues)

At the start of this section it was stated that Ayurveda is based on the balance between the three doshas, dhatus, malas and the other constituents making up a person, i.e., mind, spirit and senses. Thus far, the doshas have been described in a fair amount of detail where it is apparent that all parts of the body are under the control of the doshas including the tissues (dhatus) making up the body. In Ayurveda, it is believed that there are seven basic tissues that support and sustain the body (Vaidyaratnam Foundation, 2017:11; Ravindran, 2002). These tissues are also described as the structural units of life and are also governed by the doshas (Palep, 2004:95). These will be explained in the ensuing paragraphs.

The digestion process eventually releases energy from food to form the substrate for the formation of these seven tissues (Palep, 2004:96). Once the food is digested, the most nutritious parts are used to form chyle which is in turn used to form lymph/ plasma (Rasa dhatu), the first tissue according to Ayurveda. Thereafter *Rasa* is used as a substrate for the other six dhatus as follows:

Sanskrit: Rasa → Raktha → Mamsa → Medas → Asthi → Majja → Shukra
English: Lymph/Plasma → Blood → Muscle → Fat (adipose tissue) → Bone → Marrow; brain → reproductive tissue and secretions

Once assimilation of useful parts of the food is done, the unabsorbed parts of the food are then excreted out of the body as malas (waste products). This will be discussed later.

The ancient Ayurvedic scholars proposed that these dhatus form sequentially in the order shown. The biochemistry and science behind this conversion has been clarified by Palep (2004:97-99) thus validating this principle of Ayurveda. For example, fat and bone are two different tissues and it seems far-fetched that the one could be converted into the other. However, the scientific explanation for this is that Vitamin D is needed for the calcification of bone and since this vitamin is a sterol, it is lipid in origin.

Another example provided by Palep (2004:109) is that of the formation of the reproductive tissues from all the other tissues in turn. He explains that at puberty there is a rapid growth rate for fat, bone and marrow especially the formation of yellow bone marrow from red bone marrow in long bones. This increase in fatty yellow marrow contributes to the increase in gonadal oestrogen production thus triggering the start of the menstrual cycle in females.

Each dhatu has all three doshas (i.e. is Tridoshic) but is under the control of one main dosha such that any dosha vitiation will lead to a corresponding upheaval in that dhatu. Rasa, mamsa, medas, majja and shukra are controlled by the kapha dosha; raktha dhatu is controlled by the pitta dosha while asthi is controlled by vatta dosha. The link between the doshas and dhatus is important in the diagnosis and treatment of diseases. When the kapha dosha is increased, it leads to obesity (increased fat deposition) while increased obesity leads to a vitiation of the kapha dosha. Similarly, most blood disorders are as a result of pitta vitiation or conversely, when pitta dosha is increased, it can lead to inflammatory types of conditions, e.g., abscesses or boils on the skin. The increase in vatta dosha can lead to bone disorders (osteoporosis) as mentioned earlier.

Dhatus - links to CAPS Curriculum

The discussion of the biological tissues has direct relevance to the Life Sciences CAPS curriculum as these are dealt with under the topic on Mammalian Tissues from Grade 10. In this initial stage of the FET (Further Education and Training) phase, the Life Sciences curriculum looks at the basic organisation of an organism starting with molecules, then cells, tissues, organs and systems. The tissues in the Grade 10 curriculum that have relevance to the dhatus are blood, muscle, fat, bone, and nervous tissue where learners can see that these tissues are regarded with great importance by Ayurvedic science while still having relevance in modern times. This should in turn give the other aspects of Ayurveda greater credibility for learners to accept.

CAPS (DBE, 2011:28) stipulates the following as "Applications of Indigenous Knowledge Systems and Biotechnology:

- Traditional technology, e.g., traditional medicines and healers;
- Medical biotechnology, e.g., immunity, vaccines, antibiotics and blood transfusions; and
- The cloning of plant and animal tissues and stem cell research (ethics and legislation)."

While making provision for the inclusion of indigenous knowledge, the document is not prescriptive in terms of which indigenous knowledge to use. This then leaves room to include Indian indigenous knowledge as an example of "Traditional technology" and examples of this will be covered later on in this section. The reproductive tissues are dealt with in detail in the grade 12 syllabus. This includes the process of Gametogenesis in males and females as well as the menstrual cycle. In Ayurveda, the seventh dhatu is Shukra or reproductive tissue encompassing both semen formation and menstruation.

When learners are introduced to the Tridosha theory, they can also learn about the link to the tissues and this can help them see a link between diseases and certain behaviours. An example of this is that Parkinson's disease results when the vatta dosha is vitiated because as mentioned earlier, this dosha is responsible for the

initiation, regulation and coordination of movement in the body (Singh, 2005:20). This can then allow better contextualisation of the curriculum for the learners. Further links to the curriculum will be made later on in this section.

Malas or waste products

The Life Sciences curriculum explains that excretory products are formed during the normal process of metabolism and digestion of food. Ayurveda refers to these excretory or waste products as the malas and like Life Sciences, it recognises three malas that are formed in the body, viz., sweat (sweda), urine (mutra) and faeces (pureesha). The point of departure is that in the curriculum, emphasis is placed on the production of these waste products alone, whereas Ayurveda also places great importance on their proper elimination to maintain good health. If there is excessive elimination or retention of any of these malas it may result in disease (Singh, 2005:24).

Ayurveda views the elimination of these malas as natural urges that should not be suppressed, e.g., an imbalance of electrolytes and dehydration can result with excessive sweating; severe diarrhoea and excessive urination in people with diabetes insipidus (Palep, 2004:173). Suppression of the natural urges to eliminate these malas or if the body is unable to eliminate them due to other reasons, can lead to afflictions and disease, e.g., constipation causes not only pain and discomfort to the lower abdomen but is also the precursor to many diseases (Palep, 2004:174); suppressing the urge to urinate can lead to urinary tract infections and incontinence of the internal bladder sphincter (Palep, 2004:175); preventing sweat production (by use of certain toiletries) can lead to sweat pores and ducts being blocked. According to Palep (2004:176), ubiquitous pathogens can thrive in areas of the body where “the various micro and macro channels” are blocked thereby causing infection and disease.

Malas - links to CAPS Curriculum

The excretion of faeces is included in the grade 11 Life Sciences curriculum under the topic of Human Nutrition. However, it is dealt with superficially and no attention is placed on the health effects of improper elimination. Including Ayurveda into the lesson can therefore provide learners with useful information that can promote their good health. The Grade 11 curriculum also covers the topic of urine production under the topic of Excretion in Humans where the urinary system and urine production is dealt

with in sufficient detail. Diseases caused due to suppression of the urge to urinate are not mentioned and once again, the integration of the malas in Ayurveda can contribute to giving learners this insight. Sweat production is not dealt with in the curriculum but sweating is mentioned in the grade 12 curriculum under the topic of Homeostasis and Thermoregulation. The diseases linked to excessive sweating or suppressing sweat production can be described so that learners are aware that this could be problematic for their health.

Agni or digestive power

The fifth basic principle of Ayurveda is that of Agni or digestive fire. Ayurveda places great importance on food, how we taste food, its digestion, elimination from the body and effects on the body. To this end, there are at least four chapters dedicated to food alone in the Ashtanga Hrdaya (Vagbhata). The literal meaning in Sanskrit of Agni is 'fire' and Ayurveda uses the same term to describe all the digestive and metabolic processes in the body. Although earlier, it was explained that digestion and assimilation is under the control of the pitta dosha, this dosha is only able to perform its functions due to the presence of Agni.

In fact, Ayurveda recognises thirteen different types of Agni: one in each of the FIVE Mahabutha (basic elements); one in each of the SEVEN dhatus (tissues); and ONE in the stomach responsible for digestion and all the other types of Agni depend on it (Palep, 2004:95). This last one is called Jatharagni (Singh, 2005:26) because of its location in the stomach and is the one that is the focus of this section. Palep (2004:96) offers a scientific account for the action of Agni by explaining that through combustion it "breaks the atomic bonds in food and releases the energy necessary for forming the substrate for development of different tissues," thereby revealing how molecules (elements) become dhatus (tissues). More specifically, Palep (2004:96) explains that after digestion, nutrients are absorbed from the intestine, assimilated into the blood as chyle which becomes rasa dhatu (first of the tissues – dhatus) and then all the other dhatus form sequentially from this one. This process represents the process of anabolism in the body where various tissues and organs are formed (Singh, 2005:26).

Ayurveda also has the concept of Ama which means the undigested parts of food that result when Agni is disturbed (Singh, 2005:27). The consequence of this is that

partially digested substances are then absorbed and assimilated forming abnormal rasa dhatu, leading in turn to a vitiation of the body tissues and ultimately to disease. Ayurveda therefore considers the root cause of disease and attempts to rectify this from the source rather than treating symptoms only which is what most Western medicine does. The presence of Ama in the body manifests in lethargy, fatigue, salivation, indigestion, constipation and bloating (Singh, 2005:27). There are also various methods prescribed in Ayurveda to avoid the production of Ama and these will be covered in the next section.

Agni - links to CAPS Curriculum

As explained in the previous paragraph, Agni refers directly to the digestive process, a topic covered in some detail in the grade 11 Life Sciences curriculum under the section of Human Nutrition. Following from this is the topic of Energy Transformations including Cellular Respiration where the aspects of assimilation, anabolism and tissue formation can be brought in from Ayurveda. The curriculum does not deal explicitly with these processes but it will be interesting to show learners how Indian indigenous knowledge is able to explain them. In addition, the concept of Ama can also be introduced for learners to see the importance of digestion occurring correctly and the way certain foods, or poor dietary habits, can lead to sickness by vitiating specific doshas. It will also be beneficial for learners to know what their predominant dosha is so that they can be more discerning with their diet, thereby preventing many health issues.

Thus far, it has been shown that Ayurveda is based on five basic principles, i.e., the panchamahabhuta; the tridoshas; the Saptadhatus, the trimalas; and Agni. These provide a background for the premise of Ayurveda to diagnose and treat people suffering from various afflictions and conditions. These five principles can however also be used to prevent diseases from manifesting in the first place and the next section deals with some of the preventative measures suggested by Ayurveda.

D. Preventative regimes in Ayurveda

The premise of Ayurveda lies in the prevention more than on the treatment of illness and disease. There are precise procedures laid down in the Ashtanga Hrdaya (Vagbhata, Ch. 2; 3) that people should follow on a daily and seasonal basis in order

to maintain good health of the mind, body and spirit. The Ayurvedic terms for these daily and seasonal routines are dinacharya and ritucharya respectively, and they were followed naturally by our ancestors to keep the body in tune with the natural rhythms of the earth, moon and sun (Vaidyaratnam Foundation, 2017:16). Although nowadays, we are preoccupied with our jobs, the fast-paced world, junk food and other modern 'conveniences,' Ayurveda is able to remind us of what our habits should be so that we can avoid dosha vitiation and the resultant diseases forming.

As mentioned previously, Ayurveda is an ancient science but is still relevant today by encouraging people to develop routines as a way of getting back in tune with natural rhythms that govern our natural urges (Vaidyaratnam Foundation, 2017:16). There are three natural bodily functions regarded by Ayurveda as the Three Pillars of Life and these are food, sleep and sexual energy, which when attuned to nature will in turn allow the subtler rhythms to also be aligned, thereby enabling good health.

The following routine is prescribed for Dinacharya:

- For good health, people are encouraged to awaken from sleep during the time of Brahmi Muhurtha, i.e., before dawn, or around 45 minutes before sunrise, around 5 to 6 am. The last three hours of the night – from 3 am to 6 am – is known as Brahma Muhurta (Vagbhata, n.d: 16). This time is ideal because the atmosphere is fresh and pleasant and it is "the time apt for perceiving knowledge" (Sreekumar, 2015:64).
- This is also the time to attend to the natural urges of the bowel and bladder and also determine whether the food eaten the previous night has properly digested or not.
- The teeth and mouth should then be cleaned – this will "eliminate bad odour, inability to perceive taste and sludge deposited over teeth, tongue and mouth and improves taste" (Sreekumar, 2015:64). Earlier, when the kapha dosha was explained, it was mentioned that there is an accumulation of this dosha in the morning hence the need to brush the teeth and clear the throat of mucus, etc. This part of the daily routine therefore removes the build-up of kapha. In ancient times, twigs of particular plants were used as toothbrushes. Nowadays, some cultures still do use twigs, including in many parts of rural India. The tongue should also be

cleaned by scraping with special straps to reduce tongue swelling, stiffness, enhance taste and remove bad odour as well.

- Thereafter, gargling is prescribed using a liquid such as water, oil or herbal decoctions. The benefits include: strengthening muscles and jaws, improving voice quality, nourishes the face, removes effects of kapha dosha, and increases perception of taste.
- Application of collyrium (medicated eyeliner) to the eyes for protection against eye diseases. Special herbs are burnt, the soot is mixed with certain oils and the paste is then applied to the eyes like modern eyeliner would be. This is said to improve vision by clearing the eyes off excess kapha and giving lustre to them (Vaidyaratnam Foundation, 2017:16).
- Medicated smoke inhalation to clear the channels in the head and also to eliminate excess kapha dosha. Nowadays this is used only to treat certain ailments, e.g. sinusitis and headaches.
- Medicated oils, saline drops or particular plant juices are then administered into the nostrils to ensure peace of mind, proper functioning of all the sense organs and eventually sound sleep.
- Exercise is an important part of Dinacharya and daily walking is advisable to increase the lifespan, strength and intelligence, enhances peristaltic movement and digestion.
- Massage – using oils – for the whole body to delay the onset of ageing, promotes skin rejuvenation, relaxes the body, increases blood circulation and skin complexion and nourishes the skin when the oils are absorbed. Should it not be possible for the whole body to be massaged, the feet and head should at least be massaged.
- A bath should then be taken to improve body strength, relax the body; remove excess sweat and foul body odour.
- The type of clothes to be worn is also suggested – clean, comfortable clothes suitable to the climate that will increase confidence as well (Vaidyaratnam Foundation, 2017:17-19).

In the fast-paced world we currently find ourselves in, our lifestyles may not make it possible to complete all these prescribed rituals daily. Instead, the most practical ones

should be followed so that the body becomes accustomed to the particular routine and we attune our bodies as closely to natural rhythms as possible. When these daily regimes are described to learners during the integration of indigenous knowledge into the lesson, it should be done with the intention of showing them the reasons for the different actions we perform daily upon awakening. Ultimately these will contribute to maintaining good health.

Seasonal regime or ritucharya is prescribed in Ayurveda as well. This will be described briefly so that the general idea is seen. Humans need to align their body with the climate and weather of the region they live in. Cold temperatures in winter necessitate that warm, nourishing foods are eaten because the digestive fires are at their highest. Ayurveda does not advocate for vegetarianism so it is during winter that meat dishes are recommended together with consuming alcohol but in moderation. Vatta dosha is increased in winter; therefore, there should be an increase of kapha tendencies such as warming the body and eating warm to hot foods that will add kapha-like properties to the body.

The opposite is applicable in summer when temperatures are warmer. This is when the kapha dosha is increased and needs to be counteracted by engaging in vatta-increasing habits such as eating cooling, easily-digested foods. Alcohol consumption is discouraged except in small quantities. Day-time sleeping is also advocated, unlike in winter when it is discouraged. Both dinacharya and ritucharya show that the human body is very closely aligned with natural rhythms and that these rituals serve to accentuate this alignment to bring about good health and the absence of illness and disease. It is therefore important to show learners that according to Indian indigenous knowledge there is a precise manner in which people ought to live to achieve harmony of the mind, body and spirit by avoiding ill-health.

E. Food combinations in Ayurveda

As mentioned in the previous section, food and eating habits are one of the three pillars of life in Ayurveda, together with sleep and sexual energy. Together with suitability to one’s dosha, a great deal of emphasis is also placed on the types of food eaten as well as the time to eat, the quality of the food and its preparation, the quantity eaten, and in what combination to eat certain foods.

When considering the time to eat, Ayurveda pronounces that the most important factor to observe is that one eats only when the previous meal has been digested, usually apparent when there are feelings of hunger and thirst, enthusiasm to eat and an overall feeling of lightness (Singh, 2005:64). The negative effects of some foods on the body can be alleviated by changing the preparation method, e.g., yoghurt may cause oedema but when churned into buttermilk it relieves oedema (Singh, 2005:65). Food should also be freshly prepared and Ayurveda advocates against regularly eating left-over food or together with fresh food as this will make digestion more difficult. The recommended quantity of food eaten is that if the stomach is divided into three parts, then 1/3 should be filled with food, 1/3 with liquid and 1/3 should be kept empty to allow for effective peristalsis and therefore digestion (Singh, 2005:67; Lad, 1997:2).

There are numerous food combinations shown by Ayurveda to be harmful to the body and can lead to disease if eaten frequently. However, for the purposes of illustration, only a few of these are mentioned here (see Table 2.5).

Table 2.5: Table showing a few food combinations not recommended in Ayurveda (adapted from Vaidyaratnam Foundation, 2017)

Main Food	Should not be combined with…
EGGS	Milk, curd, cheese, bananas, fish, meat
BEANS	Milk, curd, meat, fish, fruit, eggs, cheese
LEMON	Cucumber, tomatoes, curd, milk
CUCUMBERS	Potatoes, eggplant, tomatoes
MILK	Sour fruit including citrus, melons, curd, cheese, fish, meat, bread and salt

The reasons given by Ayurveda are that incompatible food combinations can result in the digestive process becoming overloaded leading to an inhibition of secretion of certain enzymes which in turn leads to toxin formation. When eaten separately however, each of the foods can actually stimulate the digestive power making digestion and nutrient absorption more effective (Lad, 1997:1). For example, when milk is consumed together with curds, citrus or sour fruit, it can cause the milk to curdle

increasing acidity; milk and fish should not be eaten together because milk is cooling while fish has a warming effect and together it can result in an accumulation of toxins.

Milk and melon combination is also not suitable as milk takes a longer time to digest and can curdle; similarly, fruit and starchy foods like potatoes should not be combined as the fructose digests quicker than the starch. Honey is a highly nutritious beneficial food but only when eaten raw, it should never be cooked or heated because it then becomes a non-homogenised mass that digests slowly, blocks the mucous membranes and produces toxins (Vaidyaratnam Foundation, 2017; Lad, 1997:2).

Ayurveda also recommends proper chewing of food so that the digestive process is smoother while cold drinks or foods (e.g. ice cream) should not be consumed after a meal as it will cool the digestive fire and slow down the digestive process. However, many of the negative effects of poor food combinations or habits may be counteracted by people who exercise regularly, who have good digestion power and in strong, young people (Vagbhata, 7 (47):109). In addition, certain spices may be added to foods to enhance digestion, such as, asafoetida, cumin, coriander, pepper, cardamom or drinking ginger tea or chewing on some grated ginger after meals. In some cases, digestion is increased by sipping on warm liquids during or after a meal rather than having cold drinks that will reduce the Agni

The various factors described above contribute significantly to maintaining good health by avoiding dosha vitiation and consequently the onset of disease. The combination of foods is an important element in the maintenance of good health as it concerns the digestive power (Agni) in the stomach and intestines where food is broken down into nutrients and then sent to the rest of the cells and tissues in the body to maintain all the body functions (Lad, 1997:1).

Food combinations – links to the Curriculum

During Life Sciences lessons, this aspect of Ayurveda may be integrated into the curriculum to show learners the value of eating the right foods in the right combinations, of exercising regularly and eating wholesome foods. Usually the curriculum requires that learners are taught the importance of a balanced diet to

include certain proportions of foods from different food/ nutrient groups (carbohydrates, proteins, vitamins, fats and oils) for a healthy body.

The Ayurvedic principles described in this section show that food combinations as well as other eating habits are just as important for good health. The aspects of nutrients, the process of digestion and the effects of certain foods on the body are dealt with in the curriculum in grade 10 in the module on Biological Compounds and Molecules and grade 11 in the Digestive System, respectively. This will make those topics more relevant for learners who could then understand why it is important for them to be more mindful about what and how they eat. As discussed in an earlier section, this in turn can enhance conceptual change for learners so that they can understand scientific concepts better.

F. Plant-based Ayurvedic remedies

According to Ayurveda, every plant on Earth has some use for humans (Vaidyaratnam Foundation, 2017). In ancient times, people used to observe animals to see what plants they ate and the effects on them. In this way, people gradually developed a repertoire of treatments that they could use for various ailments and diseases. A few of these will be described in this section, notably that of turmeric and garlic.

The scientific name for turmeric is *Curcuma longa* and it has a multitude of uses both as a medicine, cosmetic agent and as a culinary ingredient. As a medicine, it is dried, ground into a powder and used for skin ailments such as allergies and eczema because of its anti-inflammatory and antiseptic properties. The powder "is extensively used in Ayurveda, Unani, and Siddha medicine as a home remedy for various diseases" (Ravindran *et al.,* 2009:495). It can also be used as a constituent in a type of Ayurveda massage as one of various dried powders rubbed onto the body to improve skin colour and complexion. In the kitchen, turmeric is used as an ingredient in many cuisines where it imparts a distinct yellow colouring to dishes.

The active ingredient in turmeric is Curcumin which has been scientifically shown to have the properties highlighted above (Singh, 2005:96). A piece of dried turmeric root is often burnt and the smoke inhaled as part of one's Daily Routine (Dinacharya) – outlined above. In addition, consuming turmeric has cancer-fighting properties as well

as ensuring a healthy nervous system. Ravindran *et al.* (2009:497,503) reported that "Curcumin has been shown to inhibit the proliferation and survival of almost all types of tumour cells" while also being able "to kill tumour cells and not normal cells." These researchers also concluded that since curcumin uses several mechanisms to kill tumour cells, they "may not develop resistance to curcumin-induced cell death" (Ravindran *et al.*, 2009:503). In this way, modern scientific studies corroborate ancient Ayurvedic knowledge and give reason to include such herbs in the diet. In fact, turmeric "is consumed frequently by people from southeast Asia, a continent with low incidence of most cancers" (Ravindran *et al*., 2009:495).

Ayurveda also places great importance on *Allium sativum* (garlic) as a medicine. It contains a potent antibiotic called Alinin which has anti-fungal, antiseptic, and antiviral and a host of other functions in the body. Garlic inhibits the growth of *Staphylococcus, Escherichia proteus, Salmonella providencia, Klebsiella, and Mycobacterium tuberculosis* amongst others. Pharmacological studies show that when it is eaten, garlic has several benefits for the body such as reducing serum triglycerides and low-density lipoproteins (LDL) while increasing high-density lipoproteins (HDL) and reducing blood clot formation, thus helping to prevent heart diseases and stroke (Singh, 2005:82).

Garlic and turmeric have traditionally been used as culinary ingredients by Indian people for generations and only recently have studies revealed that the numerous benefits to the body have a scientific basis. This gives impetus to integrating such indigenous knowledge into lessons to show learners the relevance and value of using certain ingredients in cooking. Indian learners, in particular, will then be able to appreciate their own culture and indigenous knowledge. The Life Sciences curriculum currently mentions cancer and a few illnesses caused by pathogenic microorganisms, e.g., tuberculosis, food-poisoning, but treatment is shown to be limited to Western pharmaceutical products. Incorporating indigenous knowledge such as this into the curriculum allows learners to realise that more natural remedies are readily and cheaply available with fewer side effects.

Although the value of the active ingredients of these plants has been described above, caution must be expressed that these are not the deciding factor of their healing

capacities (Green, 2008:52). Instead, the combination of relationships between society and the environment, including with the plants themselves all contribute to the curative abilities of each plant. Green (2008:52) explains further that the human context in which these plants grow allows people to reconnect with nature thereby relieving “the alienating experience of contemporary urban life and labour”. This view reinforces the indelible bond existing between humans and nature that renders the mere swallowing of pills insufficient for treatment, thus also confirming the holistic premise of Ayurvedic practice.

Indian indigenous knowledge or Ayurveda has a plethora of other such herbal remedies used as common cooking ingredients, but these will not be discussed in this study. Ancient followers of Ayurveda were able to incorporate them into food during preparation so that regular consumption could prevent illnesses and ensure a healthy populace. In this way, one of the premises of this ancient science, i.e. prevention rather than treatment, could be sustained.

G. Treatment regimes in Ayurveda (panchakarma)

Although Ayurveda is primarily based on the prevention of disease, very often the onset of disease or ailments are unavoidable especially when doshas are vitiated by the stresses of daily life and other circumstances that arise. Ayurveda has devised a detailed system to diagnose and then treat these illnesses so that ultimately good health is maintained once more. At the same time, it must be mentioned that “Ayurveda does not claim to be able to cure all diseases” (Singh, 2005:3) but tries to understand the cause of many of them so that some relief can be provided to the patient.

Since food and digestion is one of the pillars of Ayurveda, it is then reasonable to expect that diagnosis and treatment will also revolve around these aspects of a person’s lifestyle. Diagnosis of an ailment occurs by also considering factors such as sleeping habits, activity levels, stressors in the environment, etc. All these factors are examined before the practitioner looks at the disease itself. In this way, the cause of the condition is identified or speculated so that treatment can be based on alleviating the cause rather than on treating the disease alone. In this way, a relapse of the disease can also be avoided.

Ayurveda has devised a five-pronged approach (panchakarma) to treatment that ultimately leads to the purification or detoxification of the body, viz., emesis; purgation – decoction enema; oily enema; nasal administering of medication; and bloodletting (use of leeches) (Vaidyaratnam Foundation, 2017). The panchakarma treatment process serves not only to treat existing ailments but is also used as a preventative measure in healthy people to avoid contracting a sickness or condition as seasons change (Singh, 2005:156). Each of these treatments must also take into account the predominant dosha of the person to avoid further disruption (vitiation) of that dosha which could in turn aggravate the condition.

Similar to Western or modern treatment is that Ayurveda also has preparatory measures before the actual procedure which is then followed by the necessary post-operative care. However, unlike Western medicine which is a quick once-off operation with a long, painful recovery period in most cases, Ayurveda detoxification procedures take longer to administer (usually over a few days and sometimes weeks) and patients suffer mild to no ill-effects with "little chance of recurrence of the disease" (Singh, 2005:157; Vaidyaratnam Foundation, 2017). The five-pronged treatment modality is most often used to treat chronic diseases such as arthritis and irritable bowel syndrome (IBS).

In Western medicine, the symptoms of both these conditions are treated by the daily intake of expensive medication that leads to harmful side effects especially affecting the liver and kidneys. It is therefore important to show learners that Indian indigenous knowledge has more affordable and longer-lasting treatment methods that can minimise these conditions from the source rather than alleviating the symptoms alone.

Summary of Ayurveda Principles

This was a fairly detailed account about the ancient science of Ayurveda with reference to the modern world as well as for its integration into the Life Sciences curriculum in South Africa. The premise of Ayurveda lies in the five basic principles: panchamahabhuta (five elements); three doshas (vatta, pitta and kapha); seven dhatus (body tissues); three malas (waste products); and the digestive fire (Agni). The vitiation (disturbance) of the doshas, which occur in varying proportions in people,

leads to illness and it is necessary in Ayurveda to maintain good health by avoiding activities that will cause these vitiations.

Ultimately, the basis of Ayurvedic practices lies in the prevention of illness so that the mind, body and spirit can exist in harmony. To this end, Ayurveda has laid out a detailed and precise series of daily and seasonal regimens that should be practiced to keep our body and mind in tune with the cycles and rhythms in nature. Considerable emphasis is also placed on eating, types of foods to be eaten based on one's predominant dosha, digestion and elimination of waste products. Detailed treatment methods including diagnosis of conditions are also prescribed in Ayurveda using natural techniques and herbal remedies that are specific to individual patients. Table 2.6 summarises the basic Ayurvedic principles to show how these can fit into the Life Sciences curriculum.

Table 2.6: Table summarising Ayurvedic principles and links to the SA Life Sciences curriculum

<table>
<tr><th>Pancha mahabhuta (Element)</th><th>Dosha</th><th>Dhatu (Tissue)</th><th>Relevance to curriculum</th><th>Malas (Waste)</th><th>Relevance to curriculum</th><th>Agni (Biological fire)</th><th>Relevance to curriculum</th></tr>
<tr><td>Akasha – ether</td><td rowspan="2">VATTA</td><td rowspan="2">Asthi (bone)</td><td rowspan="4">Mammalian Tissues (Grade 10) – Blood, muscle, adipose);

Skeletal system (Grade 10) - bone and bone marrow;

Lymphatic system (Grade 10) - lymph;

Human Reproduction (Grade 12) – reproductive tissues</td><td>faeces</td><td>Digestive system – Grade 11</td><td>Digestion</td><td>Digestive system – Grade 11</td></tr>
<tr><td>Vayu – air</td><td>urine</td><td>Excretory System – Grade 11</td><td>Metabolism</td><td>Energy transformations (Respiration) – Grade 11</td></tr>
<tr><td>Teja – fire</td><td rowspan="3">PITTA

KAPHA</td><td>Raktha (blood)</td><td rowspan="3">sweat</td><td rowspan="3">Homeostasis, including Thermoregulation – Grade 12</td><td colspan="2" rowspan="3"></td></tr>
<tr><td>Jal – water</td><td rowspan="2">Rasa (lymph); mamsa (muscle); medas (adipose); majja (bone marrow); and shukra (reproductive tissues)</td></tr>
<tr><td>Prithvi – earth</td></tr>
</table>

It is envisaged that once learners are sensitized to the healthy lifestyle practices advocated in Ayurveda, they will be more aware of how to achieve good health, avoid disease and contribute more positively to society. As indicated by Martins (2011:507), this self-awareness then leads to self-healing. Ultimately, it is also imagined that if people become aware of this mind-body relationship, several of the problems plaguing humanity today could be solved holistically – including environmental pollution, the ensuing diseases, human conflicts and lack of resources (Martins, 2011:507).

Yoga

One of the aspects of a healthy lifestyle put forward in Ayurveda is that regular exercise should be included in one's daily regime to add strength, longevity, enhance digestion and even counteract the effects of incorrect food combinations or eating habits. Another type of Indian indigenous knowledge is yoga, which originated in ancient India, and has been practised for over two millennia and "is considered to be a philosophy, a science and art" (McGilvery *et al.*, 2001:172). Like Ayurveda, it is also made up of eight branches, each of which is important in yoga practice:

- Five universal rules to create a better world: non-violence, truthfulness, not stealing, leading a godly and chaste life, absence of greed.
- Five personal rules: cleanliness, contentedness, self-discipline, self-study, study of the scriptures, dedication to God.
- Practice of postures (*asana*).
- Practice of breath control (*pranayama*) and techniques.
- Detachment from worldly activities or a non-attachment towards body and mind.
- Concentration of the mind.
- Meditation to achieve inner peace.
- Trance or state of bliss/ absorption in a subject or in God.

(Adapted from McGilvery *et al.,* 2001:173)

For the purposes of my study only the third branch (the practice of postures) will be considered as being relevant for integration into the Life Sciences curriculum.

However, it must be mentioned that the remaining branches are also necessary for the good health of both mind and body, as pronounced in Ayurveda.

M.K. Gandhi (regarded as the Father of the Nation in India) “urged Indians to rejuvenate and restore the health of the nation first by healing themselves”. His sentiments are echoed in present-day India by Ramdev, “an influential proponent of alternative medicine” (Chakraborty, 2007:1173) and staunch yoga devotee who attests to the benefits of yoga to achieve a healthy population. He believes that this depends on individuals who take control of their own “bodies and souls and presents fitness as psycho-spiritual well-being rather than as merely physical well-being” (Chakraborty, 2007:1177). His view of yoga therefore alludes to the link between mind and body advocated by Ayurveda and one of the hallmarks of eastern traditional medicine described in the previous section.

There are several postures or Asanas in yoga that build strength, increase heart health, build stamina, and achieve self-discipline. Aspects of yoga can be integrated into the Grade 11 Life Sciences topic **Support Systems in Animals**. The description and practice of each Asana involves the naming of specific muscles, bones and even joints in some cases. Performing certain postures serve to stimulate the functioning of particular glands, e.g., the shoulder stand serves to stimulate the thyroid gland; twisting postures allow a detoxification of the liver. This could then enable learners to remember these terms while also highlighting exercise techniques to improve posture, muscle tone and the other functions mentioned earlier. For many learners who participate in sport at school, this could be an important way to incorporate knowledge from the Life Sciences classroom into the sports field.

In this way, yoga postures as a form of Indian indigenous knowledge can also be infused into the curriculum so that all learners may benefit both from remembering terminology and learning an alternative type of exercise. This is a valuable way to also encourage unity in diversity among children in multi-cultural classes in South Africa.

2.4.7.4 *Doctrine of signature*

> The wild woods were full of creatures whose value was written on each of them in the language of signatures, if the seeker for simples could only manage to decipher the label with which it had been considerately tagged at the creation.
>
> (Eggleston, 1901 cited by Bennet, 2007:246)

The doctrine of signature was a method used by doctors from ancient times in order to determine the ability of various plants to treat ailments based on their colour and shape (James, s.a.). This is true of African Medicine as well, and is not only a characteristic of Ayurveda. The earliest documented record was found in the Roman Pliny's manuscript of Natural History that referred to the 'pseudoscientific' Doctrine of Signatures almost 2000 years ago. In the 1500's the German-Swiss doctor, "Paracelsus, the greatest DOS *(Doctrine of Signature – italics my own)* proponent, and his followers espoused the position *similia similibus curantur* (like cures like). He believed that God provided signs within plants to indicate their uses" (Bennet, 2007:248). This notion of the doctrine of signature therefore, originally began as a 'spiritual philosophy' (James, s.a.) to confirm that God had clearly marked all His creations with His signature, as the extract by Eggleston above shows. However, indigenous people all over the world from ancient times have been using this method to build their repository of herbal remedies. Bennet (2007:246) mentions North American Indians, ancient Greeks, people from the Middle East and Oriental countries who "entertain a profound belief in the doctrine of signatures".

A visit to the Vaidyaratnam Ayurvedic Museum in Kerala, India reveals that the doctrine of signature was also used extensively in ancient India by prehistoric tribes who migrated down from the mountainous regions of the Himalayas. This was seen to be a precursor to Ayurvedic practice. In fact, according to Gopal *et al.* (2014:33), "the underlying presupposition in Hinduism is the presence of God in nature". Since Hinduism is a religion that originated in ancient India, this reaffirms the doctrine of signature as originating as a 'spiritual philosophy' even in the East. Modern science has found evidence to support many of the beliefs held by these traditional people of the world. A few examples to illustrate the doctrine of signature follows (adapted from Bjerklie, 2003). (Refer to Figure 2.10 thereafter for photographic examples.)

Carrots – have traditionally been said to promote good eyesight. In fact, a carrot sliced in cross section resembles the anterior view of the human eye. According to science, eating carrots greatly enhances blood flow to the eyes. Carrots owe their orange colour to a plant chemical called beta-carotene, which reduces the risk of developing cataracts, while also protecting against macular degeneration an age-related sight problem that affects 25% of people over 65. Merely taking tablets containing beta-carotene do not have the same effect as eating carrots, according to scientists at the John Hopkins Hospital in Baltimore, USA.

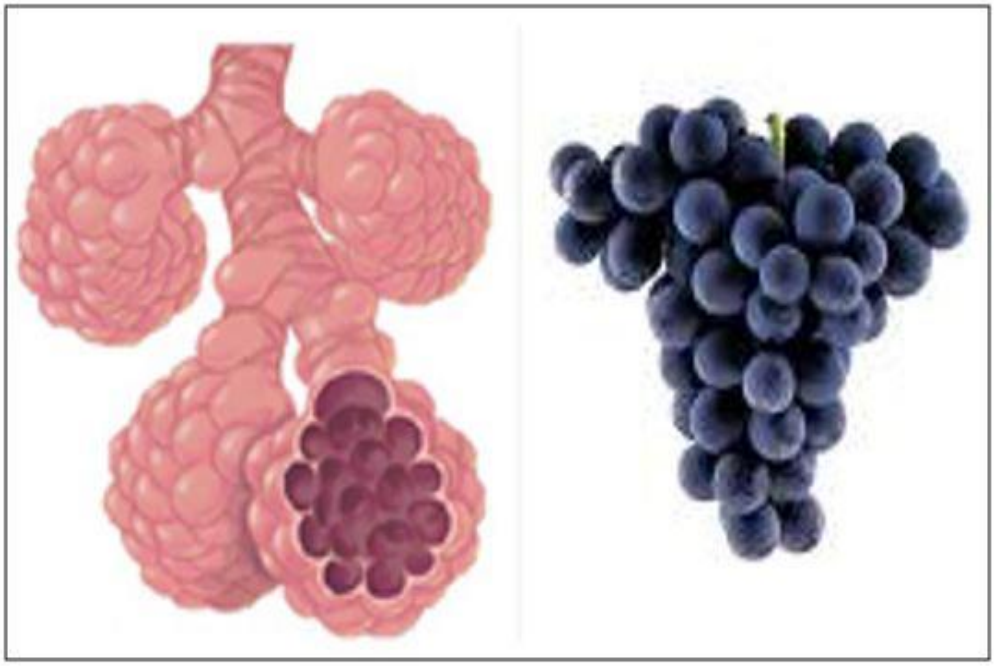
Broccoli – close examination of the tiny green tips on a broccoli head looks like hundreds of cancer cells. Researchers at the US National Cancer Institute found that a weekly serving of broccoli could reduce the risk of prostate cancer by almost 45%.

Eggplant, avocadoes and pears – are important for uterine and cervical health and functioning in females – they also resemble these organs. Research shows that when a woman eats one avocado a week, it balances her hormones, sheds unwanted birth weight and prevents cervical cancer. Interestingly, it takes exactly nine months to grow an avocado from blossom to ripened fruit! There are over 14,000 photolytic chemical constituents in each one of these foods of which modern science has only studied and named about 141 of them.

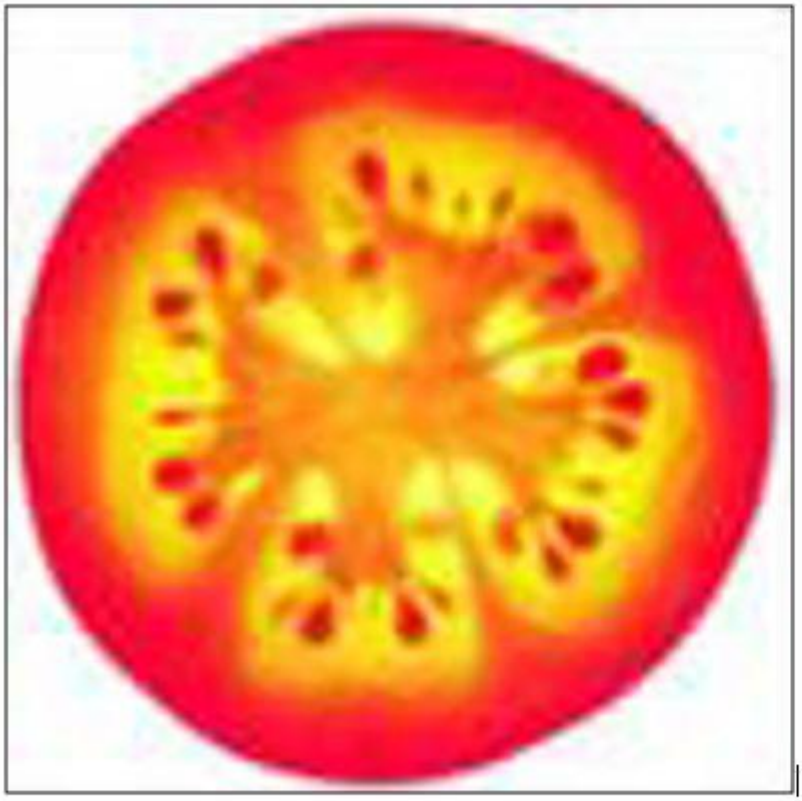
There are numerous other examples of fruit and vegetables that adhere to the doctrine of signature and have been verified by modern science to actually contain chemicals that bring about the functions offered by ancient people. Including such vignettes from the doctrine of signature in Life Sciences lessons would stimulate learners' interest in the lesson while also making them more discerning of healthier food choices in their everyday lives. Refer to the photographic plates in Figure 2.10 for a few illustrated examples.

This would then make the science lesson more relevant while giving them a more positive learning experience (De Beer & Whitlock, 2009:210). Since most classrooms in South Africa are made up of learners from many cultures, it will be necessary for teachers to include examples representative of these cultures so that the "social identity" of all learners is recognized.

Broccoli – the close-up of tiny green tips on a broccoli head looks like 100's of cancer cells. A team of researchers at US National Cancer Institute found that a weekly serving of broccoli was enough to reduce the risk of prostate cancer by 45%.

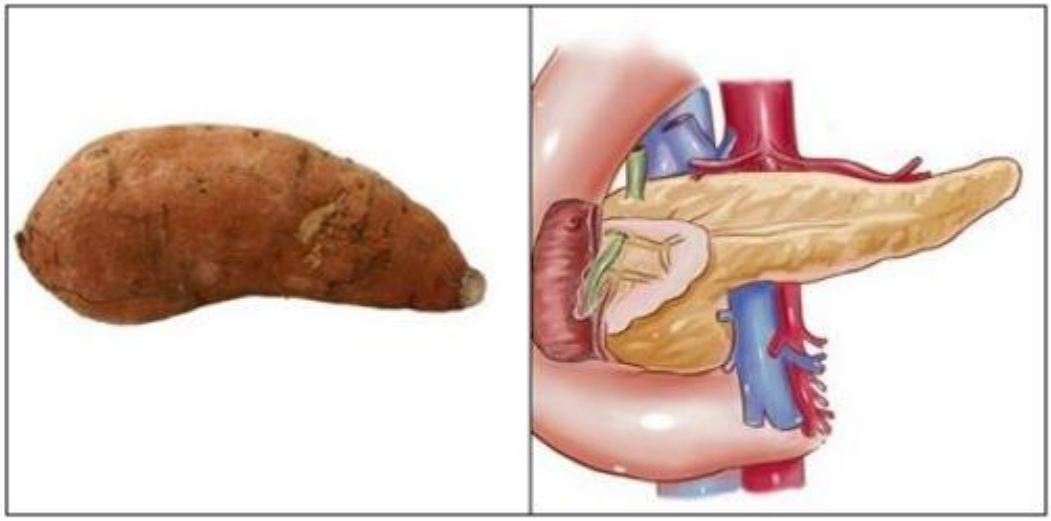


Bunches of grapes resembles the alveoli of the lungs. The lungs are made of branches of ever-smaller airways that finish up with tiny branches of tissue called alveoli. These structures allow oxygen to pass from the lungs to the blood stream. A diet high in fresh grapes has shown to reduce the risk of lung cancer and emphysema. Grape seeds also contain a chemical called **proanthocyanidin**, which is thought to reduce the severity of asthma triggered by allergy. One reason that premature babies struggle to survive is that, these alveoli do not begin to form until 23 to 24 week of pregnancy.

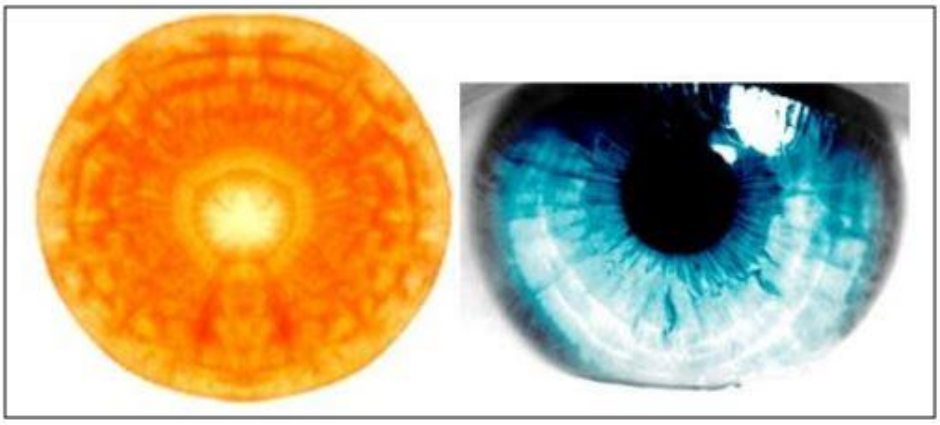


A **tomato** has four chambers and is red in colour, just as the heart is red with four chambers. Research has confirmed that tomatoes are loaded with **lycopene** and it is indeed, pure heart and blood food.

Red wine, a source of antioxidants and polyphenols including powerful **resveratrol**, resembles blood. When you drink it, you're really loading up on the nutrients that protects against destructive elements in the blood.



Sweet potatoes look like the pancreas and actually balance the glycemic index of diabetics.



A sliced **Carrot** looks like the human eye. According to science, eating carrots greatly enhances blood flow to the eyes. Carrot gets their orange colour from a plant chemical called **beta-carotene**, which reduces the risk of developing cataracts. The chemical also protects against macular degeneration, an age-related sight problem that affects one in four individuals over the age of 65. If one tries to pop a pill of beta-carotene it doesn't have the same effect, says scientists at John Hopkins Hospital in Baltimore, USA

SOURCE: Vaidyaratnam Ayurveda Foundation – Museum DVD. Thrissul, Kerala, India, April 2017

Figure 2.10: Six photographic plates illustrating healthier food choices based on the doctrine of signature

2.4.7.5 *Comparison between African and Indian indigenous knowledge*

African indigenous knowledge has its own rich repertoire of herbal remedies also with the hallmarks of the doctrine of signature. Most notably, are the Khoi-San people who use several types of indigenous plants for a variety of purposes that are expertly summarised in De Beer and Van Wyk (2011:744-749). A few examples from this paper include the use of *Ballota africana* or Kattekruie, which exudes a milky sap when cut, to stimulate lactation after childbirth; *Pelargonium antidysentericum* or Bergsalie, which secretes a red sap when cut, to treat wounds. This shows then that both Indian and African indigenous knowledge, subscribe to the Doctrine of Signature, although they each evolved on separate continents originally.

De Beer and Whitlock (2009:210) point out several characteristics of indigenous knowledge that are also shared by both Indian and African indigenous knowledge systems and some of these are:

- They are both based on experience
- They are often tested over centuries of use
- They have both developed a collective data base of observable knowledge
- They are adapted to local culture and environment
- They both use problem solving techniques
- They have an oral means of transmission sometimes expressed in metaphor
- It is not possible to separate indigenous knowledge from ethics, spirituality, metaphysics, ceremony and social order
- indigenous knowledge is holistic versus a reductionist (Western science) approach
- Both have an ecologically based approach

Martins (2011) was cited earlier as referring to eastern medicine as mind-body medicine. Similarly, African Traditional Medicine (ATM) is also referred to as mind-body medicine because of its holistic nature that tries to incorporate the physical body with the spiritual (De Beer & Whitlock, 2009:210). By describing these similarities between Indian and African indigenous knowledge, Life Sciences teachers can show their learners that a synergy exists between both cultural groups in terms of indigenous knowledge and therefore learning about Indian indigenous knowledge is very similar

to learning about African indigenous knowledge. This can then make learners more receptive towards learning about Indian indigenous knowledge as well, since the existing curriculum only makes provision for the inclusion of African indigenous knowledge. The next section deals with the reason for considering Indian indigenous knowledge in the South African context.

2.4.7.6 *Indians in South Africa*

> No gold did they find underneath any stone they touched and turned, yet every stone they touched into solid gold they turned.
>
> (Vishwamish Ganga Aashutosh – Mauritian poet.
> From High Level Committee Indian Diaspora Report, 2001:vi)

The quote above refers to the important role played by Indian immigrants in the various countries they have made their home, including South Africa. Since my study examines the integration of Indian indigenous knowledge into the South African Life Sciences curriculum, it is necessary to understand the circumstances around which Indians arrived in South Africa and how they have established themselves as part of the demographics of this country. This will then shed light on the rationale for considering Indian indigenous knowledge in South Africa. Originally Indians were introduced to the Cape in 1653 by Dutch merchants who brought them from their travels in India and subsequently sold them to the early Dutch settlers as slaves (High Level Committee Indian Diaspora Report, 2001:75).

When slavery was abolished by the British due to the Act of Abolition in 1833, the African slaves of British settlers in the Natal colony deserted their masters *en masse* making it necessary for the British to then look towards India for an alternative source of cheap labour (High Level Committee Indian Diaspora Report, 2001:76; Lal, 1998:216). The first shipment of 342 Indian men, women and children arrived in Durban on the 16th November 1860 on board the S.S. Truro. This was followed by another 383 such shipments over a period of 51 years when a minimum of “152 184 unfortunate persons” were brought to South Africa (High Level Committee Indian Diaspora Report, 2001:76). Most of these people worked on the sugarcane, sisal, wattle and tea plantations in Natal while others worked to build the railway lines and

in the coal mines (High Level Committee Indian Diaspora Report, 2001:76; Bradlow, 1970:45; Bradlow, 1991:206).

The terms and conditions under which the indentured Indians toiled were laid down in legislature by a series of Acts referred to as Natal Laws. According to Bradlow (1970:39), Natal Law 14 of 1859 legalised the system of indenture while also providing the conditions for labourers. The initial period of indenture was for five years after which they could renew their contract for another five years or return to India at their own cost. They were promised a free return trip to India or granted a piece of land if they opted to renew the contract, a choice that most of them decided to take. Standard working conditions in the various plantations entailed hard labour from dawn to sunset, seven days a week with meagre rations, sub-human accommodation in crowded barracks and no regard for any of their other needs. Withholding the rations, their already meagre wages, imposing fines and corporal punishment were some of the ways in which arbitrary "justice" was dealt to them for even the slightest transgression (High Level Committee Indian Diaspora Report, 2001:76). Although the conditions were harsh and resulted in many Indian labourers committing suicide, it did not prevent many others from deciding to remain in South Africa "as they had practically banished themselves from their own country by going abroad" (ibid, p.77).

When the first group of indentured Indians returned to India in 1871, they reported to the authorities the cruel, unsympathetic treatment to which the labourers were subjected. Further emigration was then forbidden until investigations resulted in the legislation being relaxed slightly to appease the Indian government. Emigration then resumed in 1874 under marginally better conditions for the labourers. The Wragg Commission in 1885 pronounced that the Indians had contributed significantly to boosting the economy of Natal and that they were a great asset to the colony. However, the British colonialists persisted in treating their workers as mere "units of labour" and even addressed them by the derogatory term "coolie" (High Level Committee Indian Diaspora Report, 2001:76-77). Much of this shoddy treatment stemmed from the perception that the British had of Indian people, formed during the time of their colonial rule in India. They were regarded as "ignorant semi-barbarous beings naturally suited to, and fit for little else, but arduous field labour" (Bradlow, 1991:205). Even the "Whites in Natal maintained that the Indians who followed

Hinduism were ‘heathens’ and did not recognise their faith, cultural knowledge or practices (Gopal *et al.*, 2014:32). However, despite this perception that many of the Indian labourers were illiterate, they brought with them “memories of their traditions, customs and rituals which they then strove to preserve as best as they could” (High Level Committee Indian Diaspora Report, 2001:76). In this way they were able to perpetuate their cultural habits, albeit with great difficulty, in a foreign land.

The arrival of the indentured Indians then opened the way for ‘free passenger Indians’ who used the growing Indian population in South Africa as a business opportunity to provide various goods and services and eventually made up almost 10% of the Indian population in South Africa. They also faced discrimination to limit their enterprise and economic success by the White colonial government (High Level Committee Indian Diaspora Report, 2001:77). Eventually, almost a hundred years after the arrival of the first group of indentured labourers to South Africa, all Indians were granted permanent residency status, giving them South African citizenship in 1961 (Gopal *et al.*, 2014:31). Since then, Indians have become a part of the demographics of South Africa with their own traditions and culture passed down through several generations from the time of the first group of Indian settlers who arrived in 1860. Nowadays, there are nearly 1.2 million descendants of these early Indian settlers who regard themselves as South Africans and for whom English is the dominant language (Gopal *et al.*, 2014:28).

One of the intermediate theories framing my study is that of ESDC. As mentioned earlier, Ramnarain (2008:3) explains that “the overarching tenet of ESDC” is “that cognition is physiologically embodied, socio-culturally situated, and ostensibly distributed among individuals”. As a result of my study revolving around Indian indigenous knowledge, it is therefore important to understand how the Indian people in South Africa have been able to maintain their heritage from India for more than 150 years. They were able to do this despite them not being literate as their cultural knowledge was embedded in their way of life and memories. Their arrival and shared hardships on their sea journey and appalling working conditions on various plantations further gave them a unique socio-cultural identity that they were able to pass down to their children and future generations.

2.4.7.7 *Indigenous knowledge in the rest of the world*

The debate that received momentum in 2015, and is still ongoing, to decolonise education is not unique to South Africa but has prevailed in many other countries in the world such as Australia, New Zealand and other Oceanic territories; North America and other parts of Africa (Naidoo & Vithal, 2014:253). In fact, this debate is a fairly new one in South Africa as internationally, it has been investigated at length many years earlier. The ensuing sections explore the highlights of the studies conducted in other countries regarding the integration of indigenous knowledge into the curriculum and how this can enhance meaningful learning among learners.

2.4.7.7.1 Australia and Oceania

The notion of decolonising the school curriculum in Oceanic countries entails questioning Euro-American knowledge and replacing it with local cultural studies and national histories. According to Quanchi (2004:6), these solutions acknowledge "local histories, traditions and knowledge" while also using the useful elements from Western knowledge and ideas. This idea is corroborated by Le Grange (2015:6) who opines that decolonisation is "a process of change" that does not necessarily entail "destroying Western knowledge but in decentring it".

In addition, several international conventions and declarations are used to promote indigenous knowledge and apply this to fields such as "biodiversity, coastal heritage and maritime sustainability, governance and post-colonial literature" (Quanchi, 2004:3). Western knowledge is therefore not completely discarded in favour of indigenous knowledge. Instead there is a blend of both to find a common solution to various problems. In their extensive literature study on the integration of indigenous knowledge and science, Bohensky and Maru (2011:2) confirm that "modern problems cannot be consistently solved with singular, mechanistic, science-centered solutions" thereby opening the way for indigenous knowledge to be explored as a solution to some of these problems, such as natural resource management.

Mundy and Compton (1991/3:1) refer to indigenous technical knowledge as a way of providing "cheap, locally adapted solutions to development problems" while it can also be used together with scientific knowledge to improve productivity and living standards. Many Oceanic indigenous people live their lives according to traditional

knowledge. There is therefore no need for them to record this knowledge or intellectualise their indigenous knowledge as it is their way of life (Quanchi, 2004:7). Mundy and Compton (1991/3:1) made mention of the same idea that most indigenous knowledge is not written down but is kept “in people’s heads, passed down from one generation to the next by word of mouth”.

In Australia, Sangha *et al.* (2015:198) look at the well-being of people associated with the integration of socio-economic aspects with nature. They define well-being as “living happily or leading a satisfying life”. One of the ways in which well-being can be achieved among indigenous people is by acknowledging their “social, spiritual and cultural connections with nature” and specifically with the land, since “people’s traditional relationship to land is profoundly spiritual” because of it being a source of their ceremonial objects, sacred names and languages (Sangha *et al.*, 2015:200). This powerful connection felt by indigenous people to the land is a unifying thread between many cultures in the world (Haig-Brown, 2008:12; Grayshield & Mihecoby, 2010). There is a revival nowadays in looking at the vital role played by ecosystems in bringing about human well-being and how indigenous people can contribute towards natural resources being used sustainably (Sangha *et al.*, 2015:203). Ultimately, this can enhance well-being for people on a global scale and not just for the local people. A similar study was conducted in Pakistan by Amjad *et al.* (2015:234) where the vital link between indigenous plants and people in a particular area was highlighted.

The term ethnobotany is used to describe the scientific study of the relationships between people, plants and their environment. These researchers used old people in the community to tap into their knowledge and experiences about the traditional uses of plants for various functions in their daily lives. This study is comparable to the one conducted by De Beer and Van Wyk (2011) in the Northern Cape, South Africa among Khoi-San people where similar conditions prevailed. These areas are mainly rural, lacking in modern healthcare facilities with a low rate of literacy, necessitating a greater dependence on plants and other natural resources for their healthcare and living needs (Amjad *et al.*, 2015:235). Ethnobotanical studies can also be mimicked in the Life Sciences classroom as a way of integrating indigenous knowledge into lessons and the value in doing this can then expose children to “the cultural roots of science” (De Beer & Van Wyk, 2011:96).

Like the South African Indian population, the Australian aboriginal population makes up 2.5% of the total Australian population amounting to 548 369 at the 2011 census. This shows that although they now form a minority in the country, their indigenous knowledge is considered and studied as a way to achieve greater well-being among the entire population. Similarly, in South Africa, Indian people are a minority group but their rich heritage of indigenous knowledge can also be studied and used to enhance well-being of everyone in the country.

2.4.7.7.2 Africa

The centuries-old colonisation of Africa by many Western countries has resulted in Western science being imposed on indigenous people while completely suppressing their own indigenous knowledge. This has resulted in the erosion of certain traditions, cultures and values of these people to such an extent that Western science has been used "as an instrument of exploitation, cultural subjugation and denigration of indigenous peoples" (Ogunniyi, 2004:289). School science was taught as a "culture-free subject" until about the 1980's when "the need to revive the science embedded within various indigenous knowledge systems" emerged in these previously colonised countries (Ogunniyi, 2004:290). Mhakure and Mushaikwa (2014:1555) concur with indigenous researchers in other parts of the world about the "growing acceptance of the need to integrate W(estern) S(cience) and I(ndigeous) K(nowledge) to promote multicultural science learning environments in school".

The literature search revealed several studies that were carried out on the value of integrating indigenous knowledge into the education system in various African countries. This section provides an overview of some of this research of particular relevance to my study on incorporating Indian indigenous knowledge into the Life Sciences curriculum in South African schools. One of the hallmarks of the inclusion of indigenous knowledge in the curriculum is that it can allow indigenous children to learn according to what they are familiar with in their home environment. This refers to them learning in an "informal, unstructured setting through participant observation, imitation, verbal and visual arts – oral traditions, visual images, symbols, diagrams, sequential activities and shared experiences" (Ogunniyi, 2004:295).

Indigenous and traditional modes of communication have been developed by various human societies and very often these are through oral tradition. African indigenous knowledge, like others throughout the world, is characterised by being transmitted orally from older members of the community to the younger generation (Uzochukwu & Ekwugha, 2015:1). According to these authors, “a society is defined as a group of people who have lived together long enough to evolve common norms and values” and it is one of the key indicators for the pace at which a society develops (Uzochukwu & Ekwugha, 2015:2). Their study set in Nigeria, proposes that African oral tradition should be extended towards the use of folk media like puppetry, music, dance, folklores and storytelling in order to convey and reinforce the traditional African values of “hard work, honesty, loyalty, courage and accomplishments” (Uzochukwu & Ekwugha, 2015:1).

Studies conducted in Ghana, Tanzania and Nigeria concur with the use of indigenous media to put forward important information on social and health issues especially to communities with low literacy levels. Theatre and puppetry are two ways in which these indigenous people can be informed about sensitive social topics such as female genital mutilation; HIV prevention; gender issues; sexually transmitted diseases; family planning and breastfeeding (Tham-Agyekum & Loggoh, 2011:2253-4). In this way the performing arts is used to convey science and technology information among traditional people who would otherwise not benefit from the information using the written format.

In Kenya, Kwanya (2015:4) considers the value of indigenous knowledge in promoting cultural or indigenous tourism. This is so that tourists can share in the life stories of indigenous people in the area thereby assigning importance to their traditional background. In South Africa, this is similar to ecotourism which is where tourists enjoy the natural heritage of the country in order to create authentic experiences. The Grade 10 Life Sciences curriculum also mentions the concept of ecotourism under the Environmental Studies module. However, it is only dealt with superficially according to ethics, opportunities and economics (DBE, 2011:34). Emphasis should be given to the valuable role played by indigenous people in this sector to generate revenue for their communities. These people can follow the Kenyan model of providing first-hand

knowledge as tour guides and ambassadors of their own culture thus enriching the tourism experience for visitors.

Studies in Ethiopia suggest an alternative approach for curriculum development that entails indigenising the curriculum (Yishak & Gumbo, 2012:179), thus making the curriculum more relevant for the country and in turn contributing to a stronger, more functioning educational system. It is therefore apparent that the move towards decolonising the curriculum is not unique to South Africa and the integration of indigenous knowledge into the curriculum has been considered in other countries in Africa as well. Currently, the education system in Ethiopia, like in many African countries including South Africa, is rooted in Eurocentric philosophy which is irrelevant to local people and "continues to distort, misappropriate and misinterpret the African human condition and reality" (Yishak & Gumbo, 2012:180).

Ghanaian studies also advocate for contextualising the science curriculum in an attempt to achieve meaningful learning and improving academic performance. Ngman-Wara (2015:168; 176) reveals that although teachers ought to be competent in making science lessons relevant to their learners' lives, they often lack the necessary skills or pedagogy to do this. My study shares this concern about Life Sciences teachers in South Africa lacking the necessary skills to contextualise the curriculum by integrating Indian indigenous knowledge into their lessons.

As indicated already, these studies show that the integration of indigenous knowledge into school curricula has been explored in many other countries in Africa and is not a new or unique concept in South Africa alone. The value of including indigenous knowledge into school curricula has also been studied extensively in the west where recognition has been given to indigenous people of those areas. The next section will look at indigenous knowledge in some of these Western countries.

2.4.7.7.3 Canada and North America

The holistic nature of indigenous knowledge is exceedingly prevalent among the indigenous people of North America as well. An article written by a Washo Native American Indian explains in significant detail how her people share an integrated relationship with the land on which they live. This group of people have lived around

Lake Tahoe in the state of California, USA, for almost 9000 years (Grayshield & Mihecoby, 2010:8). The reader is introduced to the epistemology of Indigenous Ways of Knowing (IWOK) which "recognizes the interconnectedness of all things" (Grayshield & Mihecoby, 2010:2). According to these researchers, indigenous academics, like themselves, serve to "affirm and activate the holistic paradigm of indigenous knowledge to reveal the wealth and richness of Indigenous languages, worldviews, teachings and experiences" (Grayshield & Mihecoby, 2010:4).

The IWOK also affirms the conscious awareness of life held by indigenous people who have maintained thousands of years of peaceful existence without causing any harm to their environment. This in itself is a lesson that Western cultures can learn in order to achieve peace and conserve the environment, particularly with regards to "climate change and eco-sustainability", to benefit all living organisms (Grayshield & Mihecoby, 2010:6). However, this was before the discovery of gold and silver in the Washo habitat in the mid-1800's (Grayshield & Mihecoby, 2010). The rush of miners resulted in the colonization of the area and destroyed all aspects of this peaceful life in a short space of less than 170 years. The message from these researchers is that the philosophy and epistemology of IWOK can teach people the importance of being self-aware of their actions to sustain their environment and how this affects all beings, rather than only looking at the environment through a cold cognitive lens (Grayshield & Mihecoby, 2010).

This is an essential message to convey to all people and can be achieved by including such beliefs of the Washo indigenous people as vignettes in Life Sciences lessons. It was mentioned earlier that the ideas of Quanchi (2004), Kapyrka and Dockstator (2012) and Le Grange (2016) about the strengths of both Western and indigenous knowledge can be blended together to enable greater cooperation in achieving sustainable environments to benefit all living beings. This idea is also echoed in the concept of 'two-eyed seeing' expounded by Hatcher *et al.* (2009) and Bartlett *et al.* (2007) in Canada.

Bartlett *et al.* (2007:2) also explore the notion of Integrative Science as a study programme at university using the guiding principles of 'two-eyed seeing' and 'trees holding hands' to continue the idea of the cooperation that can exist between both

Western and indigenous people who can work together to achieve a healthy global ecosystem. They refer to this as “knowledge inclusivity” and cite the words of a Mi’kmaq Spiritual Leader and Chief Charles Labrador of Acadia First Nation, Nova Scotia whose words have been translated as “Go into the forest, you see the birch, maple, pine. Look underground and all those trees are holding hands. We as people have to do the same” (Bartlett *et al.*, 2007:2). This idea has various levels of meaning apart from the one described about Western and indigenous people working together. It can also be interpreted as different cultures working together just as different species of trees ‘hold hands’. On another level, it shows that all of nature is connected to enable stability and unity in the environment.

Until recently, this last idea has been “dismissed as fantasy” (Rhodes, 2017:331). Scientific studies have shown, instead, that there is actually a great deal of truth to the way in which plants are able to communicate with each other using chemicals either underground through their roots or above the ground through their leaves via the ‘Common Mycorrhizal (mycelial) Network’ (CMN) colloquially referred to as the ‘Wood Wide Web’ (Rhodes, 2017; Beiler *et al.*, 2009; Kanters *et al.*, 2015). This fairly recent revelation can be used to show learners that indigenous people were the original proponents of the idea and Western science has now proved it to be factual – thereby illustrating the synergistic link between Western and indigenous knowledge that ‘two-eyed seeing’ is all about.

As mentioned earlier in Africa, Madden *et al.* (2013) also describe how poetic transcription by indigenous people can be used to integrate indigenous knowledge into lessons in British Columbia, Canada. This technique is also used in an attempt to decolonise previously colonised classrooms. Indigenous media such as poetry is therefore a common device that indigenous people can use to enable integration of indigenous knowledge into Western science and in lessons. Apart from poetry, Aikenhead and Ogawa (2007:559) describe the oral tradition of passing down indigenous knowledge from elders to youth in the indigenous Yupiaq culture in Canada, where storytelling is used rather than recording indigenous knowledge in written form. Later, Madden (2014:1) studied indigenous education in schools by using a model that arose from the Anishinaabe group of First Nation people in Canada called

the Anishinaabe medicine wheel. This was an indigenous tool that was used to examine teachers' experiences of learning from indigenous knowledges.

The idea of using indigenous methods to teach indigenous knowledge was also proposed by Lowan (2012:72) who explained that, like many indigenous scholars, indigenous knowledge programmes should first be developed from an indigenous perspective before being considered from a Western perspective, instead of the other way around, as is normally the case with indigenous knowledge education in Western schools. Battiste (2002:5) postulates that indigenous knowledge is able to provide the different dimensions of ethics and knowledge that Western education systems lack, thereby completing and balancing the analysis of "Eurocentric education and its pedagogies". This is then another way in which Western knowledge and indigenous knowledge can be integrated in such a way that they each contribute their strengths towards creating a more holistic education system.

Research into indigenous knowledge in North America and Canada shows the shared tenets and philosophies found in indigenous knowledge in different parts of Africa and Oceania, thus affirming that indigenous knowledge in many parts of the world shares the values of holism to promote environmental sustainability for the good of all mankind.

2.4.7.7.4 South Africa

While the discussion about indigenous knowledge has been taking place in these parts of the world at least for the past 30 years, South Africa has only fairly recently woken up to the value of formally introducing indigenous knowledge to the education system. However, according to Green (2007:134), and Naidoo and Vithal (2014:254), South Africa is one of the few countries in the world where the national government has legislated the importance of knowledge diversity by prescribing the inclusion of indigenous knowledge systems into the National Education policies, the Curriculum and Assessment Policy Statement (CAPS) being the most recent. To this end, in 2004, The Indigenous Knowledge Systems Policy was passed by the South African government to enable the integration of indigenous knowledge systems in different fields such as education, agriculture, the sciences, law and the arts (Green, 2007).

The evolution of formal education in South Africa began in 1652 when the Dutch established a refreshment station in the Cape for ships on route between the East and Europe. Higher education institutions only came into existence from 1873, resulting in several universities, technikons and colleges being built thereafter, catering mainly for the White population. From 1916, such institutions were also set up for non-White people (Wolhuter, 2014). This partitioning of higher education institutions was as a result of the discriminatory apartheid system that existed in South Africa since the 1900's and resulted in education that favoured Western knowledge while suppressing the indigenous knowledge of the native African people as well as of the Indians that were brought to South Africa as indentured labourers from India. This heralded the colonisation of the curriculum that has characterised the South African education system until now.

Like Lowan (2012) in Canada, Mkabela (2005) in South Africa, suggests that the move towards decolonising the curriculum be realised by using Afrocentric methods to research indigenous culture, as opposed to studying indigenous knowledge using Western techniques. She explains that currently most of the research on indigenous knowledge is done from a Western context so that true African thinking is not involved in the process and that the Afrocentric method would be an alternative way of studying indigenous knowledge. According to her "a fundamental aim of Afrocentricity is that all cultural centres must be respected" (Mkabela, 2005:180). Although this view refers mainly to different African cultures, it can also be extended to other cultures as well. In South Africa this can apply to the Indian culture as well, thereby having relevance to my study.

Some of the ways in which indigenous culture can be researched using Afrocentric methods include respecting indigenous cultures especially if the researcher is not part of that culture in order to avoid those cultures being resentful of the researcher. Often, it seems that researchers only obtain participation from these people for their own professional recognition and financial benefit while no concrete value is passed on to the people being studied (Mkabela, 2005). If the researcher does not belong to that culture, then they should be completely immersed in it by allowing the local people to be actively involved in the research process even to the extent of deciding to what level they will take part as subjects. In this way they have control over the research

process with the researcher playing more an observer role, rather than being told what to do by an outsider who is not part of their community. This method will ensure that local people feel empowered by sharing their knowledge and experience with others (Mkabela, 2005).

The participatory method described also links to the concept of *Ubuntu* which exists among African people. *Ubuntu* speaks to the shared qualities of “generosity, love, maturity, hospitality, politeness, understanding, and humility” (Mkabela, 2005:185) that ought to prevail among people to enable harmony, unity to enable looking for, gathering and maintaining knowledge for future generations. These traits of African indigenous knowledge echo those discussed earlier by indigenous cultures from the Oceanic countries, North America and Canada. The holistic nature of Ayurveda is shared by the “holistic orientation of the indigenous African people” (Mkabela, 2005:186). Another strategy entails including the elders in the community who are more knowledgeable through their experience in participating in the research.

When the elders are “kept at the forefront of any research and recommendations affecting indigenous communities and their culture” it provides a holistic, multidimensional aspect to the research process making it more meaningful and responsive to a collective African worldview (Mkabela, 2005:187). This creates “socially robust knowledge” that is less likely to be contested and is referred to as context-sensitive science by Gibbons (2000:161). This leads to a Mode 2 society that plays a significant role in knowledge production, as opposed to a Mode 1 or context-insensitive science where scientists produce knowledge in a laboratory without considering the community that would benefit or be affected by that knowledge.

South Africa has been cloaked by the nefarious legacy of colonialism that began almost 400 years ago with Dutch and English roots and was then perpetuated by apartheid and the rule of the colonial masters. The value of including indigenous knowledge into schools has been investigated and subsequently established among research circles since 2004 in South Africa. Research in this field is gaining ground rapidly as alluded to by the different studies mentioned above which reveal several common threads of the value of indigenous knowledge such as sustainable living, enhanced learner achievement in the sciences, and a more relevant curriculum that

learners can relate to more readily. Further studies are needed into the methods of how indigenous knowledge can be integrated and this will be dealt with in the next chapter of this dissertation.

2.5 SUMMARY OF CHAPTER TWO

This rather lengthy chapter of literature reviewed for my study, which looks at how Indian indigenous knowledge can be integrated into the Life Sciences curriculum, began with a general discussion on the overarching theoretical framework of social constructivism to understand how knowledge is constructed within the minds of individuals. I used Warford's (2011) adaptation of the well-known Vygotsky construct of the zone of proximal development, namely the zone of proximal teacher development, as basis, as it adequately sheds light on the scaffolding of teachers' learning during the short-learning programme. This led to an exploration of cultural-historical activity theory (CHAT) which has its roots in constructivism, as the research lens that will be used to identify various tensions that exist when learning takes place.

The conceptual framework was a multi-faceted investigation into several possible aspects that contribute to the topic. These included the broad umbrella of self-directed learning (SDL) which allows teachers to continue learning about indigenous knowledge as part of their professional development after attending a few SLPs organised by higher education bodies. Theories of embodied, situated and distributed cognition (ESDC), conceptual change and pedagogical content knowledge (PCK) were then discussed to show how an individual's background and culture influenced the way in which learning occurred. In addition, PCK was explained in detail to highlight the kind of pedagogy teachers should have in order to be effective implementers of the curriculum – a necessary skill to be able to infuse indigenous knowledge into appropriate parts of relevant lessons.

The nature of science (NOS) served as a framework to pointing out the tenets of science. Their relevance to indigenous knowledge was later compared to the nature of indigenous knowledge. The primary aspect of indigenous knowledge itself was also introduced and clarified for the purposes of this study which also necessitated a detailed description of Indian indigenous knowledge, specifically of Ayurveda and

Yoga with particular reference to the Life Sciences curriculum. The ancient treatise of the doctrine of signature was then described to provide some background to how plants were used for millennia in Ayurvedic treatment regimes. Since my study is based in South Africa, it was also necessary to provide a brief comparison between Indian and African indigenous knowledge so that learners in multi-cultural classrooms will be able to relate the new aspects of Indian indigenous knowledge to what they are already familiar with in African indigenous knowledge.

This was followed by a brief depiction of indigenous knowledge in other parts of the world as a means of providing greater perspective of other countries who have explored the inclusion of indigenous knowledge into their curricula before South Africa. A few studies already conducted into the inclusion of indigenous knowledge into South African schools were then highlighted to show that although this has been ascertained, what is needed for further research is the mechanism of how to include indigenous knowledge into lessons.

This point then leads to Chapter 3 which delves into the Methodology of my study of how Indian indigenous knowledge can be integrated into the Life Sciences curriculum in South Africa. I will provide details on the research design, more information on the SLPs, data collection, and data analysis.

CHAPTER THREE RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The research design of a study includes more than merely how the study is conducted. Instead, it includes the conceptualisation of the research; how the project was conducted; and the contribution of the study to knowledge development (Cheek, 2008). In order to achieve this, three broad aspects fall under the umbrella of research design, viz., the theoretical, methodological and ethical parameters pertaining to the study. These aspects shape the direction and intended purpose of the research (Cheek, 2008).

According to Schensul (2008), the methods used in a study should describe the way in which the study is performed with reasons why certain techniques were used, and details as to how these were used to achieve the overall goal of doing the study. Research design also considers data analysis by looking at how data is organised and why it has been organised in a particular way, while also examining the synergy between the data collected and the theoretical framework governing the study (Cheek, 2008). The ethical aspects of research design should consider the scientific responsibility of the researcher; the relationship of the researcher to the participants; the independence of the researcher in reporting and interpreting the results; as well as the practicalities of data collection (ibid).

This chapter of my study looks at some of the aspects of the research design as described in the preceding paragraphs; using the outline suggested by Cheek (2008:762) as a framework. The theoretical framework for my study was extensively discussed in Chapter 2, and will only be alluded to when relevant. The methodology, methods, data collection, and ethical parameters of the study will be discussed at length in this chapter to provide a comprehensive account of how my study was conducted. Details of sample selection and data analysis techniques will also be examined. Other pertinent information discussed in this chapter includes the reliability and validity of the study including the triangulation and crystallisation of data, and the ethics considered during data gathering.

Caelli *et al.* (2003:11) advocate for research to distinguish between methodology and method. They explain that the former must reflect the beliefs about knowledge and existence that arise from the philosophical and theoretical frameworks used to guide the research, while the latter refers to "the tools, techniques, or procedures used to gather the evidence" (ibid). Creswell and Plano-Clark (2007) share the view that the methodology of a research study refers to the philosophical framework that relates to the entire process of research and its essential suppositions. Aspects of the research design will also be elaborated in order to link the philosophical suppositions to specific methods, as well as the particular techniques used to collect and analyse data.

The research questions have also influenced the methodology chosen, as well as the methods used to collect data as part of the research design.

3.2 RESEARCH QUESTIONS AND OBJECTIVES

As already discussed in Chapter 1, this research looks at the affordances and integration, of Indian indigenous knowledge into the South African Life Sciences school curriculum and is guided by the main research question:

What are the affordances of including Indian indigenous knowledge into the SA Life Sciences school curriculum and what are the implications for teacher education?

This question then gave rise to the following research sub-questions:

1. How can Indian indigenous knowledge systems be integrated into the South African school Life Sciences curriculum?
2. Does the Indian indigenous knowledge system of Ayurveda and Yoga concur with the tenets of the nature of science and the nature of indigenous knowledge?
3. What are Life Sciences teachers' views about the nature of science and the nature of indigenous knowledge?
4. What transfer of Indian indigenous knowledge takes place in schools after the short-learning programme?
5. What are some of the tensions, if any, that arise when Indian indigenous knowledge is integrated into the SA Life Sciences curriculum?

6. What are Life Sciences teachers' lived experiences of participating in the short-learning programme (SLP), and of teaching indigenous knowledge in the classroom?
7. What is the role of such a SLP in providing teachers with a more nuanced understanding of Ayurveda as an indigenous knowledge system?

These sub-research questions led to the formulation of the following objectives that provide the rationale for my study:

1. To investigate ways in which Indian IK systems can be integrated into the SA school Life Sciences curriculum.
2. To examine whether the Indian IK system of Ayurveda and Yoga concur with the tenets of the nature of science and the nature of indigenous knowledge.
3. To look at Life Sciences teachers' views about the nature of science and the nature of indigenous knowledge.
4. To examine whether the transfer of Indian indigenous knowledge takes place in schools after the short-learning programme?
5. To identify some of the tensions, if any, that may arise when Indian indigenous knowledge is integrated into the SA Life Sciences curriculum.
6. To delve into Life Sciences teachers' lived experiences of participating in the SLP, and the teaching of indigenous knowledge in the classroom?
7. To investigate the role of such a SLP in providing teachers with more nuanced understandings of Ayurveda as an indigenous knowledge system.

The research design used to answer these questions, and realise the research aims, are discussed the ensuing sections.

3.3 THEORETICAL PARAMETERS OF THE STUDY

3.3.1 Philosophy or Paradigm: A generic qualitative study with elements of ethnography and phenomenology

In Chapter 2, social constructivism, the theoretical framework underpinning my study, was examined in significant detail. In the preface to his book, Creswell (2014: xxiii)

points out that theory in qualitative research “may often serve as a lens for the inquiry or they may be generated during the study”. He later elaborates that constructivism is typically seen as an approach to qualitative research (p.8). As such, qualitative research as a methodological paradigm (Maree, 2007) is appropriate for my study, which uses constructivism as the theoretical framework that informs the methodology used.

Maree (2007:51) explains that, as a research methodology, qualitative research deals with “understanding the processes and the social and cultural contexts which underlie various behavioural patterns”. The “quality and depth” of the responses is of greater significance than the “scope or breadth of the information provided”, which instead provides the focus in quantitative research. A qualitative approach does not aim to make generalisations across a population, but instead “seeks to provide understanding from the participant’s perspective” (Maree, 2007:115).

Armstrong (2010:880) is also a proponent of the non-generalisability of this type of research. She states that a qualitative researcher’s aim is “not to find a representative case from which to generalize findings to other, similar individuals or group [rather] it is to develop interpretations and local theories that afford deep insights into the human experience”. Therefore, this study aims to show that the indigenous knowledge of a particular culture can be infused into Life Sciences lessons in multicultural classrooms in South Africa. It does not aim to show that Indian indigenous knowledge can be integrated into all Life Sciences lessons in the country in the same way.

Johnson and Onwuegbuzie (2004:14) cite the main features of qualitative research as being “induction, discovery, exploration, theory…and the researcher as the primary ‘instrument’ of data collection and qualitative analysis”. Another characteristic of qualitative research is that it is concerned with the idiographic or “uniqueness of each particular situation” (Maree, 2007:51). A qualitative research paradigm is therefore suitable for my study on integrating Indian indigenous knowledge into the Life Sciences curriculum, while making a unique contribution to the existing field of study on indigenous knowledge.

This ethnographic study with elements of phenomenology will rely on purposive sampling to select participants that are directly significant to this study, viz., Indian Life Sciences teachers. According to Reeves *et al*. (2013: e1365), "ethnography is a type of qualitative research that gathers observations, interviews and documentary data to produce detailed and comprehensive accounts of different social phenomena". Since I will also capture the lived experiences of Indian Life Sciences teachers, the study also has a phenomenological slant, albeit not a true phenomenological study.

Various sources are, therefore, used to gather information about a social phenomenon. In this study, the social phenomenon refers to Indian teachers' views on the integration of Indian indigenous knowledge into the Life Sciences curriculum. The use of different sources (focus-group and individual interviews; lesson observations; artefacts such as lesson plans and policy documents; information obtained from the researcher attending a short course on Ayurveda in India; and questionnaires from teachers who attended a short-learning programme or intervention) will provide a 'thick description' to enhance this study. Geertz (1973), an anthropologist, first introduced the idea of 'thick description' to qualitative research. Thick description "incorporates the cultural framework and meanings of the actors, their codes of signification, providing an emic account grounded in the actors' cultural context; thick description is thus the essential activity of ethnographic research" (Maxwell & Mittapalli, 2008:880).

In support of thick description, Anderson (2010:880) adds that language is regarded as the "primary source of insight into socially constructed worlds" – hence the detailed capturing of participants' words, behaviours, emotions, and thoughts in the qualitative research environment. This detail "adds depth and texture to the body of data that qualitative researchers describe, analyse and interpret" (Anderson, 2010: 881). Reeves *et al*. (2013:e1367) define thick description as being "detailed, context-sensitive field notes" produced from "deep immersion in a particular culture". In my study this would refer to the Indian culture, and thick description was obtained by delving into the minds of the teachers who attend the SLPs, where they were introduced to Indian indigenous knowledge. Their thinking and understanding was inferred from their behaviour, as well as from their responses to the questionnaires and interviews, thereby providing the thick description needed to add credibility to this study.

3.4 METHODOLOGICAL PARAMETERS OF THE STUDY

3.4.1 Unpacking design-based research

My study uses a generic qualitative research methodology with elements of ethnography and phenomenology, framed within design-based research (DBR). According to Merriam (1998:11), generic qualitative research sets out to "discover and understand a phenomenon, a process, or the perspectives and worldviews of the people involved". Creswell (2014) describes ethnography as "qualitative research procedures for describing, analysing and interpreting a culture-sharing group's shared patterns of behaviour, beliefs". Although my study focused on Indian culture – and specifically on Ayurveda – non-Indian teachers also participated, hence the study only reflects elements of ethnography. The phenomenological elements of my study come from detailed questionnaires and interviews of the lived experiences of Life Sciences teachers. In addition, the questionnaires covered teachers' views on the nature of science and the nature of indigenous knowledge.

Qualitative research also looks at "describing and understanding phenomena within their naturally occurring context" such that they "can be described in terms of the meaning" participants have for them (Maree, 2014:51). Generic qualitative research is, therefore, suitable since my study aimed to investigate Life Sciences teachers in the classroom context. Initially, Indian teachers were used (in the pilot study – Cycle 1) since it was assumed that they ought to have some knowledge of Indian culture and Indian indigenous knowledge. However, in later cycles of the design-based study, teachers of other cultural groups were involved. (See Table 3.1 for an outline of the various cycles.)

My study forms part of a larger study on the affordances of indigenous knowledge for self-directed learning (SDL), funded by the NRF and the Fuchs Foundation. The SDL project used design-based research to investigate the integration of indigenous knowledge into the curriculum. In keeping with this methodology, my study also uses elements of DBR.

3.4.2 Philosophy of design-based research

According to Hogue (2013:1916), pragmatism is a school of philosophy on which educational design research is based. Hogue (2013:1915) views design research in education as a pragmatic approach to research with two main objectives, viz. finding a solution to an education design problem in the context of the real world, while "contributing to scholarly knowledge in the form of instructional design theory or design principles". My study is immersed in this approach since it looks at including Ayurveda in a curriculum that does not have this type of indigenous knowledge (real world problem) while formulating design principles to add to this body of knowledge.

The development of design principles improves practice through the "iterative cycles of design-enact-evaluate" which will ultimately "improve the delivery of education" (Hogue, 2013:1916). My study, which formed Cycle 2 in a larger DBR study, also entailed the use of an iterative cycle in order to enhance the research contributing to indigenous knowledge integration into the Life Sciences school curriculum.

3.4.3 Process of design-based research (DBR)

Design-based research is a relatively new research approach, having developed in the early 21st century after being first established by Ann Brown and Alan Collins (Barab & Squire, 2004:2; Anderson & Shattuck, 2012:16; Wang & Hannafin, 2005:5). These researchers explain that DBR can serve as an effective link between research and practice in learning environments. Herrington *et al.* (2007:2) explain that "design-based research should address **complex problems** in **real contexts** in close collaboration with **practitioners**", with the words in bold representing the three key features of DBR.

In this study, infusing an aspect such as Indian indigenous knowledge (especially Ayurveda) into the new CAPS curriculum is a fairly **complex exercise** since this has not been previously attempted, and text-books do not include any information on Indian indigenous knowledge. The **real contexts** apply to the actual classroom situations where teachers were required to deliver content based on the CAPS curriculum; and **practitioners** refer to the teachers themselves who were part of the research and development process.

Wang and Hannafin (2005:6-7) describe DBR as:

> a systematic but flexible methodology aimed to improve educational practices through *iterative analysis, design, development, and implementation,* based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories
>
> [italics – own]

The italicised parts of the definition above represent some of the characteristics of DBR that were used in my study, and which are summarised in Table 3.1. Cycle 2 is shaded in the table to indicate that this was the heart of my study, although aspects of Cycle 1 and 3 will also be addressed to contextualise how DBR was used. The iterative nature of this study was achieved by applying design principles distilled from earlier SLPs on the infusion of African indigenous knowledge into the CAPS. Since the initial premise was the same, it was possible to use the design principles distilled from previous SLPs (on the infusion of African indigenous knowledge) to develop an SLP for my study on the infusion of Indian indigenous knowledge. Consequently, three cycles were formulated over a three-year period (Table 3.1).

Table 3.1: Outlining the DBR process (this study formed Cycle 2 of the DBR process)

CYCLE	ASPECT OF DBR	ACTIVITY	WHERE IMPLEMENTED	TIMELINE
1	Iterative analysis	Based on pilot studies, a SLP was developed on infusing indigenous knowledge in the Life Sciences classroom.	Limpopo Province (Polokwane)	June 2016
	Iterative analysis and re-design	Based on design principles distilled during the Limpopo intervention, changes were made to the SLP.	North-West Province (Potchefstroom)	July 2016

	Implementation	After the SLP, class visits and interviews with teachers were conducted. Findings led to revised design principles.	Polokwane and Potchefstroom	August – November 2016
2.	Iterative analysis	After attending a course on Ayurveda in Kerala, India, and based on insights from Cycle 1, a new SLP was developed.	Lenasia, Gauteng	May 2017
	Design and development	The SLP was offered to teachers, with a particular focus on the tenets of Ayurveda.	Lenasia, Gauteng	July 2017
	Implementation	Class visits were conducted; interviews with teachers after the SLP.	Broader Gauteng	August 2017–July 2018
3.	Iterative analysis	Insights from Cycles 1 and 2 resulted in new design principles (e.g. a stronger focus on classroom action research) during the SLP in Cycle 3.	Northern Cape Province (Calvinia)	April/ May 2017
	Design and development	A SLP was offered to teachers of the Namaqua district.	Namaqua region (Calvinia)	July 2017
	Implementation	Class visits were conducted; interviews with teachers after the SLP.	Namaqua district	August 2017 – February 2018

Van den Akker *et al*. (2006:117) comment that “consistent, harmonious, coherent components of a robust curriculum” can be achieved when studying interventions in their intended locations. In my study, the SLPs were developed and implemented for teachers in their own setting, and in school laboratories where teachers could experience that it was possible for them to implement the activities learnt in their own classrooms. Teachers were given the opportunity to take part in various activities that would enhance their own teaching, while at the same time allowing them to learn and think about other techniques that they could customise to their own situations. This is one of the hallmarks of self-directed learning, i.e., teachers taking charge of their own learning, and developing methods that would suit the environments in which they taught.

Design-based research has three levels of output according to Van den Akker *et al.* (2006:118). On the primary level, it is the **knowledge** that arises from the research itself; on a secondary level, it is the contribution to **society** where schools and the community benefit from the curriculum developed; and on a tertiary level, it contributes towards the **professional development** of the participants. The primary output from my study was the creation of a link between Indian indigenous knowledge and the Life Sciences curriculum, a unique perspective not previously identified in prior South Africa studies. The secondary output was that the infusion of Ayurveda into the Life Sciences curriculum raises awareness of the principles of Ayurveda, which are to promote a healthy mind, body and spirit. It was envisaged that these principles would influence participants, and eventually permeate to the learners and the broader community. On a tertiary level, the professional development of the participants, specifically the development of their pedagogical content knowledge (PCK) in the integration of indigenous knowledge into the curriculum, remains an aim of the umbrella project on SDL for teachers.

My study on Indian indigenous knowledge provides an additional dimension to this overall project. The premise for this is aptly expressed by Van den Akker *et al.* (2006:120) who state that “Design research is especially warranted when existing knowledge falls short, as is often the case with highly-innovative curriculum improvement initiatives. The main aim of design research in these situations is to

develop new knowledge that can help construct pioneering curricular solutions which will prove viable in practice".

In this study, the SLP on the infusion of Indian indigenous knowledge into the curriculum was developed using design principles extracted from the design and implementation of the earlier SLPs on the infusion of African indigenous knowledge. (Refer to Table 3.1). These design principles are the focus of the next section

3.4.4 Design principles guiding the development of the Ayurveda short-learning programme

The design principles described in this section appeared in a paper I wrote as the main author and presented at the SAARMSTE Conference in Botswana, January 2018. As stated earlier, the Ayurveda short-learning programme (SLP) was designed based on earlier SLPs. The following design principles emerged from these earlier SLPs, and were used to refine and improve the Ayurveda SLP:

1. The use of the **Kirby-Bauer technique** to investigate anti-microbial properties of medicinal plants should be emphasised. The Kirby-Bauer technique consists of agar plates pre-seeded with bacterial colonies, on which filter paper discs dipped in an anti-microbial mixture are placed (Mitchell & Cater, 2000; De Beer & Whitlock, 2009). The plates are then incubated and the growth of the colonies observed. Clear areas around the disc indicate zones of no growth, thereby demonstrating the effectiveness of the anti-microbial compound (Mitchell & Cater, 2000). This is a methodology used in microbiology to determine whether a micro-organism is susceptible to an anti-microbial compound. The Ayurveda SLP used plants such as turmeric and garlic as anti-microbial mixtures to show their effectiveness as antiseptics and antibiotics – the benefits of these plants were discussed in Chapter 2.

This activity engages Life Sciences teachers in the processes of science, and they are taught how to conduct some standard protocols performed in microbiology. It is envisaged that they will continue to use these techniques, in their classrooms, with other traditional plants, thereby contributing towards SDL to enhance their own professional development. Such activities can also provide learners with a more nuanced understanding of the nature of science. In addition, the Kirby-Bauer test for

the anti-microbial properties of Ayurveda plants, confirms to participants that Ayurveda is based on scientific evidence that can be demonstrated in a laboratory. The same can be done by the teachers in their classroom to allay any doubts among the learners, especially when introducing new aspects of Indian indigenous knowledge into lessons.

2. The previous SLPs had culminated in the submission of a **paper-based portfolio** by the participants, however this resulted in a poor submission rate by the teachers – only 34 out of 71 teachers submitted and, of these 34 teachers, only 24 teachers obtained a pass mark of 50% (White & De Beer, 2017). To circumvent this problem, teachers at the Ayurveda short course were asked to submit their portfolios either online through the E-fundi learning portal, via email or as a hard copy. They also had the option to stagger the submission of the complete portfolio by submitting items over an extended time. It was anticipated that providing a choice would result in a greater submission rate. However, the submission rate was also low and only five participants took the trouble of sending in their completed portfolios.

3. The poor rate of portfolio submission also showed that the SLPs are not optimally effective, and that the professional development of teachers is best achieved within **communities of practice**. For the Ayurveda SLP, teachers were encouraged to become part of an online and face-to-face community of practice where they would be able to meet from time to time to share their experiences and resources. It was hoped that this would increase productivity among participating teachers. The online platform that was used in this study was the E-Fundi online portal for teachers. Instead of submitting a paper portfolio, teachers at the Ayurveda SLP were given the option of submitting a portfolio in stages on an online platform, and they receive electronic ‘badges’ for each submission. This system is similar to that used for ‘gamification’ in computer games to earn points. It was hoped that this would appeal to the younger teachers in the SLP who were probably more familiar with the concept, as playing electronic games was more their forte! Teachers could then use a similar concept with their own learners to encourage learning and completion of tasks. In this way, the idea of self-directed learning could be practised by the participants attending the Ayurveda SLP.

4. Teachers at the earlier SLPs complained that their effectiveness in the classroom was impaired by a **lack of resources**. The Ayurveda-infused SLP, therefore,, provided teachers with several resources that they could use once they were back in the classroom such as a DVD with relevant information; videos and pictures all with an Ayurveda slant, so that the teachers had the information for the infusion of Indian indigenous knowledge into their lessons at their fingertips; a comprehensive reference book on medicinal plants of the world; and mini-laboratory HIV-testing kits thanks to a generous grant from the Fuchs Foundation. These testing kits offered an interesting learner activity to show how rapidly HIV could spread through a population.

At the Ayurveda SLP, teachers were also made aware that they themselves are the biggest resource in the classroom, as they can improvise with common items from their environment, e.g., participants were shown how to prepare 'agar plates' using simple supermarket ingredients such as gelatine and soup powder in ordinary food-saver plastic containers if agar and petri dishes were unavailable for the Kirby-Bauer technique; and use of cloves for sore throat, mouth infections, and tooth ache (Singh, 2005:91). Cloves, garlic and turmeric are common culinary ingredients that are available from most grocery stores and do not need to be ordered from specialist laboratory suppliers.

The teacher participants were also taught how to design their own herbarium for their class, with learners engaging in pressing plants to produce herbarium voucher specimens to use during lessons. Teachers could also conduct ethnobotanical research by talking to older members of the Indian community or researching on the internet on the use of local plants to make skin and hair tonics, e.g., in Ayurveda, hibiscus flowers are ground into a paste and applied to the hair as a shampoo resulting in soft shiny hair, freshly squeezed lemon juice rubbed into scalp before washing can be used to treat dandruff (Vaidyaratnam Foundation, 2017). Using these basic ideas, teachers at the Ayurveda SLP could enhance their own SDL by applying the techniques learnt to lessons in their own classrooms.

5. Another design principle was that of including **classroom action research (CAR)**, thus encouraging participants to become researchers themselves by reflecting on their own teaching. Our aim was for teachers to critically reflect on their pedagogical content

knowledge (PCK) while also performing mini-investigations into their teaching practice in the classroom. This design principle was based on the results of the previous interventions, which required teachers to submit portfolios. As discussed in point 2 above, it was distressing that, out of 71 teachers who attended a previous SLP, only 34 submitted a portfolio; and only 20 of these 34 passed with 50%.

This indicates that most teachers did not include their reflections in their portfolio and/or did not reflect critically on their teaching. In addition, follow-up visits to schools showed that very little inquiry learning was taking place in the classroom, despite the fact that the SLPs focussed on this type of teaching and learning (White & De Beer, 2017; De Beer & Kriek, 2018; De Beer & Mentz, 2018). The Ayurveda SLP, therefore, included an activity for teachers on how to conduct CAR. The activity involved setting up a project for their learners that involves a survey of the community's knowledge of Indian medicinal plants, thus making the activity an ethnobotanical survey with research skills. The teachers' role would be to monitor their learners' research and guide them in producing a report for a science exposition or similar competition.

6. The previous SLPs focussed exclusively on African indigenous knowledge, and it was necessary to show learners that the indigenous knowledge of different cultures share common characteristics. Hence the Ayurveda SLP included a comparison between Indian and African indigenous knowledge that highlighted their holistic and contextualised nature. The SLPs carried out in Limpopo and North-West had a strong focus on generic aspects of indigenous knowledge systems. However, many indigenous cultures (African, Khoi-san, and Indian) share certain traits – their knowledge is holistic and often embedded in the spiritual.

Indian and African indigenous knowledge also share several tenets such as the Doctrine of Signature, which was discussed in Chapter 2. The doctrine of signature is an ancient concept explaining that most plants resemble, either by colour or form, the part of the body that they will benefit. For example, tomatoes, like the heart, are red with four chambers thus promoting heart health when eaten (James, n.d). The same principle is found in African indigenous knowledge. For example, certain plants are known to stimulate lactation in new mothers, attributed to their milky-white secretions

when stems or leaves are cut. In Ayurveda, lactation is also stimulated when spices such as nutmeg and garlic are given to a new mother.

Exposing this shared belief system was one of the ways of creating unity among the teachers attending the Ayurveda SLP, irrespective of which cultural group they belonged to. Since the teachers were familiar with African, rather than Indian indigenous knowledge, it was beneficial to show that there is common ground between the two, thus making it easier for them to accept Indian indigenous knowledge as a valid field of knowledge to be included in their lessons.

7. As explained in Chapter 2, one of the ways in which Ayurveda prevents an imbalance of doshas is by providing a careful and detailed daily and seasonal regimen that advocates precise ways in which a person should perform their daily rituals, including the time they get up, the way in which they cleanse their body, and the foods they eat. This aspect of Ayurveda can be infused into the curriculum to contextualise it for the learners, thereby making indigenous knowledge, particularly Indian indigenous knowledge, relevant to them. Some learners may already practice some of the rituals or they may have seen people in their community doing so. In this way the theoretical lens of ESDC was used: embodied and situated because these practices are part of the child's culture; distributed because these practices are part of the child's community; and cognition because they are learning about the reasons for these rituals and making sense of them.

8. A final design principle used to guide the Ayurveda SLP was that a 'one-size-fits-all' approach does not work. Some teachers may have practical skills and content knowledge, while others may not. It was, therefore, deemed prudent to conduct baseline assessment prior to the course, in order to adapt the course accordingly. This was an attempt to ensure that participants did not get bored and lose interest, but instead remained motivated to attend the second day of the SLP and practice the techniques in their own classroom.

These eight design principles, distilled from the Limpopo and North West SLPs (Cycle 1), were used to enhance the Ayurveda SLP. Using the experience gleaned from the

earlier SLPs, the Ayurveda SLPs design was modified and improved for a different group of teachers in Lenasia, Gauteng during Cycle 2 of this DBR study.

The guide to designing the SLP for the Lenasia group will be dealt with in section 3.4.5. The next section continues the methodology of my study by delving into the experiences gained while attending a short course on the fundamentals of Ayurveda, in India, as part of an information-gathering exercise for my study.

3.4.5 The Ayurveda course in India

The science of Ayurveda is a specialised field that requires years of study and a great deal of expertise. Since neither I nor my promoters had sufficient knowledge about Ayurveda, it was decided that the most reliable way in which we could learn about Ayurveda was to attend a short course on the topic in Kerala, India, since Kerala is regarded as being the source of Ayurvedic knowledge. A trip to an authentic Ayurvedic institute, the Vaidyaratnam Ayurveda Foundation, in Thrissul, Kerala was arranged with the AYUSH Ministry through the Government of India.

One of my promoters (Prof De Beer), another lecturer from the university and me spent ten days at the Vaidyaratnam Ayurveda Institute in April 2017. Here we learnt the fundamentals of Ayurveda under the expert tutelage of Ayurveda qualified doctors and specialists in the field of physiology, anatomy, pharmacology and Ayurvedic treatments. These professionals lectured to the three of us in between their consulting rounds at the Ayurveda hospital, where we were also accommodated. The course was customised and condensed for us since we were foreigners and non-medically qualified. Under normal circumstances, the course is three-months long and studied by medical personnel who wished to explore Ayurvedic methods as an alternative or complementary approach to the diagnosis and treatment of their patients. This was an intensive and ‘eye-opening’ experience for us as we had to learn about Ayurveda using mainly Sanskrit terminology; while also trying to make sense of the holistic nature of Ayurveda which is a change from the segmented Western idea of science that we are familiar with.

During the ten-day course, we were graciously accommodated by the institute, which was also an authentic Ayurvedic hospital where patients received diagnoses and

treatments according to Ayurvedic principles. Many of these patients were admitted to the hospital where they received various types of treatments – some of which have been discussed in Chapter 2 – including the panchakarma treatment which is fundamental to Ayurveda (refer to the Figures 3.1–3.3).

The three of us were fortunate to have been given this opportunity as it allowed us to be immersed into the world of Ayurveda during our time in Kerala. At the end of the ten-day course, we received certificates of completion (refer to Appendix A for a copy of the certificate). See Appendix O for more pictures of our time in Kerala.

Figures 3.1 (a) & (b): Patient being prepped for Ayurvedic treatment (Shirovasthi)

Figure 3.2: Shirovasthi treatment – warmed medicated oil being poured into *vasthi* (receptacle around head)

Figure 3.3: Nasyam treatment – dropping of medicated oil and herbal extracts into nose to clear the nasal passages

The Ayurveda course was an important part of my study as it personified the ESDC paradigm which is a part of my conceptual framework (also discussed in Chapter 2). Living in the Ayurveda institute, partaking of nourishing vegetarian meals prepared using Ayurvedic methods, and experiencing a part of rural India, allowed me to understand Ayurveda as a way of life rather than simply another medical regimen. My attendance at the Ayurveda course in India was, therefore, a necessary part of my study's methodology as it ensured that data gathered during the study remained authentic and aligned to my conceptual framework. The information learnt at the Vaidyaratnam Institute, together with written knowledge about Ayurveda, was used to develop the Indian indigenous knowledge SLP for Life Sciences teachers in Lenasia.

3.4.6 Guide to designing the short-learning programme

The SLP was originally designed by the SDL project for courses in North-West, Limpopo, and Northern Cape (Kimberley), where the integration of African indigenous knowledge into the Life Sciences curriculum was investigated. Based on responses

and feedback from these SLPs in the areas mentioned, the course was further modified and enhanced to include material on Indian indigenous knowledge for the Lenasia SLP (see Appendix F for the Programme). Since these modifications were made for my study by me, this part of the design process is discussed in greater detail in this section. The rationale for including certain activities in the SLP have been summarised in Table 3.2.

- One of the methods incorporated in the SLP is that of De Bono's Six Thinking Hats. Edward De Bono developed this as a strategy that allows people to consider various points of view about controversial topics such as the integration of indigenous knowledge into western science curricula (De Beer & Whitlock, 2009:214). According to these authors, it sensitizes people to consider different viewpoints thereby developing a more holistic view of an issue. The rationale for using this method entails six hats of different colours, each presenting a specific angle with which to view the problem. These are as follows:White Hat – factual viewpoint that requires the thinker to be objective and clinical – like white paper.
- Yellow Hat – allows the thinker to present the positive aspects of the issue and why it will work. It is a bright positive colour, like sunshine.
- Red Hat – this is the colour of blood and represents emotions. It provides a platform for the use of emotions, intuition and general feelings without the need for justification (De Beer & Whitlock, 2009:215).
- Black Hat – counteracts the red hat in that it adds the element of caution to the problem. It provides reasons why certain solutions may not work.
- Green Hat – since green symbolises the colour of growth in plants, this hat represents creativity, lateral thinking and new and innovative ideas.
- Blue Hat – this hat provides "an overview of one's thinking" (De Beer & Whitlock, 2009:215) so that it can be viewed from a metacognitive and holistic level – blue is chosen because it is the colour of the sky which is all-encompassing.

In Life Sciences, De Bono's Hats can be used for classroom discussions as well as a guide to essay-writing for controversial topics. This was discussed at the SLP.

Table 3.2: Summary of Questions used in questionnaires and interviews with rationale guiding their formulation

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
1. How many years have you been teaching Life Sciences for?	√	√			Necessary to establish level of experience which might influence PCK
2. Are you CAPS Trained for Life Sciences FET phase?	√	√			To see level of knowledge of new curriculum that prescribes inclusion of indigenous knowledge
3. How do you see Indigenous Knowledge?	√				To understand teacher's feeling towards indigenous knowledge in general and in the curriculum. Part of VNOIK questionnaire.
4. Do you think there is a place for Indigenous Knowledge Systems in the Life Sciences classroom? Why/Why not?	√	√			To ascertain whether teacher will include indigenous knowledge into lessons or not and their reasons. This will add impetus to my study by strengthening the rationale. Part of the VNOIK questionnaire.
5. Have you ever incorporated Indigenous Knowledge into your Life Sciences lessons? If so, explain what pedagogy you will use when teaching Indian Indigenous Knowledge.	√	√			To check whether CAPS guidelines for including indigenous knowledge into lessons was already being practiced and if so by what mechanism.

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
6. What are your views on the teaching of Indian Indigenous Knowledge amongst Indian learners in South Africa?	√	√	√		To see whether Indian indigenous knowledge is regarded with the same level of importance as African indigenous knowledge or whether it was even considered for integration. Adapted from part of VNOIK questionnaire.
7. The Life Sciences CAPS document states that the examples of IK chosen "for study should, as far as possible, reflect different South African cultural groups" (DoE, 2011:17). Are you in a position to implement this requirement? What problems do you experience when implementing this requirement?	√	√			To understand pedagogy and knowledge in including examples of indigenous knowledge as well as to ascertain any presence of SDL from teachers to take charge of enhancing their own knowledge and pedagogy. This question also explores what difficulties teachers experience or foresee experiencing in integrating indigenous knowledge into their lessons thereby making use of CHAT as a lens to view this study.
8. What do you know about Ayurveda?	√	√			To establish whether there is an awareness of Ayurveda, especially since the participants in the Pilot study where all Indian – the assumption is that they should therefore know about this ancient Indian science. As well as to check whether non-Indian participants in the SLP have heard about Ayurveda.

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
9. Would you say there are any links between the current Life Sciences curriculum and Ayurveda? Explain further.	√	√	√		This question implies that there should be adequate knowledge of the curriculum and Ayurveda, as well as any link between the two during lessons.
10. How do you think the performance of Indian learners who learn about Indian Indigenous Knowledge would be influenced compared to those learners who do not learn about it?	√	√			To gauge the opinion of teachers on the influence of including Indian indigenous knowledge on academic performance. This also contributes directly to part of the rationale of my study which looks at the importance of including Indian indigenous knowledge in the curriculum.
11. What do you understand about the Nature of Science (NOS)?	√	√	√		To determine whether teachers are aware of this important aspect of science and using its tenets during teaching. Part of VNOS questionnaire.
12. Do you see any difference between the NOS and Ayurvedic principles? Please explain your response.	√	√	√		For teachers to think about a link between these two aspects which would show that Ayurvedic principles incorporate elements of the NOS.
13. In your view what is indigenous (or traditional) knowledge? What makes indigenous knowledge		√	√		To ascertain the level of awareness about indigenous knowledge and its difference to Western knowledge being taught currently. This would show that teachers are aware of the difference between the two and can

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
different from other types of knowledge systems (such as Western knowledge)?					then be in a more informed position to integrate indigenous knowledge. Part of VNOIK questionnaire.
14. Practitioners of indigenous knowledge (e.g. elders, herbalists, traditional healers) observe nature to generate knowledge. Do they do experiments and tests in order to verify or validate this knowledge? • If yes, explain how they test or validate their knowledge. • If no, explain why not.		√	√		To see whether teachers can connect the practices of indigenous practitioners to the tenets of the nature of science and the nature of indigenous knowledge – significant aspects of the conceptual framework of this study. Part of VNOS questionnaire.
15. 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?		√	√		Same rationale as the previous question. Checking on a different tenet of the nature of science and the nature of indigenous knowledge. Part of VNOIK questionnaire.

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
• If yes, explain why it stays the same • If no, explain the causes of such changes					
16. *Hoodia gordinii* 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?		√	√		Same as previous two questions. The plant example is chosen because it appears in many Life Sciences textbooks so teachers are familiar with it. Part of VNOS and VNOIK questionnaire.
17. 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		√	√		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. In this question, the rationale was provided to the participants to make it easier for them

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
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					to answer. It gives them some background information to understand the question better. It is necessary to understand whether indigenous knowledge should be applied globally or confined to the locality in which it originated. This would contribute to how this indigenous knowledge would be taught in the classroom. Part of VNOIK and VNOS questionnaire.

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
answer with examples					
18. How did you experience this short course on indigenous knowledge? 1 - Very bad - a waste of time 2 - It had useful aspects, and made some contribution towards my development 3 - Good- it definitely made an impact, and helped me in my professional development 4 - It was fantastic, and I learned a lot. I can't wait to implement what I have learned in practice.			√		Necessary to evaluate the value of attending the course and being exposed to new teaching techniques to infuse indigenous knowledge especially the information provided on Ayurveda.
19. Would you say that there is a place for the teaching of indigenous knowledge in the Life sciences			√		After experiencing the presentation on Indian and African indigenous knowledge attendees should be in a better position to answer this question as they now have information to assist them.

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
classroom? Motivate your answer. 1 - No- IK is pseudo-science and devoid of any substance. It does not belong in the classroom. 2 - No- IK is pseudo-science and devoid of any substance. It does not belong in the classroom. 3 - Where applicable, indigenous knowledge should be brought in as a different perspective to the purely Western view. 4 - Definitely. Indigenous knowledge can make the learning of Life Sciences much more meaningful.					

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
20. What are the difficulties that you anticipate in teaching indigenous knowledge in your lessons?			√	√	After attending the SLP, teachers should be able to foresee the challenges they may face. Once again, this leads to viewing the integration of Indian indigenous knowledge through the CHAT lens.
21. How would you rate the different activities, in terms of its usefulness towards your own professional development? How did it assist in your own professional development as a science teacher? Viz. Ayurveda Lecture; anti-microbial tests on plants; problem-based learning; jigsaw method; De Bono's hats. [**Rating Scale:** bad, average, good, excellent]			√		Also, a necessary question for the researcher to understand the value of including these named techniques into the SLP. Future interventions will then refine these techniques or exclude them altogether based on responses of attendees. This and other course evaluation questions lean towards the design-based research methodology of my study.
22. Based on your experiences these two days, is it necessary for you to formulate any professional development goals for yourself? (E.g.			√		Also an evaluation-type question. Necessary to check whether the SLP stimulated the attendees' to pursue SDL in order to enhance their own knowledge and pedagogy.

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
did you identify any knowledge- or skill gaps that you would like to address in the following themes?) Viz. knowledge on IK systems; laboratory skills (anti-microbial activity lab); problem-based learning approaches; cooperative learning techniques; reflection.					
23. How would you describe your knowledge of Ayurveda after this SLP?			√		A question to evaluate the Ayurveda presentation on the attendees and whether they broadened their knowledge base after listening to it or not.
24. What is now your idea of the definition of indigenous knowledge after being here for the past 2 days?				√	To ascertain whether the idea of indigenous knowledge would change after attending the SLP
25. Describe what you think your own indigenous knowledge is. How do you think you				√	To force teachers to reflect about their own indigenous knowledge thereby realizing that all indigenous knowledge is important and can be included in lessons. Also, after

QUESTION	USED IN				RATIONALE
	Pilot Questionnaire	Pre- intervention Questionnaire	Post- intervention Questionnaire	Focus Group Interview	
can integrate it into your lessons?					listening to several new techniques that could be used in lessons to integrate indigenous knowledge, they could apply some of these to including their own indigenous knowledge.
26. Do you see any value in using herbal remedies to treat certain ailments? Would you choose Western medicines instead?				√	This question further explores the effect of the SLP on the teachers' existing views or prejudices concerning the use of traditional medicines as opposed to Western medicines.
27. We have now looked at indigenous knowledge and Indian indigenous knowledge - what would be effective pedagogies to show this?				√	For the researcher to understand whether the SLP benefitted the teachers by encouraging them to explore different ways of incorporating indigenous knowledge and even Indian indigenous knowledge into their lessons. This then enables SDL within them.
28. How do you now feel about the NOIK and the NOS?				√	An evaluation-type question that considers whether the SLP informed them adequately about the NOS and the NOIK. Part of VNOIK and VNOS questionnaire.
29. Can you think of pedagogies that would honour both tenets?				√	Again, similar rationale to question 26.

The CAPS document for Life Sciences was used as the overall guideline to content coverage, such as the topic on bacteria and other microorganisms, which is part of the curriculum for Grades 10, 11 and 12. The relevance of Ayurveda to the Life Sciences CAPS document was discussed at length in Chapter 2. The purpose of the SLP was to help teachers to integrate indigenous knowledge, with particular emphasis on Ayurveda, into their lessons using the processes of science to enable a more nuanced view of the nature of science and the nature of indigenous knowledge. The techniques of problem-based learning and cooperative learning were included in the SLP to highlight their contribution towards self-directed learning for learners in the classroom.

The course manual contained detailed information and guidelines on the importance of including indigenous knowledge into lessons, a background to Ayurveda and links to relevant topics in the curriculum. The information in this manual could be used by the participants both during the course as well as after when planning their lessons. The manual also provided guidance for the completion and submission of a teacher portfolio at the end of the course in order to earn the 16 CPTD points for SACE.

The purpose of having the participants complete the portfolio would be to enable them to reflect on their teaching practices, which should in turn make them more effective in the classroom.

3.4.7 Guide to designing the questionnaires

A set of questions was formulated for each of the questionnaires used in this study. A total of three questionnaires were used: the initial questionnaire used in July 2016 for Indian Life Science teachers; as well as the pre- and post-intervention questionnaires used before and after the short-learning programme in Lenasia. Questions on the VNOS and VNOIK were adapted from Cronje (2015) and incorporated into these three questionnaires, rather than having them in separate documents, since the SLP in Lenasia was only two-days long and time was limited.

In addition, a set of questions was formulated during the Lenasia SLP. These were used for two focus group interviews with a few of the participants. See Appendix I for the transcripts of these interviews. Although individual interviews were also conducted,

these were unstructured since they were done after the class visits and were based on the context of those visits. Their rationale is, therefore, not included here but will be dealt with in Chapter 4. According to literature, an outline of the questions and the criteria for their design is significant in order to establish reliability of the study (Franklin, *et al.*, 2010:357). Table 3.3 shows the rationale for the formulation of these questions.

Table 3.3: Rationale for activities included in Ayurveda SLP (Addendum B)

PAGE NUMBER IN MANUAL	NAME OF ACTIVITY	RATIONALE
14	Kirby Bauer Technique	To give teachers the opportunity to use simple microbiological methods to show the anti-microbial properties of certain plants. Ultimately, in the classroom this technique can be used by learners to investigate a hypothesis involving other plants e.g. *Neem*; onion. To allow teachers to use items and ingredients from their environment if these are not available in their school. Simple chromatography can also be investigated in the classroom with various herbal plants. Learners would have a more hands-on approach to doing experiments.
17	Challenge research on: *Sutherlandia frutescens*	Encourages teachers to engage in research on their own thereby stimulating the need for SDL. This exercise can lead to teachers wanting to research other information that can then be shared with their learners.
18	Problem-based learning – Activity 1 – karrikins (De Beer, 2012)	Stimulates learners to find solutions to problems such as in this case, seed germination using smoke. Investigations can be performed using simple equipment like an empty coffee tin. The relevance of

		this problem to CAPS is provided so that participants see how the activity can be incorporated into that part of the curriculum.
22	Problem-based learning – Activity 2 – ethylene (De Beer & Petersen, 2017)	The real world problem here concerns the ripening of fruit in many indigenous cultures around the world, including the burning of incense by Chinese to ripen pears. Learners have to research this and find ways in which different cultures shortened the ripening time for fruit. Once again, the manual shows the participants the relevance of this to the curriculum.
25	Problem-based learning – Activity 3 – Allelopathy	Another real world problem where learners must question why certain plants grow well together while others do not.
32	Cooperative Learning – Jigsaw method	To stimulate cooperation among each other in learning a new concept. The activity is used to introduce participants to the nature of science and the nature of indigenous knowledge.
34-36	Cooperative Learning – De Bono's Hats	Where different aspects of a problem or question are examined using different stances represented by a certain colour hat. A good exercise to stimulate discussion or an essay topic in class. In the SLP, this activity was used to encourage comments on the integration of Indian indigenous knowledge into the curriculum.
42	Ayurvedic plants and their uses	A useful source of information for a few plants used in Ayurvedic treatments. Could stimulate participants to research the use of more such plants.
43	Reflection	To guide teachers as to how they should approach the process of reflection to make them more purposeful teachers who can achieve more effective teaching and learning.

The baseline questionnaire; the pre- and post-intervention questionnaires; and the focus-group interview (conducted immediately following the completion of the programme) probed how teachers viewed indigenous knowledge, with an emphasis

on Indian indigenous knowledge. They also explored whether teachers implement the CAPS guidelines with regard to incorporating indigenous knowledge into lessons and, if so, how this was done (i.e. pedagogy used). Teachers were also asked about their thoughts on the short-learning programme itself so that their comments could be used to streamline the design of future interventions – part of the development cycle in design-based research studies.

3.4.8 Data collection

Data collection was carried out in various ways to support the qualitative research methodology. One of the methods used was document analysis, where the Life Sciences CAPS documents were analysed for instances of indigenous knowledge integration, and the depth of integration. The topics in the curriculum where Indian indigenous knowledge could be integrated were identified used to guide the development of the Indian indigenous knowledge SLPs. Life Sciences teachers completed a pre-intervention questionnaire to determine their views and existing knowledge on indigenous knowledge, specifically Indian indigenous knowledge (Appendix G). Upon completion of the course, participants completed a post-intervention questionnaire (Appendix H) in an attempt to measure the effectiveness of the SLP in refining or modifying the participants' views. Both the pre- and the post-intervention questionnaire included elements of the 'views of the nature of science' (VNOS) and the 'views of the nature of indigenous knowledge' (VNOIK), a tool developed by Cronje (2015).

Data was also gathered from two focus group interviews that were conducted after the SLP. Two different groups of participants from Cycle 2 volunteered for the focus groups interviews. Their responses to the pre- and post-intervention questionnaires, as well as to the interviews, contributed towards the phenomenological aspect of the study. The teachers who attended the short-learning programmes were required to keep a journal of their impressions and experiences during the course. In addition, they were required to compile a portfolio of evidence containing completed assignments, questionnaires, and other documents (completed worksheets, self-reflections, lesson plans, photographs, etc.). These portfolios were to assist them when they came to engage in their own self-directed learning. The journal formed part

of this portfolio for submission and analysis. Appendix K shows three examples of these portfolios.

Thereafter, the teachers returned to their schools where it was anticipated that they would implement what was learned during the short-learning programme. The researcher visited some of these teachers in their classrooms to observe the implementation of techniques demonstrated at the SLP. Classroom observations were guided by the Reformed Teaching Observation Protocol (RTOP) instrument (Sawada *et al.*, 2002). Non-verbal communication was also observed and recorded for analysis. Appendix J shows three of these completed instruments.

3.4.9 Generating and recording data

Various tools were used to generate data for this qualitative design-based research study. Since it spanned the course of three years, different methods were used to obtain participant views before and after the interventions. Initially, pilot questionnaires were used to gauge what Indian Life Sciences teachers thought about indigenous knowledge, specifically Indian indigenous knowledge, and its integration into the curriculum (Appendix E). Thereafter, a short-learning programme or intervention was designed by other researchers in this project, incorporating elements of problem-based learning and cooperative learning, for the infusion of African indigenous knowledge into the curriculum. This initial SLP (Cycle 1 in Table 3.1) yielded several design principles that were used to modify and improve the subsequent SLP on the infusion of Indian indigenous knowledge into the curriculum (Cycle 2 in Table 3.1).

Participants completed questionnaires before and after the SLPs to determine whether their views on the inclusion of indigenous knowledge had changed or not; and how this change had occurred. On the second (and last) day of the intervention, two focus group interviews were conducted with a few of the teachers. A few months after the programme, class visits were conducted to observe whether the elements learned at the intervention were actually being implemented in the classroom. Artefacts such as items produced during the short-learning programme, teachers' submitted portfolios, and learners' responses during lessons observed, were gathered as data and analysed. The questionnaires and short-learning programmes were compiled in such

a way that they provided as much information as possible to answer the research questions of this study.

The artefacts collected from the teachers after attending the short-learning programme were analysed by the researcher. Interviews with individual teachers and in focus groups were conducted after attendance of these short-learning programmes to gauge their impact on enhancing their future pedagogy and the possible impact this could have on learner performance in Life Sciences. Once the portfolios were examined, they were returned to the respective teachers for them to keep. This use of a variety of data-gathering sources characterises ethnographic studies (Reeves *et al*., 2013: e1367).

As an Indian Life Sciences teacher, my role as the researcher was to have an insider's perspective on the interview responses received from other teachers, thus lending a further ethnographic dimension to this study (Reeves *et al*., e1369; e1370). However, I needed to ensure that I was as objective as not allowing my personal knowledge to influence or judge how teachers responded. I used my perspective to better understand some of the Indian indigenous knowledge, especially after having attended the Ayurveda course in India. In addition, since "ethnography research is exploratory in nature" (Reeves *et al*., e1367) it suited my study, which explores how Indian indigenous knowledge can be integrated into the Life Sciences curriculum.

3.4.10 Transcription of data

Rather than being simply a phase of data preparation and management, transcription is regarded as "interpretive work that takes place early in the analysis phase of most qualitative research projects" (Poland, 2008:885). Transcription should, therefore, be subjected to the same levels of "reflexivity and rigour" as other parts of data analysis, although it should actually be at a higher level as it "involves the production of raw material upon which subsequent analytic work is done" (ibid). Reflexivity is referred to in Reeves *et al.* (2013:e1370) as "the self-reflection of [the researcher's] background, values and history". In my study this is of special significance since, as the researcher, I am also an Indian Life Sciences teacher whose 'background, values and history' allowed me to reflect on the transcriptions during analysis; while continuing to maintain the objectivity of a researcher. The notion of rigour is dealt with in Section 3.4.11.

The focus group interviews were recorded using the voice recording facility on a cell phone. A third party, not connected to this research project, transcribed the audio data collected from the interviews. These initial transcriptions were then checked for accuracy by the researcher by reading through the transcripts more than once while listening to the recordings. Maree (2007:104) suggests that while listening to the recordings, impressions should be written down in a process called “memoing”. These impressions then formed the basis of reflections by the researcher, thereby enhancing the discussion of results in Chapter 4.

The responses from each of the different questionnaires were summarised for each respondent in order to make the data easier to organise for analysis. The various types of data, viz., interview transcripts and questionnaire responses were then coded using data analysis methods described in Section 3.4.10.

3.4.11 Analysing data

According to Reeves *et al.* (2013:e1370), “data analysis in the ethnographic methodology is iterative and unstructured” and is made up of three parts: “description, analysis and interpretation”. Maree (2007) elaborates that the iterative nature of qualitative data analysis is non-linear and the researcher will have to move back and forth between the data described, its analysis, and its interpretation. Description deals with the “recounting and describing of data”; analysis deals with the process of studying “relationships, factors and linkages” among different data sets; and data interpretation develops “an understanding or explanation of the data beyond the data points and analysis” (Reeves *et al.*, 2013:e1370). The data gathered in my study was analysed in this way.

Two approaches to qualitative data analysis and coding are suggested in Maree (2007:99), viz., an inductive and a deductive approach – the latter being referred to as an *a priori* categorisation. An inductive approach is less structured; where the data is described and analysed according to themes that emerge as the analysis proceeds. A deductive approach is one where codes and themes are pre-determined before data collection, such that the description and analysis of data will be according to these pre-existing categories.

Saldana (2009:3) defines a code as, most often, a word or short phrase that encapsulates the "evocative attribute for a portion of language-based or visual data". Since my study was influenced by ethnography, which is "exploratory in nature" (Reeves *et al.*, 2013:e1367), it was deemed fitting to use an inductive approach to data description, analysis and interpretation, rather than trying to place the data into preconceived categories. This inductive approach was also more appropriate in attempting to answers my research questions on the integration of Indian indigenous knowledge into the Life Sciences curriculum.

Coding is a subjective process that is influenced by the type of qualitative study being conducted, as well as the personalities and "quirks" of the researcher doing the coding (in Saldana, 2009:7). Gibbs (2007:38) further explains the subjective nature of coding by referring to the way in which a researcher defines what the data being analysed are about. As a qualitative researcher, I was in a unique position (as an Indian Life Sciences teacher) to provide a more insightful interpretation of the coded data. This subjective analysis allowed for a more nuanced understanding of the data. Saldana (2009:8) explains that coding is a method that allows the organisation and grouping of similarly coded data into categories that share a particular characteristic.

Gibbs (2007:38) adds that coding entails grouping items from various sources together so that the common idea or theme eventually surfaces, and that the easiest way to code is to use transcripts. Questionnaires, interviews and other recorded observations were, therefore, first transcribed as described in the previous section. Together with the artefacts these transcripts were then analysed, mostly by using the open-coding method described in Maree (2007:105) which involves:

1. Marking meaningful segments of text in the transcripts or artefacts with "symbols, descriptive words or unique identifying names" – these are then the codes.
2. These codes are used as markers for interpretation of the text; or the codes serve to group important data. They also offer deeper insights into the data.
3. Each transcript or artefact is coded separately.
4. A master list of all the codes and their meaning is compiled as the coding occurs.
5. Once all the transcripts are coded in this manner, the next step is to group similar codes into sub-themes as applicable to the research questions.

6. These themes were then analysed and interpreted according to the research questions to ascertain whether they offer any answers or explanations.
7. One of the ways in which this is done was to count the frequency of similar codes appearing in one transcript or multiple transcripts.
8. This then enables the over-riding themes to emerge, which in turn focus the interpretation on the research questions.
9. The minor themes are not ignored as they offer important nuances to the data and can enhance interpretation.
10. Once the number of sub-themes reaches a saturation point, they are grouped into major themes that speak directly to the research questions.

The process outlined above is represented in Figure 3.4 taken from Saldana (2009:12), which shows how codes eventually become themes. The transcripts were coded by scrutinising each line of text, a technique referred to by Gibbs (2007) as line-by-line coding. Gibbs (2007:52) advocates line-by-line coding of transcripts to "force analytic thinking" and to avoid inserting personal bias, values, motives and preconceptions rather than that of the respondents. At the same time, researchers using this type of coding should not expect to blindly accept what the respondents are saying, and should instead reflect on their responses by being more analytical and theoretical when coding and analysing them (ibid). The questions dealing with aspects of VNOIK were analysed using the procedure described by Cronje (2015). Using Cronje's rubric, teachers' responses were classified as informed views (I), partially informed views (PI), or uninformed views (UI). Weighted averages were determined for each participant.

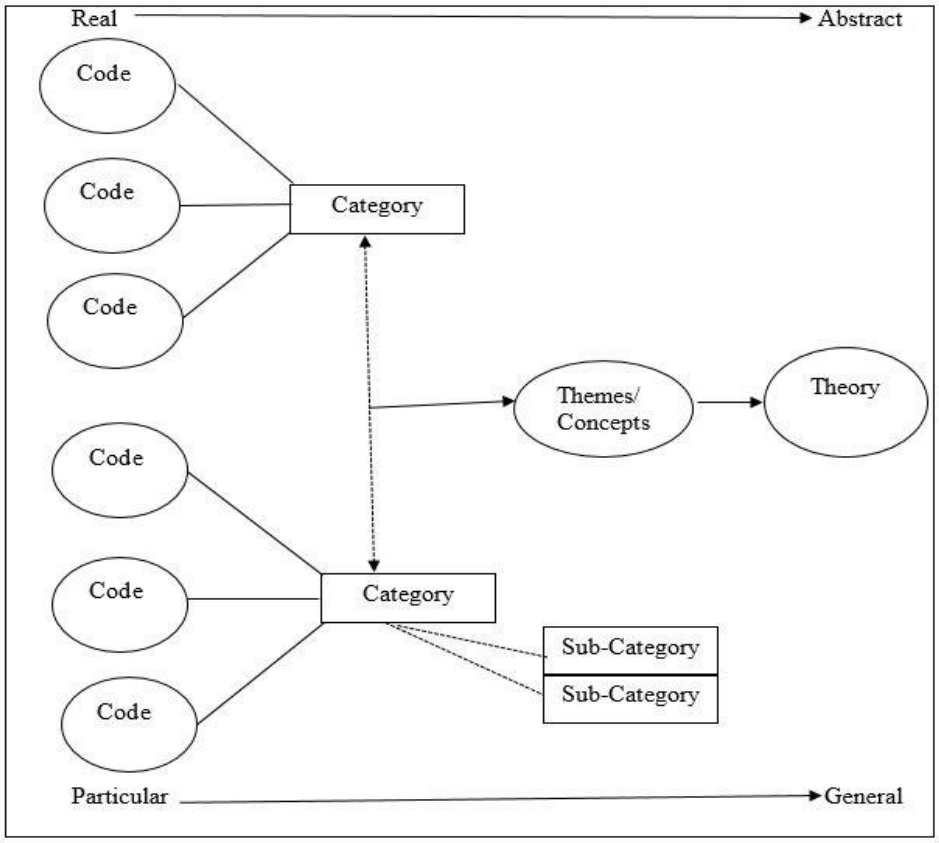


Figure 3.4: A representation of the coding process in qualitative study (Saldana, 2009:12)

There are several software programmes available for the analysis of data; and, according to several researchers (Reeves *et al.*, 2013; Maree, 2007), these have considerable benefits. However, I decided to forego these in favour of manual analysis. The reason for my choice was that computer analyses emphasise “quality and breadth over meaning and depth”; are unable to provide thick descriptions of phenomena; and make data analysis “rigid and structured” (Reeves *et al.,* 2013:e1371). In qualitative research, such as the current study, it is necessary to probe the implications and significance of what people say. Their unspoken gestures are also important and can only be sufficiently analysed using human thought processes. As stated in Maree (2007:117), computers cannot reveal “deeper meanings that are hidden in the nuances of a transcript” and that “only the human mind can begin to see and understand the world through the eyes of the participants”.

Saldana (2009:22) shares the view that manual analysis and coding of data gives one "more control over and ownership of the work". As mentioned in the previous paragraph, I felt it important to use the human element to make connections and uncover finer points during data analysis – aspects that a software package may miss – especially given that my background, experience and values are those of an Indian Life Sciences teacher (qualities that a software package cannot be programmed to have).

Sawada *et al.* (2002) suggest that the researcher follow a holistic approach when analysing data collected using the Reformed Teaching Observation Protocol (RTOP) instrument. I did not, therefore, use the RTOP instrument to collect quantitative data (despite the Likert-scale items) for statistical analysis, but rather to make qualitative judgements that could strengthen the emerging themes.

3.4.12 Rigour in the study

My study is based on a constructivist theoretical framework and uses a qualitative methodology. According to Jones *et al.* (2012:377), citing Denzin and Lincoln, constructivist paradigms usually centre on "trustworthiness, credibility, transferability and confirmability". As indicated earlier, qualitative research differs from quantitative research in that the history, experience and skills of the researcher offer subjectivity to data collection, analysis and interpretation. In addition, Miller (2008:754) states that researchers in this type of research "are seen as visible, biased integral players in the process" and that "the richness and meaningfulness of qualitative research is largely dependent on its creativity and originality". Regardless of the subjective and unique nature of qualitative research, it is essential to ensure research rigour.

Saumure and Given (2008:795) define research rigour as meeting high quality standards so that the findings can be trustworthy. Validity and reliability are the two main concepts that contribute to research rigour. Although they have traditionally been linked to quantitative studies, they are increasingly regarded as crucial for assessing the objectivity and credibility of qualitative studies as well (Anderson, 2010:2). Another concept associated with research rigour is that of researcher reflexivity. Reflexivity deals with "the immediate and continuing critical self-reflection that considers how the

researcher might have influenced the research process" (Jones *et al.,* 2012:377). Reflexivity in my study will be dealt with in the next chapter, with the analysis of data.

Miller (2008:754) mentions that the subjective nature of qualitative studies can be weakened by rigid expectations of reliability, historically the domain of quantitative studies. Several researchers have, therefore, assigned alternative concepts that speak to reliability and validity in qualitative studies. For instance, Miller (2008:909) identifies Lincoln and Guba, among other researchers, who put forward alternative concepts for the quantitative ideas of reliability, validity, objectivity and generalizability. They consider "trustworthiness, credibility, authenticity, transferability, and plausibility" as more appropriate alternative criteria by which to ensure rigour in a "fluid and continually contested" subjective qualitative research environment.

3.4.13 Reliability

Reliability in quantitative research is often described as the repeatability, consistency and/or dependability of a study's data collection, analysis or interpretation; whereas in qualitative research, reliability in the form of credibility and dependability, is based on three main strategies, viz: (Miller, 2008:753)

- Methodological coherence (the appropriate and thorough collection, analysis, and interpretation of data);
- Researcher responsiveness (the early and continuing verification of findings and analyses with participants); and
- Audit trails (a transparent description of all procedures and issues related to the study).

These three strategies were used in my study as follows:

- Methodological coherence – appropriate and thorough data collection was ensured through the use of various data sources, i.e., questionnaires, interviews, artefacts and class visits. The various sources of data contribute to the thoroughness of the information received.
- Researcher responsiveness – findings were verified early in the research process when questionnaires were administered to Indian Life Sciences teachers during

the pilot study. Findings were again verified during the SLP the following year, and during the third-year class visits.

- Audit trails – this chapter provides a clear description of the procedures related to my study, as well as reasons for the various methodological choices.

Shah and Corley (2006:1829), drawing on various researchers, also provide a set of alternative criteria by which to ensure trustworthiness or rigour in qualitative research. These are provided in Table 3.4.

Table 3.4: Alternative criteria used to ensure research rigour in qualitative research [Source: Modified from Shah and Corley (2006:1830)]

TRADITIONAL CRITERIA (Quantitative)	TRUSTWORTHINESS CRITERIA (Qualitative)	METHODS FOR MEETING TRUSTWORTHINESS CRITERIA
Internal Validity	Credibility	Extended engagement in the field Triangulation of data types
External validity	Transferability	Thick descriptions of data collection and analysis processes
Reliability	Dependability	Purposive sampling Protection of informants confidentiality
Objectivity	Confirmability	Meticulous data management and recording Verbatim transcription of interviews Careful notes of observations Accurate records of contacts and interviews

The notion of **credibility** in my study is achieved by using a design-based research methodology with the data-gathering process spanning three years in which there was extensive engagement with the participants. Triangulation (which will be discussed in

greater detail in Section 3.4.14) was obtained by making use of various types of data such as interviews, questionnaires, and artefacts.

Transferability has been made possible since, for each step of my study (particularly in this chapter) detailed descriptions, explanations and rationales are provided.

Dependability was achieved through purposive rather than random sampling; and regulations around ethics and participant confidentiality were strictly adhered to.

Confirmability was achieved by the scrupulous and accurate control over data collection and recording throughout the three-year research process; including the careful transcription of interviews and detailed observation notes. Based on these four criteria of trustworthiness, as well as the three strategies to ensure reliability described earlier, my study was deemed to have an appropriate level of reliability, and hence research rigour. Validity accompanies reliability in achieving research rigour and is discussed next.

3.4.14 Validity

In research, validity generally refers to the "goodness" or "soundness" of a study (Miller, 2008:909). Anderson (2010:2) states that it "relates to the honesty and genuineness of the research data" and is considered to be the central part of research (Knight & Cross, 2012:48). Like reliability, it is usually associated with positivist/deductive research. Consequently, criteria for validity are often inaccurate and over-simplistic when applied to qualitative studies. Qualitative studies have a vast array of paradigms and methodologies, such that the type of validity depends on the aims and methods of each study (Miller, 2008:909). My study used design-based research as a methodology, thus validity would be measured in terms of how practical it is for teachers to integrate Indian indigenous knowledge into their Life Sciences lessons.

According to Knight and Cross (2012:48), there are different levels of validity that can be established in a research study, viz: construct validity; internal validity; external validity; reliability; and conceptual validity. Transactional validity and transformational validity are also identified by researchers (Jones *et al.*, 2012:377). Based on Knight

and Cross (2012:48), each of these levels of validity are discussed below. Added to each is a brief overview of how they were addressed in my study:

Construct validity – is established through the correct design and use of data collection methods for the concept being studied so that the methods measure what is intended to be measured (Maree, 2007:217). The deployment of more than one investigator in the collection and analysis of data can further increase the validity and trustworthiness of findings (Rothbauer, 2008:893). Another researcher in the SDL project conducted the SLP with me, and we also conducted a few class visits together. In addition, the results from other SLPs conducted in other parts of the country were used as a means of comparison. In these ways we were able to discuss and share our findings thereby enhancing construct validity for my study.

Internal validity – is helpful when replicating a study and is needed if the study intends to show the relationship between aspects of the phenomena. One of the threats to internal validity is attrition which refers to the systematic decrease in the number of participants that might influence the results (Maree, 2007:151). This was a very real problem in my study especially when it was necessary to conduct classroom observations, as many teachers displayed a great deal of reluctance in agreeing to class visits.

External validity – is needed to establish a level of generalizability with the findings to other contexts. According to King and He (2005:882), it is essential to show that "research results are applicable in natural settings, as contrasted with classroom, laboratory, or survey-response settings". In my study this would refer to the teachers who attended the SLP and then had to implement what was learnt in their own classrooms. Class visits determined whether there was a correlation between the two contexts.

Reliability – involves using the same data collection methods in order to reproduce the results. Data collection methods in my study entailed the use of questionnaires and interviews among purposefully sampled participants. However, as explained by Merriam (1998:205), it is highly unlikely that the same results will be obtained if

research is repeated in qualitative studies since “human nature is never static”. Hence, it is important for validity to be established (Maree, 2007:37).

Conceptual validity – is achieved when there is concord between the design of the investigation and the underpinning philosophical assumptions. In the case of my study, the latter is a constructivist philosophy and the former is design-based research, which allows the development of knowledge through each stage of the study.

Transactional validity – looks at increasing the accuracy of data analysis by triangulation, and by revisiting and validating emerging findings with participants (Jones *et al.*, 2012:377). The issue of triangulation is dealt with in the next section.

Transformational validity – is a reflexive process during which the researcher’s own background, biases and skills play an important role in framing studies to obtain a unique perspective (Miller, 2008:754). This is an important part of my study, since my background as a South African Indian Life Sciences teacher provided a distinctive angle to this study.

According to Knight and Cross (2012:48), these levels of validity do not need to be achievable for all studies but conceptual and construct validity “are absolutely essential to all research” to ensure valid and reliable findings. Ellis and Levy (2009: 333), on the other hand, state that internal and external validity are the most important. In my study, all of the validity criteria listed above were applied. It is also necessary to point out that, as long as a study has validity, it is sufficient to establish reliability because “there can be no validity without reliability” (Lincoln & Guba, 1985:991). One of the techniques in which validity is substantiated is by the triangulation and crystallisation of data, which has been used to ensure the credibility and trustworthiness of this research.

3.4.15 Triangulation and crystallisation

Triangulation refers to the many different methods used to collect and analyse data in order to achieve a more coherent and stable understanding of the phenomenon under investigation, as well as to reduce prejudices or paucities that arise from using only a single data collection method (Rothbauer, 2008:892). It intends to provide a deeper,

more holistic understanding of a phenomenon while serving as an important means for researchers to ensure methodological rigour (Reeves *et al.*, 2013:e1369). The many different methods used in my study to collect data include the CAPS curriculum document, questionnaires, individual and focus-group interviews, the SLP with Life Sciences teachers, class visits, and artefacts such as learner and teacher portfolios.

Chenail (1993:3) explains that triangulation originates from the procedure used by sailors and surveyors to plot their location using the intersection of three points. In research, "researchers use different sets of data, different types of analyses, different researchers, and/or different theoretical perspectives to study one particular phenomenon. These different points of view are used to situate the phenomenon and locate it for the researcher and reader alike" (ibid). According to Reeves *et al.* (2013:e1370), there are four types of triangulation in ethnographic studies, viz:

- Data triangulation – using different sources of data. The different sources used in my study have been mentioned in the previous paragraph.
- Methodology triangulation – using many research methods to compare different ways of understanding according to each method. The overall method in my study was that of design-based research with elements of phenomenology and ethnography included. Each of these methodology types provided a different dimension to understanding the behaviours of the teachers attending the SLP.
- Investigator triangulation – entails different investigators collecting data to formulate more complex empirical accounts by understanding possible differences. Many different researchers were involved in the SDL project and collected data. For my study itself, a researcher worked with me during the SLP and class visits. This allowed us to corroborate and confirm findings.
- Theory triangulation – the use of different concepts and theoretical perspectives to view the data in different ways. Constructivism is the over-arching theory of my study and enabled the use of CHAT as a lens with which to view the findings. (CHAT was introduced in Chapter 2. In Chapter 4, I will study my data using CHAT as a research lens). In addition there were several concepts that were explicated in Chapter 2 such as PCK, NOS, indigenous knowledge and controversial conceptual change. All of these formed part of the theoretical and conceptual

frameworks of my study, and they each provided a unique perspective on data analysis.

3.4.16 Using CHAT as a methodological tool

CHAT offered a valuable methodological tool in this study by considering the design principles that emerged from the earlier SLPs (in Cycle 1) and using these to refine the SLP in Cycle 2. According to De Beer and Kriek (2018?) “CHAT provides special insight into teachers’ learning and professional development by considering contextual factors, that is, the specific variables that characterise any given SLP”.

In support of triangulation, Johnson and Onwuegbuzie (2004:19) state that corroboration across different approaches leads to “greater confidence in a single conclusion”. On the other hand, Maree (2007:81) explains that qualitative studies rarely, if at all, consist of three sides to warrant the two-dimensional concept of triangulation, which is actually more suited to quantitative studies. The concept of crystallisation is favoured instead, since it provides a multi-faceted view with a limitless number of nuances, views and approaches with which to view, analyse and interpret the data collected. This results in “a complex and deeper understanding of the phenomenon” such that findings are actually a crystallisation of the data (ibid).

The SDL project, that my study formed part of, used triangulation and crystallisation to identify tensions in the teaching of indigenous knowledge by using CHAT as a research lens. The four different types of triangulation outlined above actually contributed to the process of crystallisation since they each provided a different slant to the research. These tensions were in turn used to extract design principles (discussed earlier) for the SLP involving the infusion of Indian indigenous knowledge into Life Sciences lessons.

My study itself used triangulation and crystallisation by, firstly, using multiple data collection techniques and, secondly, by analysing and interpreting this data in different ways using the generation of themes from coding. In this way the credibility and trustworthiness, or rigour, of my study was strengthened.

3.4.17 Participant selection

The selection of participants or sampling forms a significant part of the research process as it contributes to informing "the quality of inferences made by the researcher" that arise from the fundamental outcomes (Onwuegbuzie & Collins, 2007:281). Purposive sampling of Indian Life Sciences teachers was used in the pilot study. These teachers were selected during the Grade 12 senior certificate marking session in July 2016. They were asked to complete a questionnaire via email that elicited their existing conceptions about indigenous knowledge, specifically Indian indigenous knowledge. This exercise was mediated by the chief marker at the Life Sciences marking centre who asked eleven male and female Indian Life Sciences teachers to volunteer to complete the questionnaire. Eventually seven of these teachers took part in this initial stage of the study by submitting their responses to the questionnaire via email.

A year later, in July 2017, a different set of teachers attended a two-day short-learning programme focussing on Ayurveda. The SLP took place in Lenasia – a predominantly Indian area. At the planning stage of the study, it was hoped that mostly Indian teachers would attend this programme, however, this was not the case, and it was attended by a diverse group of White, Indian and African teachers. Since the Department of Basic Education (DBE) had given permission for the short-learning programme to proceed, contact was made via the subject specialists in different districts in Lenasia – see Appendix C. However, since this was scheduled at the start of the Winter school holiday, and many teachers were involved in the SSIP (Secondary Schools Improvement Programme) convened by the GDE to help Grade 12 learners prepare for their final exams, the response was extremely poor.

It was then decided to open up the invitation to all Life Sciences teachers regardless of race and an invitation was subsequently posted on social media, viz., Facebook. An overwhelming response was received which enabled the short-learning programme to proceed. A total of twenty teachers eventually indicated an interest in attending the two-day programme. This round of the research, therefore, involved snowball sampling. Nieuwenhuis (2007:80) explains that snowball sampling involves a few participants who are initially contacted and who, in turn, use their social networks to direct the researcher to other potential participants who could contribute to the study.

The number of participants used in Cycle 2 of this DBR was deemed sufficient as "qualitative research necessitates having a small sample because of the detailed and intensive work required for the study" (Anderson, 2010:4). Sample sizes in qualitative research should not be so small that data saturation is difficult to achieve; or so large that it is difficult to perform an in-depth analysis of the responses (Onwuegbuzie & Collins, 2007:289). In my study, the total number of participants was twenty-seven, which falls within the range suggested by the authors cited on ethnographic studies (ibid).

s part of the larger study, in which mine is situated, many teachers from different areas in South Africa participated in short-learning programmes focussing on integrating African indigenous knowledge into the Life Sciences curriculum. In terms of sampling, these were all Life Sciences teachers who belonged to various cultural groups.

3.5 ETHICAL PARAMETERS OF THE STUDY

3.5.1 Participant protection

Cohen *et al.* (2002:56) provides the following definition of ethics: "Ethics is a matter of principled sensitivity to the rights of others. Being ethical limits the choices we can make in the pursuit of truth. Ethics say that while truth is good, respect for human dignity is better, even if, in the extreme case, the respect of human nature leaves one ignorant of human nature". The larger SDL project already enjoyed ethical clearance (NWU-00271-16-A2), which was obtained in 2016, yet I also applied for ethical clearance from the NWU Ethics Committee for this specific study (NWU-00358-18-A2).

Although the generic ethical clearance for the funded NRF project also covered Cycle 2 of this DBR, my promoters felt that I could benefit from the experience of completing the ethics application, and having to defend my application during the meeting of the Research Ethics Committee (REC). Both these ethics approval certificates are provided in the Appendix (see Appendix B). Written permission was obtained from the Department of Education, and the teachers who attended were asked to complete ethical consent forms. Parents were also informed and their permission sought when classroom observations were made that involved photography. The principal of the school at which the short-learning programme was conducted, and where classroom

observations were done, was also consulted and permission was obtained. These documents are provided in Appendix C.

All participant portfolios and journals were returned to them after data analysis and completion of this study, so there was no danger of these artefacts falling into unauthorised hands. Participants were not harmed in any way during the course of the study as they were not required to perform any risky physical behaviour, neither were they expected to partake of any pharmaceutical products. In their written informed consent to participate in this study, the participants were advised that they were doing so on a purely voluntary basis and that they could withdraw at any time from the research without prejudice. They were also assured of anonymity for both themselves and the schools at which they taught.

Their wellness was protected at all times and appropriate feedback was given to them on the outcomes of the investigation once it was completed. All written submissions from the participants such as their responses to questionnaires, interview transcripts, and portfolios will be kept in a secure facility for at least seven years as per the ethical requirements of the university. As the researcher I respected the respondents' privacy, confidentiality and anonymity at all times during the study; and will continue to do so in future. The photos provided in the thesis were included with permission from those participants.

3.5.2 Building rapport among the participants

Indian Life Sciences Teachers who participated in the pilot study in July 2016, were contacted by the researcher via email and were given a choice between two offers as a token of appreciation: they could have either chosen to attend a three-day short-learning programme on indigenous knowledge free of charge at North-West University, Potchefstroom; or a reference book on medicinal plants of South Africa to be used as a classroom resource during lessons. Although rapport was only established via email, the teachers were highly cooperative with the researcher and completed the questionnaire within the stipulated time, providing valuable responses and insights that were used to inform this study on the integration of Indian indigenous knowledge into the curriculum.

The researcher communicated via telephone and email with the teachers who attended the short-learning programme in Lenasia a year later. This allowed a stronger rapport to be established with them. Apart from the actual course material, these teachers received several resources during the programme including a reference book on indigenous plants; an HIV testing kit for classroom simulations; a DVD with multiple resources and information to enhance lessons. In addition, every teacher who completed and submitted their portfolio of evidence after the programme received 16 CPTD points (Continuous Professional Teacher Development) towards their professional development as teachers, a requirement by SACE (South African Council of Educators) for all teachers.

These benefits for the teachers who attended the SLP in Lenasia served to ensure their attendance and active participation in the programme. Commitment was also encouraged by providing the attendees with lunch and tea-time snacks, on each of the two days. During refreshment times, they were able to converse with one another as well as with the course presenters and the researcher in an informal setting, thus establishing rapport. During the actual programme, the teachers were invited to ask questions, share their thoughts and generally participate freely without fear of ridicule. The atmosphere in which the SLP was presented was relaxed and friendly, and participants appeared comfortable and interacted with ease. This served to enhance the presentations and the benefits of participating in the course, especially since they were all learning about a concept they knew little about, i.e., Indian indigenous knowledge.

The overall impression created by the teachers at the course was one of enthusiasm and excitement about learning something new, i.e., Ayurveda. This appeared to be the result of a positive and comfortable rapport that developed between them and the course presenters.

3.6 CONCLUSION TO CHAPTER THREE

This chapter deals with the research design, methodology and methods that were used in my qualitative study. The research questions, aim and rationale for my study are also highlighted, since the methodology was selected to address these research questions. The overarching research design, that of design-based research, is

explained in some detail as DBR was the chosen methodology for the larger SDL project, of which my study forms part. The Ayurveda course that was attended in India is also substantially elaborated on, since this was pertinent to my study.

The rest of this chapter entailed a detailed examination of data collection, its transcription, analysis and the way in which research rigour was achieved. Some theoretical background is provided for all these aspects in order to show their relevance to the research questions, while also expanding on the meaning of each for clarity.

The next chapter deals with the presentation of data, and the analysis and discussion of this data as it contributes towards the aim and rationale for this study.

CHAPTER FOUR RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter is a presentation of the data gathered during the three-year period of this study and its detailed analysis that is aligned with the theoretical and conceptual frameworks discussed at length in Chapter 2. The previous chapter examined the methodology used in gathering this data and the design-based research (DBR) that followed in developing teacher development programmes of intervention for Life Sciences teachers. Table 4.1 represents a timeline that places the study in context and indicates the development of the various cycles in the research.

Table 4.1: Timeline for study using principles of design-based research (DBR)

YEAR	RESEARCH MILESTONES	CONTEXT/MORE INFORMATION
1	Pilot study involved an earlier short-learning programme (SLP) in Limpopo, Potchefstroom and Kimberley.	The 3-day SLPs had a rhizomic development, based on data obtained and the design principles that were developed for the SLP.
2	Attended an Ayurveda course in Kerala, India, with my promoter. SLP intervention with a tailor-made Ayurveda course in Lenasia.	First-hand exposure to the tenets of Ayurveda, at a world-renowned Ayurveda training institute. SLP was formed by design and basic principles of Ayurveda.
3	Post-intervention research – visiting teachers' classrooms, to study transfer methods. Re-visit the design principles to make changes to the SLP that was later presented in Calvinia (Namaqua district, Northern Cape).	Based on the data obtained, it was realised that more emphasis should be placed on teacher reflection and, for this reason; classroom action research was incorporated into the portfolios.

Data was obtained from multiple sources comprising curriculum documents, questionnaires, interviews, the interventions conducted with teachers, teachers' portfolios submitted after the SLPs and lesson observations. The use of multiple sources of data served to triangulate results and contributed to research rigour. Due to the nature of qualitative research, a detailed background for each source of data

was provided in order to understand the context in which the responses were received. Data from the questionnaires and lesson observations were subjected to the inductive method using descriptor codes, meaning units and the themes as outlined in Saldana (2009). The analysis of each data source resulted in the emergence of the provisional themes and these were then used to derive the major themes or findings for my study.

The descriptor codes extracted from each data source was first clarified to enable an understanding of their actual meaning and why they were chosen in each source; particular reference to the research questions and objectives of this study was maintained. These are represented in separate tables for each data source used. For ease of reference, the research questions led to the following aims which were used to offer the rationale for the study:

- To investigate ways in which Indian indigenous knowledge (IK) systems, such as Ayurveda, could be integrated into the South African Life Sciences curriculum for school purposes.
- To examine whether the Indian IK system of Ayurveda concur with the tenets of the nature of science and the nature of indigenous knowledge.
- To determine Life Sciences teachers' views about the nature of science and the nature of indigenous knowledge prior to, and after the intervention.
- To examine whether the transfer of Indian indigenous knowledge takes place in schools after the short-learning programme (SLP).
- To identify some of the tensions, if any, that may arise when Indian IK is integrated into the South African Life Sciences curriculum.
- To delve into Life Sciences teachers' lived experiences of participating in the short-learning programme (SLP), and the teaching of IK in the classroom.
- To investigate the role of such a short-learning programme (SLP) in providing teachers with more nuanced understandings of Ayurveda as an IK system.

4.2 OUTLINE OF CHAPTER 4

The data will be presented and analysed according to the chronological order in which it was gathered and the role that it played in the three cycles of DBR.

Table 4.2: Table outlining the layout of Chapter 4

CYCLE IN DBR	ACTIVITY	TYPE OF DATA COLLECTED	
1	1. Curriculum policy document analysis 2. Limpopo SLP [Cycle 1] 3. Pilot Study	4.3. Life Sciences Curriculum and Assessment Policy Statement (CAPS) Curriculum document analysed for IK and for the infusion of Ayurveda principles 4.4. Post-intervention questionnaires (after Limpopo SLP) 4.5. Pilot Questionnaires	
2	Lenasia SLP [Cycle 2]	4.6.1. Pre-intervention questionnaire 4.6.2. SLP itself – interaction during SLP and activities done, e.g., posters 4.6.3. Post-intervention questionnaires 4.6.4. Focus-group interviews 4.6.5 Class visits/Lesson observations 4.6.7. Portfolios analysed	
3	Calvinia SLP [Cycle 3]	• Portfolio analysis • Themes that emerged	***Note:*** *Although mentioned here, these will not be discussed separately or in detail since this is not the focus of the study. However, reference will be made to the findings to provide context within the DBR methodology, and how the study has contributed to the SLP in Calvinia.*

4.3 CURRICULUM DOCUMENT ANALYSIS

The CAPS has been in operation in South Africa (SA) since 2012 and has been touted as a content-laden and teacher-centred curriculum. The CAPS has a few general aims that speak to the integration of IK into the curriculum. The analysis of these aims and other aspects of the policy document were done in order to design the SLP. However, it must also be noted that even though the CAPS "advocates for the inclusion of IK, it does not provide teachers with much guidelines on how to do such epistemological border-crossing in the science classroom" (De Beer, 2018).

Several reasons are cited in the CAPS that will benefit learners if they study Life Sciences including: “greater awareness of the ways in which biotechnology and knowledge of Life Sciences have benefitted humankind; an understanding of the ways in which humans have impacted negatively on the environment and organisms living in it; a deep appreciation of the unique diversity of past and present biomes in Southern Africa and the importance of conservation; an awareness of what it means to be a responsible citizen in terms of the environment and lifestyle choices that they make” (DoE, 2011:8). Each of these reasons makes it possible for the integration of IK and is of particular significance to the study, for Ayurveda to also be integrated. In Chapter 2 the relevance of specific aspects of Ayurveda with regards to certain topics in the Life Sciences curriculum are explored. The summary table (Table 2.6) indicates these links at a glance so that teachers can understand the feasibility of including Ayurveda into specific topics in the curriculum.

One of the drawbacks of the CAPS curriculum is that, due to it being content-heavy, the completion of this content is driven by a work schedule known as the “pace-setter”. This tool is designed to ensure that teachers teach a prescribed number of topics within strictly specified times during the school term. Teachers’ progress on the pace-setter is monitored and enforced by the school management and the education department officials whose primary function often appears to be the quarterly regulation and verification of curriculum coverage. This places excessive pressure on teachers who are forced to complete content merely to comply with the pace-setter rather than being concerned with the learners’ understanding of the topics or if the learners have grasped the concepts. However, satisfactory learner performance is still expected and learner performance is stringently monitored, especially at Grade 12 level. Compulsory provincial examinations, colloquially known as “Common Exams”, based on the topics prescribed in the pace-setter; further exacerbate the demands placed on the teachers to complete the syllabus and to get learners to perform well regardless of the lack of time provided to achieve this.

The content-laden nature of CAPS, therefore, appears to present a stumbling block for the transfer of information learnt at the SLPs into actual lesson units in the participants’ classrooms. The focus of the SLP was on inquiry, problem-based

learning, with the expectation that it would probe problem-based learning (PBL) in the classrooms.

4.4 CYCLE 1 – EARLIER SHORT-LEARNING PROGRAMME HELD IN LIMPOPO

This was one of the earliest SLPs held as part of the larger 'affordances of IK for self-directed learning (SDL)' project in which the study is situated. The three-day SLP, held at the University of Limpopo, was attended by 62 teachers, who were mainly African, a few Whites and no Indians. Racial groups are mentioned here because in the discussion of the pilot study in the next section, it was specified that purposive sampling was used to select only Indian teachers. The SLP in Limpopo involved the integration of IK into the Life Sciences curriculum, with an emphasis on African IK (specifically Khoi-San IK). After the SLP, participants completed questionnaires which contained generic questions on this integration that guided future SLPs, including the one held in Lenasia on which the study is based. In this section, only the questions relevant to the study will be discussed.

4.4.1 Limpopo programme: Findings from pre-intervention questionnaires

Question 1: How would you describe indigenous knowledge (IK)?

This question was adapted from the views of the nature of indigenous knowledge (VNOIK) questionnaire (Cronje *et al*., 2015) and determined what the participants had learnt about IK during the SLP. In this way, the effectiveness of the programme could be deduced and any future SLPs could be modified and improved based on the responses provided.

Table 4.3: Table of analysis for Question 1 after Limpopo short-learning programme (SLP)

QUESTION	DESCRIPTORS	FREQUENCY AMONG RESPONSES	CATEGORIES FROM DESCRIPTORS	PROVISIONAL THEMES
How would you describe indigenous knowledge (IK)	Old/traditional knowledge	14	IK passed down from one generation to another and over a long period of time.	The SLP reinforced teachers' awareness that IK is an ancient knowledge descended from ancestors over many generations. SLP confirmed for teachers that IK is local knowledge using natural resources of that area in a sustainable way. Teachers participating in the SLP realised that IK shares some features with Western science by considering the tenets of the nature of science (NOS). However, for some participants it also constitutes pseudoscience.
	Use of plants and animal products	8		
	Rituals and religious beliefs	3	Elements of pseudoscience and supernatural influence of IK.	
	Pseudoscience	2		
	Common habitats for indigenous plants	6		
	Western science	1		
	Distributed knowledge	1	Dominant influence of natural world and sustainable use of resources by local people.	
	Link to science	1		
	Sustainable use of resources	1	Link to science through identification of tenets of NOS.	
	Nature of science (NOS) tenets and misconceptions	4		
	Healing of diseases	1	Some misconceptions of NOS.	

According to the responses received for this question, three provisional themes or categories emerged regarding what the teachers learnt about IK, the descriptor with the highest frequency, viz., IK is an old, traditional knowledge acquired by our forefathers for their survival and has subsequently been passed down through several generations. Some of the statements that illustrate this idea were that IK "*was used by our forefathers; traditional way of doing things; imported from elders; the way in which old people use to do things"*. This idea implies distributed cognition as the knowledge has been passed down from one generation to another in a particular society. The Inter-Commission Task Force on Indigenous Peoples (in Onwu & Mosimege, 2004:2) and Letsekha, *et al*. (2013:4577) are two examples of research studies confirming that IK is indeed knowledge that has been developed over many generations and "evolved over many years". The SLP, therefore, served to confirm this definition for the teacher participants.

The second category showed that teachers regard IK as local knowledge depending on the type of vegetation and other natural resources found in their habitat that is used sustainably to ensure the survival and the treatment of diseases. One participant mentioned that even though IK is confined to a certain locality, it can be distributed to other parts of a country, i.e., "…*it can be localised or nationalised*". Other participants remarked that IK "*is specific to a certain community or society; it comes from different localities; it is information gathered by inhabitants of a particular area"*. This idea that IK originated in certain areas by the inhabitants has been put forward by several researchers of IK, such as Khatri and Choukhande (2012); Kwanya (2015:1); and Letsekha *et al.* (2013:4577), indicating that the Limpopo SLP reinforced this concept for several teachers about IK. It was, therefore, not just knowledge found in books but the teachers could now relate to this after attending the SLP.

The third category indicated that teacher participants seemed to have a more nuanced understanding of the tenets of the NOS as related to IK. This arose from the responses involving the origin of IK as being "*learnt through discoveries, viewing; is a knowledge …that was not based on medical test but proven to be working*" and another participant stated that it is "*knowledge gained from past generations which is gained through experience"*.

These statements imply some knowledge of the tenets of the NOS, in particular, that science is empirically based, as it is derived from observations of the natural world as reported by Vhurumuku (2011); Lederman (1999); Bell *et al*. (2000). Some of the teacher participants seemed to have a better understanding of how integration of IK into lessons makes science more relevant for the learners. However, there were also some misconceptions of the NOS where teachers believed that IK is "*knowledge that hardly changes*" and that "*it is a way of knowing things by not using scientific methods"*. The tenets of the NOS that do not support these views is that scientific knowledge is tentative as it is subject to change yet durable; and that there is no single scientific method, respectively (ibid). Some teachers also referred to IK as pseudoscience, as it also has a metaphysical character. The Limpopo SLP, therefore, did succeed in providing teachers with a more nuanced knowledge of the tenets of the NOS in relation to IK; although a few misconceptions about the NOS from some teachers were flagged. Thus, future SLPs need to incorporate elements of the NOS to better inform teachers and enhance their own understanding of science thus making them better science teachers.

Question 2: Would you say there is a place for the teaching of IK in the Life Sciences classroom?

The responses to the Likert scale part of this question are shown in Table 4.4 [Note: n=61]

Table 4.4: Table of results for Question 2 from Limpopo SLP: Is there a place for IK in the Life Sciences classroom? [n=61]

OPTION	1 No, IK is a pseudoscience and does not belong in the classroom	2 Maybe, some aspects of IK only	3 Where applicable, IK should be used as a comparison to the Western view	4 Yes, IK can make the learning of Life Sciences more meaningful
NUMBER OF RESPONSES	1	5	24	31
PERCENTAGE	1.64	8.20	39.34	50.82

The question served as a means of gauging the effectiveness of the SLP by showing the teachers how IK could be integrated into the curriculum. According to the responses, after the SLP, 50.82% of the participants were convinced that the integration was necessary to enhance the learning of Life Sciences in order to make it more meaningful. This indicated that not many participants were in agreement; nevertheless, a majority showed that the SLP was positively received and achieved the objective of making teachers see that IK in the curriculum could make learning more meaningful for learners.

On the other hand, 39.34% of the participants remained unconvinced of this and felt that IK should only be used where applicable, as a different perspective to Western views. This indicates that many teachers continue to believe that Western knowledge and examples are superior and should remain the standard by which all knowledge should be measured. They believe that IK should, therefore, only be introduced in lessons when there is a suitable example compared to Western examples. Only one teacher continued to believe that IK is a pseudoscience with no place in the classroom. In contrast to the pilot study conducted, all the teachers felt there was a place for IK in the classroom; even though the study was conducted without them attending an intervention programme on the integration of IK into the curriculum.

Together with the Likert scale, the question also asked participants to comment on why they selected a particular option. Their responses would measure whether the SLPs achieved the desired outcome or whether teachers thought it was not needed. In other words, the question validates the need to continue developing future SLPs. The participant's comments were then subjected to Saldana's (2009) coding technique as shown in Table 4.5.

Table 4.5: Table of analysis for comments from Question 2 from Limpopo SLP: Why is IK important?

QUESTION	DESCRIPTORS	FREQUENCY AMONG RESPONSES	CATEGORIES FROM DESCRIPTORS	PROVISIONAL THEMES
Would you say there is a place for teaching of IK in Life Sciences classroom?	Relevance to topics and to daily life	12	Enhance learning and improved learner performance	The teachers felt that the SLP showed them that IK in lessons can make science relevant for learners and better contextualised learning could improve their performance.
	Link to curriculum	3		
	Occasional integration into lessons	3		
	Curriculum compliance	2		Teachers are of the opinion that the integration of IK is not always possible as it can be impeded by religious beliefs. *[Researcher's notes: this theme fits in better with Question 3 and I have taken the liberty of moving it to that discussion].*
	Pseudoscience/ myth	2	Tensions that may prevent integration into curriculum	
	NOS tenets evident	4		
	Decolonisation	1		
	Tensions	2	Use of cheaper, readily available resources	Teachers attending the SLP realise that they should be resourceful and could even use people from local communities as resources. *[Researcher's notes: this theme fits in better with Question 3 and I have taken the liberty of moving it to that discussion].*
	Religious conflict	1		
	Preserve for future generations	1		
	Resources used	4		
	Bridge between Western science and local knowledge	1		

Responses from the teacher participants on whether there was a place for IK in the Life Sciences classroom were distilled into three provisional themes. The first of these was: **The SLP made teachers see that IK in lessons can make science relevant for learners thus improving their performance** and was derived from the descriptor with the highest frequency, i.e., the integration of IK makes learning relevant for

learners who could relate more easily to the topics in the curriculum. This descriptor appeared twelve times from the analysis of the responses, showing that several teachers shared the view that adding IK to lessons would enhance learning by making it more meaningful for learners. The teachers' realisation after the SLP adds weight to the wealth of research indicating that adding IK to the curriculum makes science more relevant for learners.

The relevance of topics to learners is important because it acknowledges "the particular social identity of the student" and once their culture (social identity) is acknowledged, it transforms science learning into "a more positive experience for students who are resistant to studying the Westernised science curriculum" (De Beer & Whitlock, 2009:210). These authors explain that including IK into lessons would allow learners to understand "academic science" while using "scientific language" because the vocabulary used in indigenous cultures is "less demanding cognitively than Westernised science" (ibid) and in this way forming a link between Western science and local knowledge. The ripple effect of this result was that Life Sciences could become less intimidating and more interesting for learners who might then perform better. Participants stated that "*most chapters, e.g., plant growth hormones, need the infusion of indigenous knowledge; and integrating life science will give best results*", indicating that the teachers were of the opinion that an infusion of IK might improve learner performance.

Another provisional theme that emerged was: **Teachers attending the SLP realise that they should be resourceful and even use people from local communities in designing learning opportunities**. Although this provisional theme emerged from the analysis of Question 2, it will be discussed under Question 3 which deals with difficulties experienced by teachers. The same applies to the third provisional theme to arise from the responses to this question, viz: Teachers are of the opinion that the integration of IK is not always possible as it can be impeded by religious beliefs. Since Question 3 deals explicitly with the difficulties associated with the integration of IK into lessons, this provisional theme will be discussed in that section. The analysis of the participants' responses to Question 2, therefore, showed that despite most teachers supporting the inclusion of IK into the Life Sciences curriculum, many of them pre-empted this by indicating various challenges in preventing successful integration.

Question 3: What are the difficulties that you anticipate in teaching IK in your lessons?

This question provides first-hand information from participants about the challenges they foresee experiencing when incorporating IK into their Life Sciences lessons. The over-arching theoretical framework of the study was constructivism using a CHAT lens as a barometer of the tensions that arise in an activity system. The study also used elements of phenomenology in the methodology; hence it was essential that such information was obtained from the participants directly. The tensions that arose from the Limpopo SLP, therefore, guided the development of the Lenasia SLP, which my study was based on. These comments will be analysed as for the other questions.

Table 4.6: Table of analysis for Question 3 from Limpopo SLP: What difficulties do you envisage in infusing IK in the classroom?

(Note: 'rules', 'community', 'tools', etc., refer to nodes in the CHAT activity system)

QUESTION	DESCRIPTORS	FREQUENCY AMONG RESPONSES	CATEGORIES FROM DESCRIPTORS	PROVISIONAL THEMES
What are the difficulties that you anticipate in teaching IK in your lessons?	Learners' attitude and interest	3	Belief systems	Teachers are of the opinion that the belief systems of both learners and teachers may impede the effective integration of IK in lessons. RULES COMMUNITY
	Pseudoscience	2		
	Beliefs	5		
	Shame/inferiority about own culture	2		
	No tensions experienced	1	Cultural limitations	
	IK limited to elders – inaccessible	3		
	Multicultural SA society – *who's* IK should be included?	4		
	Resource limitation	3	Resources	Teachers feel that inadequate and/or inaccessible
	Documenting of IK	1		

	Confirmation of IK as factual	1		resources in most South African schools create challenges for successful IK integration into the curriculum. TOOLS COMMUNITY
	SDL of teachers	2	Pedagogical content knowledge (PCK) for IK	Teachers' under-developed PCK for IK integration lead to ineffective or no integration of IK into the lessons DIVISION OF LABOUR SUBJECT COMMUNITY
	Teacher misconceptions	2		
	Poor lab skills	1		
	Under-developed PCK for IK	3		
	Systemic pressure	1		

A total of sixteen different descriptors arose from the responses to this question, implying that participants felt they were going to experience difficulty in integrating IK successfully into their lessons. Only one participant stated that there will be no difficulties experienced.

These descriptors were then grouped into four meaning units which were then condensed into three provisional themes. These provisional themes will be analysed using the CHAT lens as indicated in Chapter 2 with the relevant nodes of the activity system shown in capital letters as seen in the last column of Table 4.6.

The first provisional theme is: **Teachers are of the opinion that the belief systems of both learners and teachers may impede the effective integration of IK in lessons.** Participants highlighted that as South Africa is multicultural based, it will be difficult to accommodate all cultures during the lessons. They also pointed out that they were not sure whose IK should be considered. One participant stated, "*There are learners from various cultures in our school, I think it will be difficult to find a common ground in incorporating IK*". Another participant remarked that "*learners were told*

different from their respective home". Teachers are, therefore, aware of the different cultures in their classroom and the affects it will have in implementing IK learnt during the SLP.

According to the participants, the religious beliefs of learners and teachers will also pose a barrier for effective inclusion of IK into lessons, for example, many believe the religious dogma that only God is able to heal sickness and nature is not part of this process. Supernatural beliefs in the Divine are often instilled by elders in the family or community and these will be difficult to change among learners when IK and science are brought together in the classroom. In another example, the Christian religion does not believe in indigenous healing practices where some traditional healers make contact with the ancestors for healing. This leads to the issue of pseudoscience, where many religious or supernatural beliefs are misconstrued as IK. Teachers need to be skilled in using the tenets of the NOS to show the distinction between science and myth. It is also important for teachers to realise that IK share common tenets with Western science, e.g., its empirical and tentative nature; however, there are also differences, e.g., IK also has a strong metaphysical component. There is some overlap with the provisional theme on PCK and it will be further discussed in that section.

The concern that IK conflicts with religious beliefs was also raised as a reservation by some of the participants. As one participant explained "*the other information is contrary to the rules and regulations of God our Creator, our Father, e.g., Jesus Christ heals. … So, it does not fit into Christianity*". A few participants raised the notion of IK being viewed as a pseudoscience; "*some believe it is witchcraft and do not believe it; it has myths and unpredictable where science is pure*". These statements are symptomatic of one of the major challenges facing the integration of IK into schools as many teachers are reluctant to incorporate IK "out of fear of infecting classroom teaching with pseudoscience" (De Beer and Whitlock, 2009:209).

Various other tensions were expressed by participants such as the absence of sufficient IK in documented teaching resources; "*if it was recorded, it would then be taught very smooth*". One participant stated that indigenous plants usually grow in certain areas and are, therefore, not obtainable in other areas, making it difficult to use as a resource.

The occasional use of IK in certain topics only, was also a challenge raised by at least two of the participants; "*IK can only be incorporated into some science chapters; it is not everything that can be introduced in the class; I don't believe one should incorporate IK in every topic. It should be used as a perspective to keep learning interesting*". In fact, these should not be regarded as challenges but as realistic points, researchers De Beer and Whitlock (2009:209) also "do not argue that all IK claims should be accepted". These participants' comments reveal their candour and pragmatism in thinking about the implementation of strategies learnt at the SLP.

It also emerged from teachers' comments that there is some shame and feelings of inferiority when aspects of IK are raised in lessons; "*some feeling shy because their parents' grandfathers practising it; learners may not be open and free enough to communicate what they've been taught by their elders before*". It is apparent that these feelings of inferiority about their own culture may have stemmed from school curricula being devoid of opportunities to share cultural experiences in a safe environment that is free from shame and ridicule. This 'cultural apartheid' (Odora-Hoppers, 2005) must, therefore, be opposed so that learners are comfortable and proud of talking about their culture and traditions; teachers will play a pivotal role in creating and sustaining such an environment in their classrooms. (A side note: it is interesting to note how there is recently a renewed pride among many Khoi-San descendants, who are re-discovering their own cultural roots.)

Using the CHAT activity system, the nodes of RULES and COMMUNITY are involved in the emergence of this provisional theme as the rules of the CAPS curriculum document and the tenets of the nature of indigenous knowledge (NOIK) might, in some contexts, be in conflict with the community that is made up of the learners, elders and religious bodies. While the CAPS document does prescribe the inclusion of IK from diverse cultures, this may not be implemented smoothly as it conflicts with the religious beliefs and different cultural practices of learners in the multicultural classrooms.

If the tenets of the NOS or the NOIK are adhered to by the teacher in the delivery of the lesson, these may cause tension between the religious bodies and the objective of the lesson, such as when the topic of evolution is taught. The tenet that science is empirically based on observations in nature, may conflict with religious or cultural

beliefs, e.g. the Venda people believe that during a thunderstorm, people wearing red clothes must remove them because lightning will strike anyone wearing red, however, this is an “erroneous misconception” that science teachers can discuss in class as to why it is not a valid belief (Kibirige & Van Rooyen, 2006:246). On the other hand, a skilled teacher with an advanced PCK in the topic under discussion will be able to generate positive tension by looking at other beliefs and providing valid scientific explanations for them, e.g., crushing the leaves of the ‘soap plant’ can be used to make soap as it has large amounts of the chemical Saponin which dissolves fatty substances (ibid).

Coupled with this is a third node in the activity system – the SUBJECT, which is the teacher who may feel that his/her own culture is being side-lined or who may favour his/her own culture, both instances will have some effect on the achievement of the objective for effective integration of IK into the lesson. The teacher in the various roles of facilitator for learning, assessor, reflective practitioner and disciplinarian represents the division of labour node in implementing the rules of CAPS.

The second provisional theme or idea that arose from the question on the anticipated difficulties in teaching IK is that: **Teachers feel that inadequate and/or inaccessible resources in most South African schools create challenges for successful IK integration into the curriculum.** Participants indicated that in most of their schools, resources were scanty or completely absent, making it difficult to integrate IK into Life Sciences lessons. Other teachers commented that they lacked the required laboratory skills to conduct practical work. There was also a concern raised that certain plants are available in a specific place and, therefore, cannot be used as examples when teaching certain topics. One comment, “*it is not documented and thoroughly researched*”, refers to the absence of validated printed information on IK which teachers could refer to for their lesson plans. Other comments indicated that IK was inaccessible as it was confined to elders who lived in outlying rural areas and who may not be willing to part with their knowledge.

This is an interesting tension that may not be simply resolved, Kibirige and Van Rooyen (2006:247) point out that if IK is recorded and transferred, it may result in the “disempowerment of indigenous people” and “that IK can only be preserved in situ,

and through continuous application". The formal documenting of IK in books, therefore, comes with a price such that by preserving the knowledge for future generations in written form, it will also serve to remove the authenticity of the information from the people who hold this knowledge. A possible solution is, therefore, to get elders or more knowledgeable people from the community to be a resource; this notion also arose in the analysis of Question 2 above. Kibirige and Van Rooyen (2006:248), posit instead, that science curricula should use the information unique to different cultures to benefit these communities and in this way, teachers will also be sensitised to the abundance of IK available for use when issues arise during lessons.

Another possible solution emerged from the analysis of comments under Question 2, the SLP made participants realise that integrating IK into lessons is possible by using the local community resources that are inexpensive and readily available. Although many teachers regarded the lack of resources as one of the challenges, the SLP showed them how they could be resourceful by using their own environment and community to obtain the necessary resources. This included "*using indigenous plants and animals as resource materials in a classroom*", as described by one of the participants. For instance, learners can be engaged in preparing herbarium voucher specimens for the classroom herbarium.

A few of the responses indicated the use of human resources as well, for example, community elders or local people who were knowledgeable about aspects of IK that were not found in books. One participant mentioned that integration of IK would ensure that "*knowledge will not die and will be transported to the next generation*", echoing one of the global aims in giving prominence to IK, i.e., to preserve the knowledge for future generations.

The nodes of TOOLS and the COMMUNITY in the CHAT lens can be used to examine this theme. The TOOLS part of the activity system is formed by the resources that consist of all the teaching aids used to enhance learning, such as textbooks, curriculum documents, laboratory equipment, local plants, computers and PowerPoint presentations. Since participants indicated that resources are lacking in most schools, this creates a tension at the TOOLS node of the activity system. An important TOOL to be included in this activity system is the pedagogies of PBL and cooperative learning

promoted during the SLP to encourage teachers to manoeuvre away from the traditional transmission modes of teaching to a more inquiry-based learning. Tension at this node impacts negatively on the SUBJECT (Life Sciences teacher) and the OBJECT (to integrate IK into Life Sciences lessons). The more knowledgeable elders, who are the current holders of IK, make up both the TOOLS and the COMMUNITY nodes. They form part of the resource component while also making up the members of the community with information that may be passed on to enhance the curriculum.

The third provisional theme that emerged is: **Teachers' under-developed PCK for IK integration led to ineffective or limited integration of IK into lessons.** Participants commented on the questionnaire that in order to teach IK they need "*to have a sound knowledge of culture and traditions of people;* and *it will need a lot of time to prepare for it and to do some research in it".* They have acknowledged that in order to integrate IK into their lessons, they need to do more preparation as not much of the information is found in textbooks. This approach, therefore, relates to the concept of SDL, teachers should have intrinsic motivation to find out more on their own about a topic such as IK, and identify suitable resources.

On the other hand, some participants admitted they were not equipped to handle the teaching of IK, in particular if "*learners may ask questions that the teacher may not be able to respond to";* one participant stated "*I have never taught IK*". These statements point towards the weak or non-existent PCK of teachers towards teaching IK and show that there is a need to have more such SLPs so that part of this challenge could be addressed. This realisation from the Limpopo SLP thus also necessitated conducting the SLP in Lenasia for the study, using Indian IK as the focal point.

Two of the participants raised the issue that "*learners have never been exposed to that before and, moreover, are not in line with the CAPS policy document; some of learners are not familiar to the IK. They don't understand the cultural part of the lesson*". These observations made by the participants highlight the misconceptions that some teachers have about the curriculum document. This is concerning as knowledge of the curriculum policy is a fundamental requirement for any teacher; the CAPS document specifies that IK should be taught, if teachers attending a SLP on IK are unaware of this aspect, it is of grave concern and needs to be rectified. The SLP

using Indian IK provided several opportunities in the Life Sciences curriculum where Ayurveda could be integrated into lessons to make it easier for teachers to implement in their classrooms.

However, some teachers were *more* aware of the policy documents and that teaching is a specialised profession requiring a great deal of theory, as can be seen by this comment, "*as a teacher, you first have to clear the myths and misconception about IK*". This indicates that teachers should have a certain measure of skill and knowledge, i.e. PCK, to be able to find out what knowledge learners are able to bring to the classroom, whether this knowledge is myth, misconception or truth and then proceed to correct or validate by using evidence. This process stems from the idea that pre-scientific conceptions, referred to as "everyday concepts" by Vygotsky (Howe, 1996:38) and as "spontaneous concepts" by Piaget (Howe, 1996:38), are formed from a child's personal experiences and independent thinking, while he referred to Piaget's "non-spontaneous concepts" as "scientific concepts" learnt at school (Howe, 1996:38).

The participants also felt that learner attitudes and interests play a significant role in how IK will be taught. Some participants mentioned that they anticipated a lack of interest from learners while others hinted at the lack of discipline from learners as a factor that would make the teaching of IK more difficult. This is mentioned under this provisional theme because teachers do need to have a superior skill in ensuring effective classroom management or discipline among learners.

Poor learner attitude creates negative tension in the CHAT activity system between the SUBJECT (teacher) and the COMMUNITY (learners), thereby hindering the achievement of the objective for effective integration of IK into lessons. Without discipline, or learner interest in a topic, learning will be more difficult and may not even take place effectively. Using the CHAT lens makes it clear that under the division of labour node there should also be a focus on the teacher as a disciplinarian; to help teachers with challenges such as learner ill-discipline. The challenge of ill-discipline could be alleviated if the school management could intervene with learner issues as well as provide the means and opportunities for teachers to attend training courses and obtain necessary classroom management resources. In this way, less pressure will be placed only on the SUBJECT (teacher) to achieve the objective.

If teachers were more well-versed in these various 'roles' as depicted in the 'division of labour' node above, there might be a smoother implementation of the curriculum and techniques learnt at the SLP; however, it seems that in the current South African education climate, this is not the case. One participant commented about the systemic pressures affecting delivery of curriculum and implementing what was learnt at SLP. This referred to the current summative assessments used in schools where learners have to write common examinations that are set by the DoE according to a pace-setter[1], "*The kind of assessment used is common this doesn't include IK. Doesn't allow learners to apply what they have learnt in the classroom then the approach becomes meaningless".*

Such a statement shows that the participant identified a systemic pressure facing the teaching of IK as assessment in CAPS does not cater for the kind of IK integration that is prescribed in the document itself, indicating an internal conflict in the curriculum policy, which teachers have to try and resolve with limited resources.

Overall, the three provisional themes that emerged from the analysis of Question 3 showed that participants were challenged by the existing belief systems of their learners and even themselves conflicting with IK; inadequate resources in many schools hindering the teaching of IK; and the under-developed PCK of teachers regarding IK teaching.

The fourth question to be analysed looked at a possible solution to parts of these problems, by considering the concept of SDL.

Question 4: Based on your experiences these three days, is it necessary for you to formulate any professional development goals for yourself? (e.g. did you identify any knowledge or skill gaps that you would like to address in the following aspects?)

This question was included in the questionnaire as a way of evaluating the SLP with specific reference to whether it stimulated the participants to pursue further plans for

[1] Pace-setter refers to a rigid time plan prescribed by the DoE to ensure curriculum delivery according to specified time frames. This does not take learner understanding into account and is a teacher-centred approach to teaching and learning.

their professional development, with SDL. In addition, their responses would also guide the design of future SLPs, in particular, the one incorporating Indian IK for the study. There were two aspects to this question, one looked at knowledge on IK systems and the other looked at laboratory skills.

The responses from both these parts were coded and analysed together in order to arrive at four common provisional themes that will be shown in Table 4.7 and discussed in this section.

Table 4.7: Table of analysis for Question 4 from Limpopo SLP: What learning goals (in terms of knowledge or skills) did you identify?

QUESTION	DESCRIPTORS	FREQUENCY AMONG RESPONSES	CATEGORIES FROM DESCRIPTORS	PROVISIONAL THEMES
Based on your experiences these three days, is it necessary for you to formulate any professional development goals for yourself? (E.g. did you identify any knowledge or skill gaps that you would like to address in the following aspects?)	Valuing IK in curriculum	1	Appreciation for IK after SLP	Teachers expressed the need for more learning opportunities to learn about indigenous knowledge, and how to implement it in their lessons.
	Benefitted from SLP	4		
	Introduce IK in lessons	5		
	Improvisation in lessons	1	Open to including IK in curriculum	
	Curriculum change for IK	2		
	IK learnt in community	1		Teachers indicate that they have learnt new skills for Life Sciences teaching at the SLP as part of their professional development.
	Multicultural classes	1		
	Observation skills	3	Laboratory skills needed to be learnt	
	Microbial skills	2		
	Lab equipment	3		Teachers realise that they need to take charge of their own
	Scientific method	5	Identified the need to learn more about	
	Group work	1		

	Safety techniques	2	different teaching techniques	professional development, thereby embarking on SDL.
	Knowledge of IK content needed	1	Elements of self-directed learning (SDL) develop	
	Need to learn more about IK	4		Teachers acknowledge the fact that, as self-directed learners, they need to take responsibility for learning more about IK. Teachers view the absence of labs in their schools as a factor preventing the teaching of IK. *[Discussed under Question 3 above].*
	Responsible for own learning	3		
	No labs	1	Gaps in SLP	
	Gaps in content for IK inclusion	6		

Provisional Theme 1 – Teachers expressed the need for more learning opportunities to learn about IK, and how to implement it in their lessons.

Seven descriptors were identified based on their link to the meaning units 'Appreciation for IK after SLP' and 'Open to including IK in curriculum'.

According to their comments on the questionnaire, many of the participants felt that they had benefitted from attending the SLP in Limpopo and saw the value in integrating IK into the curriculum. Their comments, "*valuing the IK in the curriculum; I've developed an understanding in the IK; workshops such as this can make a difference; the approach is very good*" are testament to the participants regarding the SLP as a positive influence on their professional development. Other remarks showed that the SLP motivated the participants to introduce IK into Life Sciences lessons while also being more confident to improvise with various resources and teaching techniques to enhance the learning process for their learners. To this end, participants commented,

"*improvise to enhance learners' activities*; *initiate IK in my teaching; linking class activities to home and communities; the importance of including indigenous knowledge in class".*

The level of motivation the participants experienced from attending the SLP was evident as they advocated for the curriculum to change to include more IK as stated by two participants; "*There is still more to be learnt. Our curriculum must make room for IK; to speak to people which involve this on our curriculum."* The SLP helped the participants to understand that IK originates in communities and ideally elders in their own communities should teach learners about IK. One participant remarked, "*Learners should firstly acquire this knowledge in a community"*, this lends itself to situated learning, espoused by the concept of ESDC, which forms part of the conceptual framework of the study. ESDC proponents includes; cognition as being "socio-culturally situated" (Chahine, 2016:54) and that each society has its own culture that is "embedded in the way of life of a people transmitted from generation to generation either through written form or words of mouth" Uzochukwu and Ekwugha (2015:2-3).

One participant felt that it was necessary for teachers to understand the IK of other cultures to increase their effectiveness as teachers in multicultural classrooms in South Africa. This is a significant viewpoint, particularly for the study, as teachers need to realise that there are several frames of reference with which to view IK, due to the multiple and varied cultures not only in South Africa but also globally. Having a broader perspective on as many of these cultures as possible, starting with the multitude of different cultures in South Africa, should give teachers the advantage to deliver more effective lessons integrating IK.

Ultimately, knowing about the IK of different cultures should show their commonalities, that they share the tenets of the NOIK and by extension, the tenets of the NOS. Hence, the study as a whole and the SLP in Lenasia, which dealt with Indian IK in the curriculum, has a significant contribution to make in informing teachers about the IK of the Indian population in South Africa.

Provisional Theme 2 – **Teachers indicate that they have learnt new skills for Life Sciences teaching at the SLP as part of their professional development.** Six

descriptors were identified based on their link to the meaning units ‘Laboratory skills needed to be learnt’ and ‘Identified the need to learn more about different teaching techniques’. Participants appreciated that the SLP taught them several skills, e.g., microbial skills; use of equipment; safety skills; group work techniques; observation skills and other aspects of the scientific method, that they could use and apply to their lessons in both the classroom and in the laboratory. These skills were infused into the various activities that participants engaged helping them to master their skills in during the three-day SLP and are similar to the activities described in Chapter 3 (Section 3.6.6) for the SLP guide that was used in the Lenasia SLP.

The scientific method and observation as a descriptor arose eight times from participants’ responses, indicating that this method made a significant impression on them. Statements such as, “*being able to formulate hypothesis and stick to the procedure for them to be reliable; conducting experiments; observation, experimenting and get more data; perfecting experimental solutions; kombinasie met videoclips + elementêre prakties [translated = a combination of videoclips and basic practicals]”,* show that the participants intend to implement some of the elements of the scientific method with their lesson plans, thereby introducing learners to the tenets of the NOS to make Life Sciences lessons more meaningful. By also including IK in these lessons, it is then envisaged that the tenets of the NOIK will be drawn out, showing that IK can be based on scientific principles rather than on myth and witchcraft that learners might conceive it to be.

Microbial skills refer to the Kirby-Bauer technique that participants used during the SLP where they were allowed to use simple microbiological techniques with inexpensive and easily available resources to provide evidence that certain plants, used as traditional remedies, have anti-microbial properties. This activity could then be replicated by participants when they return to school with the advantage that formal laboratories are not required as the materials can be improvised, thereby also providing a solution to the challenge of lack of resources in many schools. Two participants mentioned safety and the use of equipment as a concern for them when conducting laboratory work, so greater attention on these aspects need to be infused into future SLPs.

One of the professional development goals identified by a participant is that of group work. Two learning styles, namely cooperative learning (CL) and PBL, were introduced to participants, using the jigsaw method and De Bono's Hats, respectively. These methods are explained in Chapter 3 with the design of the guide to the SLP. Both these techniques focus on group work which can be used in larger class sizes to facilitate learning content-laden topics such as Plant Physiology in Grade 10 and 11. IK can then be infused into these topics with ease as there is an abundance of plants that are used by indigenous people for various herbal remedies and treatments. Therefore, more activities involving group work ought to be included in subsequent SLPs.

Provisional Theme 3 – Teachers realise that they need to take charge of their own professional development thereby embarking on SDL. Although there were only three descriptors that led to the formation of this theme, there were eight responses to them in total. These descriptors (viz. 'Knowledge of IK content needed'; 'Need to learn more about IK'; and 'Responsible for own learning') formed the meaning unit – 'Elements of self-directed learning (SDL) develop'. The SLP initiated in participants the realisation that they need to take responsibility for their own professional development regarding the infusion of IK into their lessons, with one in particular commenting, "*I really need to do some research on IK and learn a lot because there is more to learn*". Another participant remarked: "*One can never know enough*" indicating that s/he acknowledges there is a great deal of information that needs to be accessed for use in the classroom.

The two or three-day SLPs are unable to provide participants with all there is to know about IK or its integration into lessons; teachers should actively seek more information on their own. All teachers should, therefore, be life-long self-directed learners who are continually researching to find out more and to keep up with new developments in various fields of knowledge. In this way, they would become more effective teachers and be more equipped to deal with questions from academically advanced learners in their classroom. The study, which is part of a larger project of the Research Focus Area on SDL, encourages teachers to pursue SDL activities. Additionally, the two-day SLP with an infusion of Indian IK was unable to provide participants with all the

information about the 6000-year old science of Ayurveda, but it can inspire teachers to research further on their own.

Participants stated that they would like to "*find out about more in my area; I would like to learn more; I firstly need to understand and do more*", all of which indicates the desire to research further on their own in order to increase their knowledge base on IK. The need for all the participants to formulate personal professional development goals is in itself testament to SDL.

Provisional Theme 4 – Several gaps were identified in the Limpopo SLP serving to refine the next cycle in the DBR. There were two descriptors identified that formed this theme, viz., 'Lack of labs' and 'Shortcomings of the SLP'. The former is only regarded as a gap because the participant who made the statement did not learn much during the SLP, s/he did not realise that improvisation is possible in the absence of resources. There were six gaps in the SLP that were pointed out by participants, four of which centred on the need to know more about plants and their functions as part of IK. Teachers wanted to know more about the use of traditional herbal remedies as well as the way in which they could be used as alternative treatments for any Western medicines. The SLP with Indian IK (in Lenasia), therefore, addressed this gap by including several examples of the multitude of plants used for various ailments in Ayurveda. In addition, the participants in the Lenasia SLP were provided with a comprehensive resource book, *Medicinal Plants of the World* by Ben-Erik van Wyk and Michael Wink (first published in 2004).

One participant mentioned that they would like to know more about plants "*that could replace traditional physical sciences lab apparatus like (indicators) and organic compounds".* Therefore, the Lenasia SLP, dealing with Ayurveda, also contained information about how certain techniques derived from IK, could be used to speed up fruit ripening, ensure that cut flowers remain fresh after a trans-Atlantic flight, and the influence of smoke on seed germination (De Beer, 2012; De Beer & Abrie, 2016; De Beer & Petersen, 2015).

Additionally, the focus of the activities during the Lenasia SLP was based on designing learning opportunities where students could engage in inquiries to explore inquiry

learning, and not to simply provide the participants with information. A participant suggested the inclusion of more information on indigenous artefacts such as "*pottery making, African Beer creativity*". The proceeding SLPs, held in other parts of South Africa, addressed this request. The participant can also find out more about this aspect on his/her own as the SLP did draw attention to African artefacts.

Since this is a DBR, these gaps were considered during the re-design of the Lenasia SLP (Cycle 2), as well as other SLPs held later on making up Cycle 3 in the DBR.

4.4.2 Conclusion to post-intervention questionnaire findings

The preceding section contains the detailed analysis and discussion of the participants' responses for the relevant questions to the study taken from a post-intervention questionnaire administered to teacher participants after a SLP in Limpopo. Only four questions that are relevant to the study have been subjected to this process. Each question resulted in the distillation of between three to four provisional themes or main ideas. Table 4.8 summarises these themes as they appeared for each question:

Table 4.8: Table summarizing provisional themes from the relevant questions from Limpopo SLP

QUESTION	PROVISIONAL THEMES/CATEGORIES
1. How would you describe indigenous knowledge (IK)?	• The SLP reinforced teachers' awareness that IK is an ancient knowledge descended from ancestors over many generations. • SLP confirmed for teachers that IK is local knowledge using natural resources of that area in a sustainable way. • Teachers participating in the SLP realized that IK shares some features with Western science by considering the tenets of the NOS. However, for some participants it also constitutes as pseudoscience.
2. Would you say there is a place for the teaching of IK in Life Sciences classroom?	• The SLP showed the teachers how to make IK relevant in science lessons for learners, and how better contextualized learning could improve their performance. • Teachers are of the opinion that the integration of IK is not always possible as it can be impeded by religious beliefs.

	• Teachers attending the SLP realised that they should be resourceful and could use people from the local communities as resources.
3. What are the difficulties that you anticipate in teaching IK in your lessons?	• Teachers are of the opinion that the belief systems of both learners and teachers may impede the effective integration of IK in lessons. • Teachers felt that inadequate and/or inaccessible resources in most South African schools create challenges for successful IK integration into the curriculum. • Teachers' under-developed PCK for IK integration lead to ineffective or no integration of IK into lessons.
4. Based on your experiences these three days, is it necessary for you to formulate any professional development goals for yourself? (E.g. did you identify any knowledge or skill gaps that you would like to address in the following aspects?)	• Teachers expressed the need for more learning opportunities on IK, and implementation strategies. • Teachers indicated that they have learnt new skills for teaching Life Sciences at the SLP as part of their professional development. • Teachers realised that they need to take charge of their own professional development thereby embarking on SDL. • Teachers acknowledged that, as self-directed learners, they need to take responsibility for learning more about IK.

The analysis of the results from the Limpopo SLP is used in the study impacted the modification of the design for the Lenasia SLP which has direct relevance to the investigation of the research questions.

My study on the integration of Indian IK into the Life Sciences curriculum used DBR as part of the methodology and was, therefore, dependent on previous such interventions whose shortcomings could be rectified and strengths replicated with perhaps minor adjustments.

4.5 PILOT STUDY

The pilot study was conducted in July 2016 with a group of Indian Life Sciences teachers. The intention was to find out from teachers why IK should be integrated into the Life Sciences curriculum and whether teachers consider themselves as having an adequate PCK to implement, such integration together with an adequate knowledge of the NOS to facilitate this integration.

The teachers' inherent experiences were ascertained from this questionnaire, to add insight into one of my research questions: "What are Life Sciences teachers' lived experiences of teaching IK in the classroom?" In addition, the findings from this pilot study were used to develop the content for the Lenasia SLP where IK, in particular, Indian IK, would be the focal topic in which the principles of the NOS are explored in order to enhance PCK.

Specifically, Indian Life Sciences teachers were needed in order to ascertain whether being Indian, enabled these teachers to have a better knowledge of Indian IK, e.g., Ayurveda and Yoga that could be used in the classroom. The principles of ESDC informed this as indicated by Chahine (2016) that indigenous cultures have a variety of complex ways in which they deal with knowledge and that they share these ways with other members in their community thereby distributing this knowledge.

Questionnaires were used to gather information at this stage, see Appendix E for the Questionnaire used. Seven teachers responded from the eleven questionnaires that were originally issued and these seven questionnaires were then subjected to the coding process outlined by Saldana (2009). The descriptor codes used in the analysis of the responses are listed in Table 4.9.

Table 4.9: List of descriptor codes used in the analysis of the PILOT STUDY questionnaires and their explanation in relation to the research questions and aims of the study
[The Aims for the study can be found in Section 4.1]

DESCRIPTOR	CODE USED	EXPLANATION ACCORDING TO RESEARCH QUESTIONS AND AIMS
Value of having IK in Life Sciences curriculum	V	Aligned with Aim 2 dealing with the importance of IK to society.
Other cultural practices/artefacts/examples in the curriculum	C	Aligned with Aims 2 and 6 as it shows that Indian IK should be treated similarly to African IK in the classroom and curriculum.
Appreciation of own culture	A	Aligned with Aim 3 which shows that the teacher participants valued their Indian culture.

DESCRIPTOR	CODE USED	EXPLANATION ACCORDING TO RESEARCH QUESTIONS AND AIMS
Nature conservation	N	A reason provided by participants for wanting to include IK in the curriculum, linked to Aim 2.
Indigenous Indian plants	IIP	In line with Aims 1, 3, 4 as it shows that the participants had some knowledge of Indian IK at least in terms of the plants that could be used as healing herbs.
Awareness of IK	IK^{+}	Displaying some indigenous knowledge, it was necessary to gauge what teachers already knew about IK.
No awareness of IK	IK^{-}	Shows that there was very little awareness of IK, thereby necessitating the SLP.
Lack of scientific terms in the curriculum for indigenous knowledge	ST^{-}	Aligned with Aim 6 to show the shortcoming of the curriculum in integrating IK.
Misconceptions of Ayurveda	Mis^{AV}	Aligned with Aim 6 to show that the lack of correct information about Ayurveda forms as one of the tensions in the CHAT activity system of this study in integrating it into the curriculum; further substantiating the need to conduct SLPs to train teachers.
Links between Life Sciences and Ayurveda	L	Can be aligned with Aims 4 and 5 to show integration of Indian IK and any similarities with the tenets of the NOS and the NOIK.
Improved performance in Life Sciences	P^{+}	To be aligned with Aims 1 and 3, such that integration of Indian IK into the curriculum could lead to learners improved performance in Life Sciences.
Misconceptions about the NOS	Mis^{NOS}	In line with Aims 5 and 6, to show that teachers are not very familiar with the tenets of the NOS, this can be a negative tension in the activity system. Therefore, the SLP is necessary to point out these tenets.
Some idea about the NOS	NOS^{+}	Both Aim 5, to highlight that some of the participants were aware of the tenets of the

DESCRIPTOR	CODE USED	EXPLANATION ACCORDING TO RESEARCH QUESTIONS AND AIMS
		NOS; and Aim 6, to create some positive tension in the activity system since the participants have knowledge about the NOS.
Medical value of IK	M	Aligns with Aim 2 as learning about IK in school should contribute to improving society by increasing learner awareness of their health, fitness and even nature conservation.
Knowledge about Indian indigenous knowledge	IIK^- (poor) OR IIK^+	Aligned with Aim 6, as the poor knowledge of Ayurveda creates a negative tension in the classroom activity system impeding the integration of Indian IK into the curriculum. Positive tension results if there is some knowledge about Indian IK.
Under-developed or no PCK around indigenous knowledge	PCK^-	A further negative tension in the activity system, aligned with Aim 6.
Embedded knowledge	ESDC	Indian IK in the curriculum would contribute to Indian learners being able to share their IK and embedded experiences, relating to Aim 1. Positive tension is created in this way, which connects to Aim 6.
Technology and IK	Tech	Aim 2 as it highlights the participants' ability to show the uses of IK with modern developments.
Fear of non-tolerance	F	Aim 6 as it is a negative tension that blocks the integration of IK into the curriculum.
The economic benefit of IK	E	Aim 2 as IK economically benefits society.

Using Saldana's (2009) method of coding, these descriptor codes were then assigned to relevant phrases in the responses to questions by each of the seven participants. Even though this is not a quantitative study, the frequency with which each descriptor emerged during the responses is indicated to indicate the extent to which they arose. Thereafter, the descriptor codes were grouped into meaning units which were further clustered into provisional themes, as shown in Table 4.10. These themes then became

the findings from the pilot study and served to inform the planning and development of the SLP with an emphasis on Indian IK.

Table 4.10: Table of analysis for the Pilot Study

Descriptor	Code Used	Frequency of Occurrence	Meaning Units	Provisional Themes/Categories
Value of having IK in Life Sciences curriculum	V	4	Benefit of IK	1. IK integration into the curriculum will benefit society and people's health. 2. Teachers are of the opinion that Indian learner performance would improve with the integration of IK into the curriculum. 3. Teachers are of the opinion that they possess a poor knowledge of IK and Indian IK. 4. Teachers have an under-developed PCK for IK and Indian IK. 5. Teachers' poor understanding of the NOS and NOIK.
Other cultures in the curriculum	C	4		
Indigenous Indian plants	IIP	8		
Appreciation of own culture	A	2		
Nature conservation	N	1		
Links between Life Sciences and Ayurveda	L	3		
Improved performance in Life Sciences	P^+	5		
Medical value of IK	M	4		
Embedded knowledge	ESDC	5		
Technology and IK	Tech	1		
The economic benefit of IK	E	1		
No awareness of IK	IK^-	8	Level of IK among participants	
Awareness of IK	IK^+	1		

Lack of scientific terms in the curriculum for indigenous knowledge	ST^-	2		
Lack of knowledge about Indian indigenous knowledge	IIK^-	1	Level of Indian IK among participants	
Some knowledge about Indian indigenous knowledge	IIK^+	3		
Misconceptions of Ayurveda	Mis^{AV}	3		
Misconceptions about the NOS	Mis^{NOS}	8	Knowledge of NOS by participants	
Some idea about the NOS	NOS^+	4		
Poor or no PCK around indigenous knowledge	PCK^-	7	Unsatisfactory PCK or misconceptions about IK	
Some PCK about teaching IK	PCK^+	1		

4.5.1 Analysis of results

Twenty-one descriptors emerged from the seven completed questionnaires. These were then reduced to five meaning units which were re-grouped into five provisional themes based on the aims of my study. The intention of using this process of analysis was to devise a structured approach of using the findings to guide the remainder of the investigation using DBR as the method.

Four descriptors have the highest frequency with three of these indicating that among many of the teacher participants there was a lack of awareness of IK coupled with a

poor NOS and a weak PCK regarding the integration of IK into the curriculum. This is concerning as the teaching experience of the seven participants ranges from 5 years to 28 years which shows that all of them are sufficiently experienced and, therefore, should have a more developed PCK for CAPS topics, as well as knowledge of the tenets of the NOS. In addition, all of the participants have been CAPS trained, implying that they received in-service training on the new curriculum where important concepts such as IK and the tenets of the NOS should have been covered. All seven participants indicated that there was definitely a place for IK in the curriculum.

Despite the participants agreeing that IK had a place in the curriculum, none had a clear idea of what this entailed, there was also no attempt made from six participants to find out more about IK to enable future integration into their Life Sciences lessons. Participant 6 listed six different indigenous Indian plants (IIP) together with their uses and how s/he was able to integrate this information into the Life Sciences Grade 11 lessons on viruses and bacteria; this contributed to the fourth descriptor having a high frequency of occurrence for IIP in Table 4.10. Participant 6 has 24 years of teaching experience and was also a facilitator for CAPS training workshops for other teachers. S/he was able to obtain this additional information as it is not found in any current textbook, thereby showing a strong sense of SDL and integrate this Indian IK into the Life Sciences lessons, indicating a stronger PCK than any of the other participants. Participant 6 is a keystone species in the community of practice to mentor other Life Sciences teachers to enhance their own lessons.

4.5.2 Findings from the pilot study

Further analysis of the descriptors used in the pilot study will ensue with the discussion of each of the four provisional themes that emerged from the coding process.

4.5.2.1 *Infusing IK into the curriculum would be beneficial to society and health.*

This provisional theme emerged quite strongly from the responses as all of the participants were unanimous that IK has a place in the Life Sciences classroom because of the benefit it can provide. The benefit to society was seen clearly in two responses to Question 4.1 that indicated the presence of IK in the curriculum would lead to tolerance, “respecting each other’s cultures and learning from each other”. This

view can contribute towards the nation-building, social cohesion and ultimately corroborate the decolonisation debate whereby South African IK can be integrated into Life Sciences lessons and learners can realise this can be viewed on the same level as Western knowledge.

The benefit to **health** was indicated by the descriptor 'Medical value of IK' (M) and this was expressed by three participants who said "*indigenous knowledge can help treat many ailments"*; *"indigenous knowledge systems (IKS)... can contribute towards the eradication of diseases. Modern medicine is failing to keep us well. Perhaps indigenous knowledge systems (IKS) can make a greater contribution to modern health*", and "*IK … as a lifestyle survival mechanism to overcome illnesses, diseases and increased their living – lifespan age*". These responses are in line with Mosimege's perturbation that most people narrowly equate IKS with traditional healing alone when; it is actually only a small part of this vast field (Onwu and Mosimege, 2004:4).

Although these three participants had limited knowledge on Ayurveda, their views quoted in this paragraph relate directly to Indian IK (Ayurveda) which advocates for a balanced mind, body and spirit in order to prevent and in some cases treat most illnesses and diseases. This balance can be achieved by following particular lifestyle regimes that will, in turn, contribute to having a longer lifespan. Therefore, even though the participants were not able to define Ayurveda, their awareness about the fundamental principles of IK are the same as those for this ancient Indian practice and are reflected in the benefit of integrating IK into lessons to promote good health.

4.5.2.2 *Teachers are of the opinion that Indian learner performance would improve with the integration of IK into the curriculum.*

Increased learner performance is another benefit of integrating IK into the curriculum, according to the participants. This descriptor (P^+) appeared five times in the coding process and was expressed by the participants in various ways. Most of the participants were of the opinion that Indian learners would perform better than their non-Indian classmates mainly because of their prior knowledge and cultural background which could enhance their understanding and, therefore, their academic performance. Studies by Ogunniyi (2004:303) and Lelliott *et al.* (2009:56) affirm that

when the IK of learners is given prominence in the curriculum, science teaching and learning is more effective.

The assumption by teachers that the inclusion of learners' IK into lessons will lead to improved performance, speaks to the important role played by embedded culture in learning and follows on from the ESDC concept which is part of the conceptual framework of the study. In addition, the descriptor (ESDC), which appears five times, further enhances the view that learners' everyday home knowledge would contribute significantly to their performance in the classroom. This shows that the participants are of the impression that incorporating IK into lessons could improve the dismal Mathematics and Life Sciences results prevalent in South Africa as learners would be learning about relevant and relatable topics.

The emergence of provisional themes 1 and 2, therefore, shows that all of the participants felt that infusing IK into the curriculum would benefit society as a whole, good health would be achieved and learner performance would improve. This then validates the research question and aim of the study, indicating that there is value in including IK and in this case, Indian IK, into the curriculum.

4.5.2.3 *Teachers are of the opinion that they possess a poor knowledge of IK and Indian IK.*

Although all the participants saw the value in having IK as part of the curriculum, most lacked substantial knowledge about either IK or specifically Indian IK. This was evident in the emergence of this third provisional theme from the pilot study and served to confirm the initial hypothesis that South African teachers lack significant knowledge about teaching IK as seen by many researchers, such as Le Grange (2007:581); Ogunniyi (2007:972). Since Indian IK was not in the curriculum, this implied that teachers knew even less about it and were, therefore, ill-equipped to teach Indian IK. This justified the need to conduct interventions in the form of the SLPs as the next phase of the study.

The participants' responses indicate that they have a vague idea of what IK entails but apart from Participant 3, none had an informed view about Indian IK. Participant 3 had the most correct idea that Ayurveda is "*based on the idea of balance in bodily systems*

and uses diet, treatment and yogic breathing…. And is the balanced and dynamic integration between our environment, body, mind and spirit" with the definition of IK focused on knowledge unique to a culture being "*passed down for centuries*".

Participant 2 stated that IK is "*an integral body of local knowledge. It opposes scientific knowledge, or provides an alternative for scientific knowledge*". S/he had the idea that IK is confined to a locality but did not clarify the role of indigenous people in developing this knowledge. S/he also held the view that Western knowledge is superior to IK, since she used the words "*oppose*" and "*alternate*". S/he is aware that Ayurveda is an Indian practice and like Participant 1, holds the view that it uses natural remedies/products and therapy to cure diseases and promote a healthy lifestyle. Participant 1 associated IK with "*earlier times*" and that it is often used as a "*last resort*" when modern technology fails but did not cite any examples to illustrate this point. Participant 4 states that Ayurveda is "*the holistic approach to healthy living*" but was misinformed by grouping Chinese medicine with Ayurveda.

Although these views from the participants do not provide an accurate and complete definition of either IK or Indian IK, they nevertheless do touch on relevant aspects of both fields of knowledge to some degree; namely, there is insufficient knowledge about these fields in textbooks. This results in participants feeling inadequate when discussing IK, as they do not know what terminology to use when referring to IK. One of the requirements of the CAPS document is to include IK of diverse groups in lessons but no further direction is provided in this regard. Apart from Participant 6, none of the participants undertook their own research to implement this curriculum requirement. This shows a shortcoming on their part to engage in SDL; a further reason to conduct the SLP which served to stimulate SDL among the teachers who attended.

4.5.2.4 *Teachers in the pilot study have an under-developed PCK for IK and Indian IK.*

Following from provisional Theme 2, it is not surprising that a weak knowledge of IK and Indian IK would lead to a weak PCK for these topics as well, thus giving rise to this third Theme. For Question 7, Participants 1 and 5 admitted that they were not in a position to implement the CAPS requirement that the examples chosen "for study should, as far as possible, reflect different South African cultural groups" (DoE,

2011:17). Although Participant 5 claimed to have an idea about Indian IK, s/he could not provide a suitable response for what s/he knew about Ayurveda (Question 8), stating that it "*makes a positive contribution for healing in a natural way. Encourages getting the body to be in a natural state as far as possible*".

Participants 2 and 3 responded that were able to implement the CAPS requirement but were faced with the challenges of not having sufficient information and the lack of information in textbooks. Participant 4 indicated that s/he cannot have "*100% implementation*" since there is a lack of IK and scientific terms of other cultural groups.

Participants 6 and 7 seem to have the right idea about how to teach IK since they state that they are able to implement the CAPS requirement without experiencing any challenges in doing so. Participant 6 mentions making use of learners' prior knowledge and their cultural background in order to incorporate IK into the lessons. Participant 7 states "*I also tried and successfully incorporated other IK (inclusive) of different South African cultural groups ... Learners enjoyed information sharing of IK*". These two teachers show that it is possible to successfully implement the CAPS requirement regarding IK. Their superior teaching experience of 24 and 28 years respectively could have a significant role to play in enhancing their PCK together with a stronger sense of SDL that motivates them to find ways in which to implement curriculum policy in the classroom.

Similar to the second provisional theme, the emergence of this fourth provisional theme in the pilot study shows the necessity of having the SLP for teachers so that PCK for IK and Indian IK can be enhanced and SDL can be stimulated among teachers to enhance their effectiveness in the classroom.

4.5.2.5 *Teachers in the pilot study have a poor understanding of the NOS and the NOIK.*

According to Lederman (1999), effective teachers need to have strong PCK as well as knowledge of the NOS. Science teacher training programmes should, therefore, consider structured and deliberate activities that will allow teachers to develop techniques for their increased understanding of science and how to apply this understanding to their lessons. This will then strengthen both PCK and the

understanding of the NOS for more effective science lessons. In the pilot study conducted, one of the highest frequency of responses was on the misconceptions about the NOS (descriptor Mis^{NOS}), hence the SLP needed to include activities for teachers that would foreground the tenets of the NOS to increase their understanding of science.

Since the tenets of both the NOIK and the NOS have been closely linked together (Cronje *et al*., 2015) and the understanding of IK among the participants was negligible, it implies also, that the NOIK is poorly understood as well. All the participants had some minimal knowledge about the NOS, they listed the following characteristics in response to Question 11: "*science is derived from observation of the natural world; subjective; theory-laden; theories and laws that describe science; characteristics of scientific knowledge*". These are aspects of the tenets of the NOS discussed at length in Section 2.2.6. Only Participant 3 provided an idea about the NOIK when in response to Question 12 by drawing similarities between Ayurveda and the NOS; "*its biases, level of uncertainty, its social aspects*", which indicates that s/he was able to see a relationship between science and IK.

However, there were also some misconceptions that surfaced, such as one participant who responded that the NOS is "often accepted by most people while Ayurvedic knowledge is accepted by few people. NOS could be seen as the right way. Ayurvedic knowledge could be seen as a myth". Another participant said that s/he was "not sure what she understood about the NOS but ventured possibly that science has to be natural and always in touch with nature". These responses indicate that the participants did not have knowledge on the NOS and possibly were never exposed to it during their pre-service teacher education. Thus, if the NOS is not understood, then the NOIK will also be unclear, leading in turn to a weak PCK for the integration of IK into lessons.

4.5.3 Conclusion to the pilot study

Although the sample for this pilot study was small, the results nevertheless directed the development of the SLP to be held for Life Sciences teachers as the next step in this DBR study. SLPs were developed and conducted for Life Sciences teachers in different parts of South Africa over a period of one year and one of these SLPs was

modified to include Indian IK and is the basis of the intervention for my study. Cognisance must be taken that the pilot study was conducted before any intervention (SLP) was done, whereas the Limpopo SLP questionnaire analysed was after the intervention when the participants already had some knowledge about IK.

Comparing the results from the Limpopo SLP with those of the pilot study showed the emergence of similar provisional themes regardless of the cultural group of teachers involved. These include their acknowledgement of the value that IK has in the curriculum but that their intention to include IK in their lessons is often impeded by a lack of resources, conflicting belief systems, as well as their own under-developed PCK for Indian IK, specifically. Although the Limpopo SLP gave teachers a more nuanced understanding of the tenets of IK, this did not translate directly into their ability to include IK into their lessons. This was observed during class visits after the SLP; and is the subject of various research papers (De Beer and Kriek, 2018?; De Beer and Mentz, 2018; White and De Beer, 2017).

4.6 Short-learning programme in Lenasia

The two-day SLP in Lenasia was based on the over-arching theoretical framework of social-constructivism while using Warford's (2011) concept of the zone of proximal teacher development (ZPTD) – discussed in detail in Chapter 2 of my study. In a nutshell, this entailed, as indicated by De Beer and Kriek (2018?), scaffolding the skills and knowledge of the teacher participants from their 'actual development' to their 'potential development,' across the ZPTD. These researchers devised a means for the identification of principles to guide teachers' professional development (PD) and this was adapted in my study to also illustrate the construction of the Lenasia SLP (see Table 4.11)

Table 4.11: Table showing the principles used for developing the Lenasia SLP [adapted from De Beer and Kriek (2018?)]

Principles of PD identified	How these principles were used in the SLP
1. Focus on specific content.	Demonstrate pedagogies/strategies with authentic content that is feasible for classroom implementation with a focus on Indian IK.
2. Ensure coherence by aligning curriculum and policies.	Using the CAPS policy document to guide the integration of IK into the activities so that teachers can use them in their lessons thereby ensuring compliance with policy.
3. Engage in active learning.	Teachers were physically engaged in activities rather than passively observing demonstrations, such as cooperative learning (CL) and problem-solving activities.
4. Activities need to be practised.	Teachers took part in the jigsaw method (a cooperative learning (CL) strategy). Hands-on apparatus was provided for basic laboratory procedures (Kirby-Bauer technique) and teachers had to engage in problem-based activities. They were also engaged in using De Bono's Six Thinking Hats, thus providing different perspectives on Indian IK.
5. The programme must be of sufficient duration (intensity and contact hours).	After the face-to-face two-day intervention, teachers were expected to transfer their competencies in the classroom and provide evidence thereof in their portfolios. Class visits were done to extend the contact time with participants.
6. Teachers need to be actively involved in their own learning by being reflective practitioners.	One of the activities in the SLP expected teachers to keep a journal as evidence of their reflection on their teaching. This was to be submitted as part of their portfolio.
7. Good curriculum materials are essential for teachers and students.	Learning materials that enhance self-directed learning (SDL) were developed as part of the SLP manual; participants also received resources that were used during the SLP and that they could keep for continued use in their own classrooms, among others a full-colour textbook on medicinal plants.
8. Teachers must be immersed in inquiry experiences.	Problem- and project-based activities were emphasised. Teachers worked in groups to solve real-world problems viz., transporting cut flowers from the Netherlands to New York, an activity drawing on IK practices, and developing experimental

	procedures to reduce the effect of ethylene on flowers, resulting in a longer post-harvest shelf life of the flowers.
9. Teachers' needs should be considered when planning PD.	The pilot study and the pre-intervention questionnaire were used to ascertain what these needs were by considering their existing knowledge on IK and Indian IK. This refers to Stage 1 of Warford's cycle, where teachers' needs should be established.
10. Transfer must be researched after PD.	Research led to improvement of the intervention in every cycle. The Lenasia SLP was based on gaps in the Limpopo SLP. The Calvinia SLP (Cycle 3) was in turn, modified based on gaps in the Lenasia SLP. After the SLP, I visited selected teachers/ classrooms, do research the transfer that took place after the intervention.
11. There must be collaboration with the Department of Education.	There was liaison with the Department of Education, whose officials also attended the SLP and assisted by granting official permission for the SLP to proceed.
12. A theoretical framework should underpin PD.	The intervention was conceptualised from a social-constructivist perspective using Warford's ZPTD which is based on Vygotsky's model of the ZPD.

The two-day SLP in Lenasia produced the following sets of results which are presented and analysed in this section: pre- and post-intervention questionnaires; feedback during SLP; focus-group interviews conducted immediately after the SLP; class visits and analysis of portfolios submitted three months after the SLP. The questionnaires were used to gauge participants' views on IK and Ayurveda, using parts of the views-on-the-nature-of-indigenous-knowledge questionnaire (VNOIK), developed by Cronje *et al*. (2015). The responses to the questionnaires, interviews, and class visits were coded using the technique described by Saldana (2009) which led to the emergence of several themes. The responses from both the pre- and the post-intervention questionnaires were also compared with each other to see whether the SLP helped improve participant views about IK and Indian IK.

4.6.1 Analysis of responses to the pre-intervention questionnaires

See Appendix G for the pre-intervention questionnaire and responses. Although there were 18 participants at the SLP, only 15 submitted their responses to the pre-intervention questionnaire. The participants had between 0 and 23 years of teaching experience among them and 80% were CAPS trained. Each question was then analysed and the provisional themes or categories that emerged are represented in Table 4.12.

Table 4.12: Table representing an analysis of the Lenasia SLP pre-intervention questionnaire [n=15]

QUESTION	PROVISIONAL THEMES/CATEGORIES
3. Do you think there is a place for IK in the Life Sciences classroom?	100% of participants felt that IK has a place in the curriculum, in order to allow decolonisation and to promote tolerance among people. Additionally, that including IK facilitates understanding among learners for various Life Sciences topics.
4. Have you ever incorporated IK into your Life Sciences lessons classroom? Why/Why not?	33% of the teachers indicated that they had not incorporated IK into their lessons while the remaining 67% said that they had included IK by mainly incorporating traditional medicines specified by the CAPS document. A response indicated: "*Yes, because there's a section on biomes and plant diversity. Welwischia treats cancer. African potato, Hoodia and the rest zeroed in on how plants were used traditionally.*"
5. In your view what is indigenous (or traditional) knowledge? What makes IK different from other types of knowledge systems (such as Western knowledge)?	33% of the teachers felt that Western knowledge is mainly scientific while IK originates from our forefathers and is transmitted orally. 13% of the teachers regarded IK as "*knowing and understanding egg natural resources on how they occur … and how they can be used;*" or that it "*can be medicinal, spiritual or used in other ways"*.
6. Practitioners of IK (e.g. elders, herbalists, traditional healers) observe	33% of the teachers were of the opinion that IK practitioners mainly use trial and error over long

nature to generate knowledge. Do they do experiments and tests in order to verify or validate this knowledge? • If yes, explain how they test or validate their knowledge. • If no, explain why not.	periods of time to generate and verify this knowledge; and 20% of the teachers said that there was no way to verify this knowledge.
7. IK 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.	47% of the teachers indicated that IK changes over time due to the dynamic nature of scientific knowledge, as stated by one teacher: "*Depending on background, culture, level of understanding there will be change*"; while the remaining 53% felt that IK does not change due to the rigidity of science.
8. Hoodia gordinii 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?	60% of the teachers believed that the San probably used trial and error to discover the properties of *Hoodia gordonii* and 27% believed that chance determined these properties.
9.1. Do you believe that IK reflects the social and cultural values of a specific community? Explain with the use of examples how IK reflects the social and cultural values of a local community. 9.2. Do you believe that IK 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.	• Several examples cited from CAPS and a few from the teachers' own experiences such as the use of *Hoodia gordinii*; cannabis smoked by Rastafarians and cannabis oil for cancer treatment; and mopani worms as a food source. • 93% of the teachers were of the opinion that IK should be shared because it is universal and can promote tolerance. • Only one teacher indicated that the limitation to using IK globally is the availability of plants which are often confined to certain habitats.

10. What are your views on the teaching of Indian IK among Indian learners in South Africa?	• Indians need to know their own IK, the opinion of 27% of the teachers. • Teaching Indian IK will enhance understanding by Indian learners, the opinion of 13% of the teachers.
11. The Life Sciences CAPS document states that the examples of IK chosen for the study should, as far as possible, reflect different South African cultural groups (DoE, 2011:17). Are you in a position to implement this requirement? What problems do you experience when implementing this requirement?	• The lack of resources; content knowledge and overloaded syllabus impair the implementation of the CAPS document. • There is uncertainty about whose IK should be taught.
12. What do you know about Ayurveda?	• The knowledge of Ayurveda was completely absent in 67% of the participants. • 20% felt that Ayurveda dealt with herbal remedies and 13% had an idea that it was "*an ancient Indian traditional way of treating and curing illness*".
13. Would you say there are any links between the current Life Sciences curriculum and Ayurveda? Explain further.	33% of participants did not know of any links, while one participant knew about certain Indian herbal medicines "*such as turmeric/ borrie".*
14. Do you think that learning about Ayurveda could benefit the learners? Explain.	53% of the teachers said that learning about Ayurveda would promote tolerance while learning about remedies used and the knowledge would be valued; while 40% declined to comment on this question.
15. What do you understand about the nature of science (NOS)?	47% of teachers did not answer this question; 20% decided that NOS refers to the scientific method using empirical methods of investigation; 13% said that NOS concerned the "*affective domain*" and the "*emotional factor*". The remaining 20% referred to the NOS being

	empirical, "*result-oriented; process of discovering; practical investigations*".
16. Do you see any difference between the NOS and Ayurvedic principles? Explain your response.	60% of the teachers did not respond to this question while 40% felt that there was no difference between the NOS and Ayurvedic principles.

The provisional themes/categories show that the majority of teachers (67%) had not heard about Ayurveda prior to the SLP, while a few (13%) knew it was Indian-based concerning herbal treatments. One participant commented, "*I haven't heard about it but I know it is the treatment of chronic diseases using herbs*"; another said that s/he knew "*many aspects of plants are linked to medicinal uses as well as cultural practices such as turmeric/ borrie*". Many of the participants felt that integrating IK into the curriculum would teach children to be more tolerant of each other while also *"where decolonisation can first be achieved in curriculum/through curriculum*".

Although the group of participants at the SLP was a different sample of teachers compared to the group who responded to the pilot questionnaire and to the group at the Limpopo SLP, the challenges experienced by all three groups were similar in that they all cited a lack of resources, they did not have good content knowledge, they felt that the syllabus was too crowded and there was not enough time to integrate more IK into their lessons. A recurring limitation in both SLPs was that participants were not sure whose IK to include as they had learners from diverse backgrounds in one class. The participants had a vague idea about the NOS and seemed to think that it is very similar to Ayurvedic principles. Some of their comments to support this included: "*There is truly no difference, this is all science"; "No, Ayurveda has been tested and tried over centuries so it is also accurate, reliable and ethical to use, it also changes with time and can be tested*".

The overall responses to the pre-intervention questionnaire indicated that teachers who attended the SLP in Lenasia were uninformed about Indian IK. They shared the view that despite the challenges mentioned, integrating IK into the curriculum would be beneficial to their learners. They also had a naïve view of the NOS especially

pertaining to IK. The SLP, therefore, attempted to address these issues so that the teachers would develop a more nuanced view of the NOS, the NOIK and Ayurveda

.

4.6.2 Feedback during the programme and activities

Based on observations made by the facilitators, the teacher participants displayed a high level of attention and interest throughout the two-day SLP and took part enthusiastically in all the activities planned in the SLP guide (Appendix F). The presentation on Ayurveda was met by the participants with an active response, with several questions seeking clarity, some sharing their own experiences and a desire to learn more about Indian IK.

On the second day of the SLP, the participants were asked to use one word to describe the SLP they had experienced the previous day. Figure 4.1 represents their responses as a word cloud: [compiled using https://www.wordclouds.com/].

Figure 4.1: Word Cloud describing Day 1 of Lenasia SLP

The participant responses indicate the positive impact that the SLP had after the one day and verifies the observation made by the facilitators. One of the teachers had done further research on turmeric and found studies that discredited its effectiveness. This generated some healthy discussion around how such information may be confirmed or refuted in the classroom, especially in the light of empirical evidence using the Kirby-Bauer method for anti-microbial testing. This was done on Day 1 and the Indian Ayurvedic herb turmeric was used to demonstrate its anti-microbial properties (Page

16 of SLP Guide). See Figure 4.2 for photographs showing participants conducting this technique.

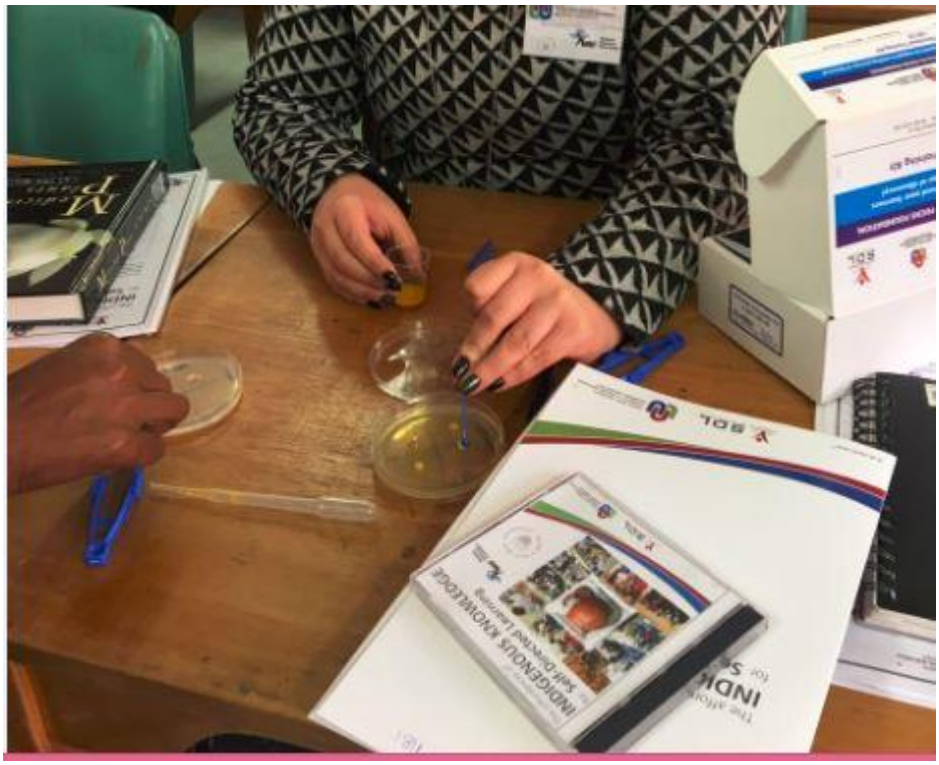


Figure 4.2 (a) & (b): Photographs of participants engaged in Kirby-Bauer Technique

Another teacher had given some thought to the activity involving the use of ethylene to stimulate fruit ripening and seed germination (Page 24 of SLP Guide), which was also performed on Day 1, and questioned whether ethylene would stimulate the germination of avocado seeds, which usually took a long time to sprout. This was an interesting question that prompted further research as it was not known whether any information was available on this topic. Both these teachers demonstrated that SDL was taking place after one day of being exposed to an SLP that encouraged inquiry-based learning and self-directed learning.

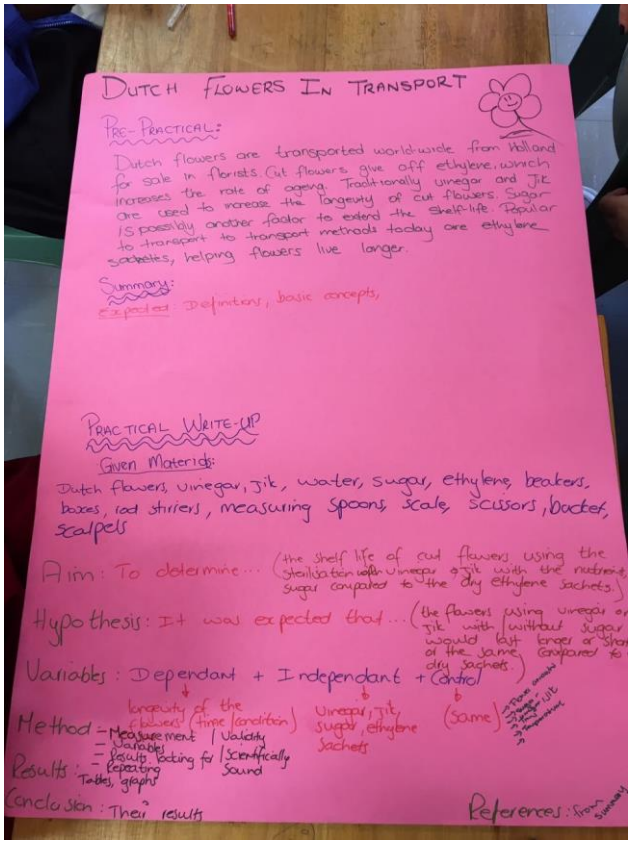
Day 2 activities involved the jigsaw method (Page 32 of the SLP Guide); participants explored the various aspects of Indian IK in their expert groups and then relayed the information learnt to the rest of their home group. This activity simulated what they could do in class with their own learners to make learning meaningful and where learning is actually 'forced' onto learners unlike in most traditional classrooms where teaching does not necessarily mean learning is taking place. Teacher participants made the following comments:

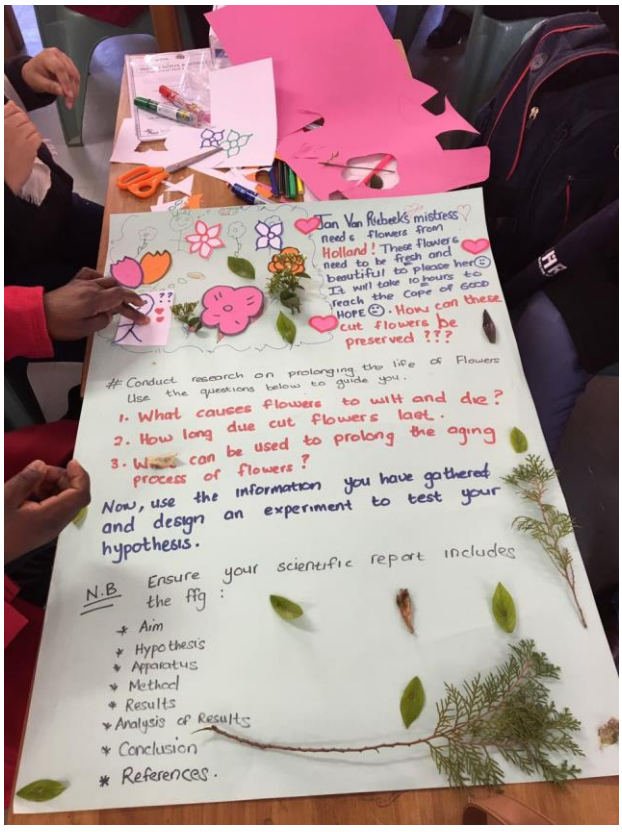
- "*This is an interactive method of learning that helps to support others".*
- *"It allows weaker learners to get involved from a non-academic level; it forces interaction, dependence and trust from all learners".*
- *"This method of teaching helps to enhance learning".*
- *"It may work well in senior classes rather than in junior classes".*
- *"It teaches learners how to sift information and be more discerning".*
- *"It will teach learners to be independent and disciplined".*
- *"It forces teachers to be prepared and plan well for their lessons".*
- *"It forces learners to read – lessen information for weaker learners so that they are not overwhelmed".*
- *"It improves learner confidence and increases their ability to express themselves".*
- *"It helps learners to understand content better and can help to cover more ground in the curriculum*".

Together with these comments, which were in support of this method of learning, there was a high level of energy and total immersion in the activity, prompting the facilitator to describe them as *Homo ludens* (in Brits *et al*., 2016). This term refers to the 'playing human' and shows that the participants were completely engaged in the activity and enjoying it to such an extent that they did not even realise they were learning. This is the type of atmosphere that should be generated in the classroom with the teachers own learners. See Figure 4.3 showing participants immersed in the Jigsaw Activity.

Figure 4.3 (a) & (b): Participants engrossed in Jigsaw Activity

Another activity on Day 2 involved group work where participants had to create a poster that outlined a possible solution to the problem of extending the post-harvest shelf life of cut flowers (Page 28 of the SLP Guide). Although this was not Ayurveda IK, this activity was based on Dutch IK. After receiving some background information on the topic by the facilitator, the participants gathered in groups to design and produce the poster. They were provided with the materials to do so, such as poster paper, markers and paper glue. This activity also solicited enthusiasm and active engagement to work out possible solutions to the problem by working together in groups. Each group was then allowed to present their posters to the rest of the participants. See Figure 4.4 for photographs of some of the posters created.





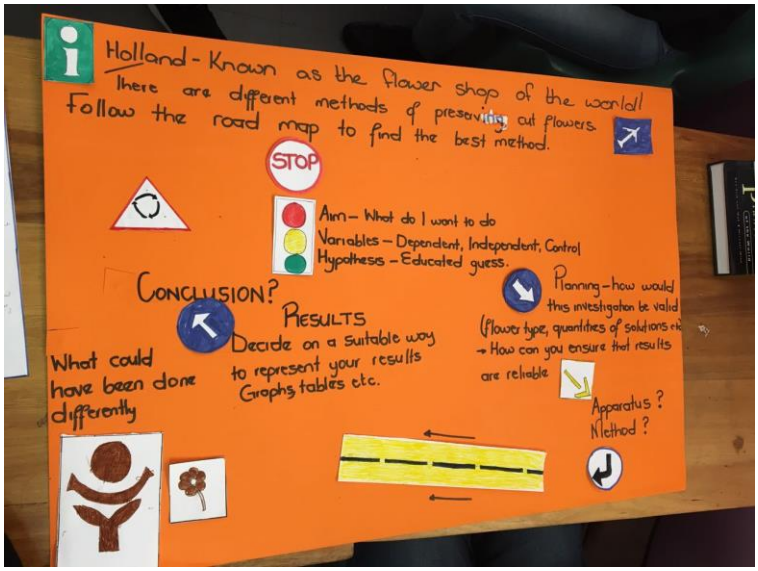


Figure 4.4 (a), (b) & (c): Three of the posters produced during the SLP

These activities each served to demonstrate to the participants that it was possible to integrate IK and Indian IK into their lessons using inquiry-based learning strategies. It was envisaged that the participants would then be sufficiently inspired to transfer what they learnt into their own classrooms and in this way enhance learning while also including IK into their lessons.

4.6.3 Analysis of responses to the post-intervention questionnaire

See Appendix H for the post-intervention questionnaire responses on the 18 participants who submitted their responses.

This questionnaire had elements of the VNOIK questionnaire included in it. The responses from the post-intervention questionnaires were analysed by comparing them where relevant to the responses for the pre-intervention questionnaire. Using Saldana's (2009) coding technique, the teacher responses were coded into meaning units or categories and then distilled into provisional themes in order to determine trends and thoughts around the integration of Indian IK into the Life Sciences curriculum. Four provisional themes emerged from this exercise:

1. Teachers held more nuanced views of the nature of indigenous knowledge (VNOIK) after the short course.

Teachers demonstrated more nuanced VNOIK in the post-intervention questionnaire and the focus-group interviews. Prior to the SLP, 87% of teachers were uninformed

about IK and afterwards almost the same percentage indicated they had an informed view (Cronje *et al*., 2015). See Table 4.13 and Figure 4.5 representing this result.

Table 4.13: The participants' views of Indigenous Knowledge before and after the SLP

	VIEW [n=18]		
	Uninformed (UI)	**Partially Informed (PI)**	**Informed (I)**
Before SLP	87%	13%	0%
After SLP	0%	13%	87%

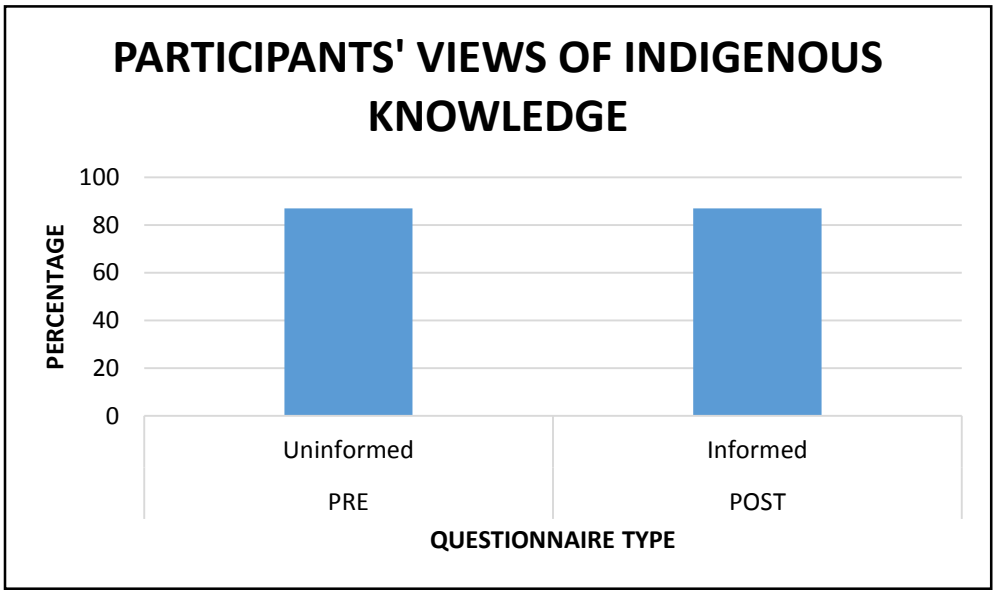


Figure 4.5: The participants' views of Indigenous Knowledge before and after the SLP

Some teachers were surprised to notice that science and IK share similar tenets, e.g., both are empirical, inferential and tentative. Seven out of the 18 respondents attributed the dynamic NOIK to new information being discovered; the contribution by technology; nature evolving continuously; climate change; and even due to errors during the oral transmission of IK from elders to the next generation. One of the

responses that exemplifies this was, "*oral transmission has problems – there can be omissions, additions and even alteration of information*".

The dynamic NOIK is aligned with the tentative NOS, as explained by Cronje (2015). Both science and IK are tentative with IK also being attributed to people's experiences. This provisional theme shows that teachers do recognise that IK, and by extension, science is constantly changing. Ascribing this dynamic nature to the various reasons mentioned also indicates that the participants were able to identify the factors bringing about change thereby making teachers more amenable to the integration of IK into the curriculum.

One of the responses from the post-intervention questionnaire was that "*an Ayurveda IK may differ from an African IK*" thereby acknowledging that the IK of different cultures may contribute to its dynamic nature. For example, certain plants, like turmeric, have specific medicinal uses in Ayurveda but not in African culture because these plants did not grow locally when most African IK was being established. Ayurvedic plants were only introduced to South Africa when the indentured Indians arrived about 160 years ago.

2. Teachers agree that there is a place for IK in the Life Sciences curriculum.

All the respondents agreed that there is a place for IK in the curriculum. Three main reasons arose to justify their agreement, the first one being that including IK would enhance the learning process and make it easier for learners to grasp certain concepts, as stated by one of the teachers: "*IK empowers students and facilitates comprehension*". Teachers remarked that "*integrating IK will provide learners with real-life situations*" that they "*would be able to contextualise*". This is in keeping with Odora-Hoppers (2005:3) that the integration of IK makes it "cognitively easier" for students to learn science as opposed to learning it from a purely Western perspective.

The second reason provided by the teachers is that integrating IK would contribute towards the decolonisation of the curriculum and towards being more tolerant of different cultures and their beliefs. This reason verifies the view of Odora-Hoppers (2005:22) who outlines the crippling effect of colonialism on indigenous people and

their knowledge. According to her, colonialism completely erased the value of IK and replaced it with Western knowledge that divided the people.

The third reason given by the participating teachers for integrating IK is that there will be a renewed effort to conserve the environment and its herbal remedies. According to one of the teachers, "*IK will help learners appreciate their environment*". One of the effects of colonialism was that it harmed nature, e.g., hunting wildlife in protected areas, unlike IK which regards certain places as sacred "to be avoided and…. conserved" Odora-Hoppers (2005:4).

One teacher mentioned that IK integration would create in learners "*a desire to pursue a career in research*" thereby fulfilling one of the aims of this SLP to encourage SDL among the teachers and transfer to their learners. Another teacher stated in the post-intervention questionnaire that IK integration is necessary for learners "*to come up with new ways of making medicine and treating ailments*" thus extending the technique of PBL that was work-shopped in this SLP. Both of these comments show that the teachers were inspired by the SLP to in turn motivate their learners to think outside the prescribed curriculum and to find solutions to problems facing local and global communities, such as food security and climate change.

3. **Teachers understood that IK reflects the social and cultural values of a specific community but can be applied globally**.

Drawing from the comparison made between the NOS and the NOIK (Cronje, 2015), it is evident that both fields are social and cultural constructs as both science and IK are developed locally in a social environment but the knowledge can be universally applied; this idea emerged in both the pre- and post-intervention questionnaires. The participants cite two unavoidable reasons for IK being confined to specific cultural groups mainly as a result of the type of plants growing in their area and because of the habits of the cultural group living there. An example mentioned is that of the *Hoodia gordonii* which was only known to be used by the Khoi-San when hunting, as an appetite suppressant because food and water were scarce in their habitat while in ancient India, hunting may have occurred in forests where supplies were more available and appetite suppression was unnecessary.

However, the pre-intervention questionnaire revealed respondents who thought IK should be kept local. One of the respondents put forward a counter-argument in that globalising IK would contribute to the exploitation of these plants with the increased supply, thus concluding that IK should be confined to local areas. One of the teachers offers legislation as a compelling reason for keeping IK local, i.e., some countries prohibit the use of certain herbal remedies such as cannabis which has recently been proclaimed as a cure for several conditions including cancer and asthma.

There was an overwhelming response to the global application of IK from the post-intervention questionnaire as all responded that IK should be shared for the benefit of all people throughout the world. They believe that IK is universal and can be used to treat all the new illnesses that currently plague humans. The sharing of IK will also contribute to the unity and tolerance of other cultures as there will be greater awareness of what is considered important or useful by these cultures.

4. Ayurveda (Indian IK) has a place in the Life Sciences curriculum.

The pre-intervention questionnaire showed that although none of the respondents had any knowledge about Ayurveda, 10 out of the 15 teachers who responded agreed that it was necessary to integrate it into the curriculum so that Indian learners could also know and value their culture. One of the teachers commented that "*just like African learners it would create excitement and interest in science knowing that it relates to their culture and what they grew up with*", indicating that the teacher believed Indian IK would contextualise science education for Indian learners.

The post-intervention questionnaire revealed that 17 out of the 18 respondents agreed that it was important for Indian IK to be included in the curriculum so that all learners could benefit from learning about it. This would lead to more tolerance and would "*break down cultural barriers*". According to one of the teachers, it would also encourage the learners to want to find out more about Indian roots and that of Ayurveda, thereby promoting SDL among learners. This comparison between the pre- and post-intervention test responses for the inclusion of Indian IK into the curriculum is shown in Figure 4.6.

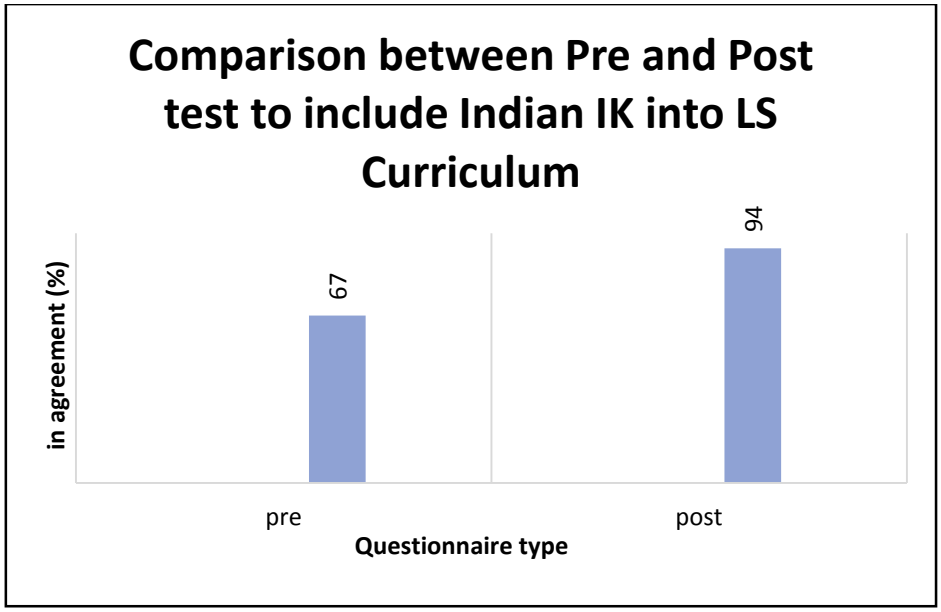


Figure 4.6: Comparing pre- and post-intervention test responses of teachers on the inclusion of Indian IK into the curriculum

The positive and appreciative response from the 15 teachers after the two-day course was recorded when the participants were asked about their knowledge of Ayurveda. Additionally, two teachers felt that the course had stimulated their interest in wanting to learn more about Ayurveda, promoting SDL in them. Ten respondents indicated the presence of links between Ayurveda and the current Life Sciences curriculum, for example, the dhatus with mammalian tissues; the several plant remedies that link to the plant biology; and the anti-microbial action that was described in the two-day programme.

The main benefits that emerged are: learning what their predominant dosha is would foster greater understanding among each other and possibly lessen behavioural issues; having a holistic approach to one's health and treatment of certain conditions; since Ayurveda does not have a religious base it makes it more open for all learners to learn about alternative remedies and there were also teachers who felt that it would improve learners' attitudes towards the environment. The post-intervention questionnaire revealed 87% of participants appreciating the exposure to Indian IK in the course and 67% participants indicated the presence of links between Ayurveda and the Life Sciences curriculum; this is illustrated graphically in Figure 4.7.

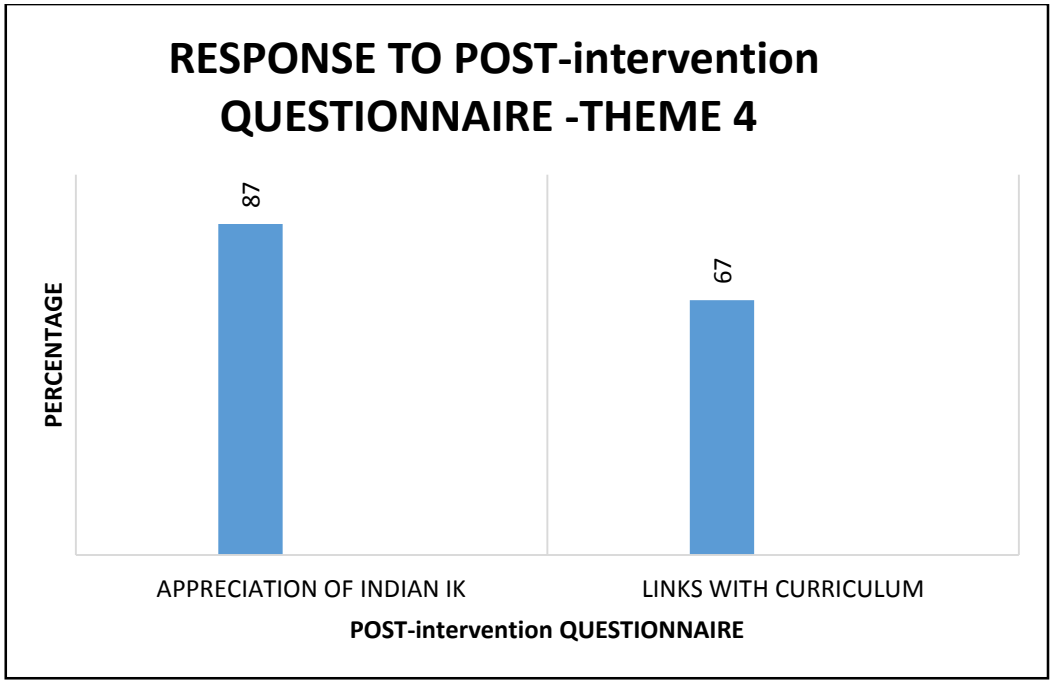


Figure 4.7: Graph showing responses to Indian IK having a place in the curriculum

Additionally, the respondents were asked whether they saw any difference between the NOS and Ayurvedic principles; most of the teachers indicated that there was a similarity. It must be noted that the two-day course focused implicitly on the NOS by including inquiry-based activities, however, many of the teachers did not form a sound idea about the tenets of the NOS; their response in comparing Ayurveda to it is therefore not reliable. Although they did not address aspects of the NOS in their responses because of this shortcoming, many attempted to justify their views by addressing the holistic nature of Ayurveda as opposed to science which is compartmentalised or reductionist in nature.

In conclusion, the analysis of the pre- and post-intervention questionnaires showed that before the course, teachers were unfamiliar with Ayurveda tenets or in the integration process of IK into the curriculum, but afterwards, the participants expressed a nuanced view of both these aspects. This finding is also in response to the research questions of my study: “What are Life Sciences teachers’ views about the nature of science (NOS) and the nature of indigenous knowledge (NOIK)?” and “What are Life Sciences teachers’ lived experiences of participating in the SLP, and teaching IK in the classroom?”

Teachers also learnt that Ayurveda can lead to a holistic and good health; and to the tolerance for nation-building while reducing the evils of colonialism and environment degradation. Additionally, as a by-product, learners would appreciate the relevance of IK included in the Life Sciences, to their daily lives, thus ultimately enhancing their performance in Life Sciences.

4.6.4 Focus-group interviews after the Lenasia programme

Two focus-group interviews were conducted with five teachers in each group. The interviews were mostly unstructured with the questions from the interviewer being guided by the discussion itself. However, a few questions to prompt the discussion were prepared beforehand but were not used in exactly this order and neither were they all used:

- What is your idea now about IK after being here for the past two days?
- Do you foresee any challenges in including IK and Ayurveda into your lessons? Explain.
- Describe what you think your own IK is. How do you think you can integrate this into your lessons?
- Do you see any value in using herbal remedies to treat certain ailments – would you rather use Western medicine?
- How do you now feel about the NOS and the NOIK?

The interviews were recorded and then transcribed so that coding could be done to determine the descriptors, meaning units and provisional themes according to Saldana (2009). See Appendix I for these transcripts. The codes that were used to analyse both transcripts, as well as the reason for selecting them, are indicated in Table 4.14.

Table 4.14: Table showing descriptors, codes and reason used in the analysis of focus-group interviews held after SLP

DESCRIPTOR	CODE	REASON SELECTED
Relevance	R	IK is relevant to daily life.
Changing IK	C	A characteristic of IK that is similar to that of the NOS.

Value of older generation/ past	V	Characteristic of IK.
Authentic, validate IK as being a science	A	NOIK aligned with NOS.
IK link to modern medicine	I	The relationship between IK and modern medicine clarified.
Holistic characteristic of IK	H	One of the tenets of IK.
Curriculum document implemented	Cu	To show teachers' knowledge of CAPS.
View of SLP	VSLP	To see whether the view of the SLP was consistent with what was written in post-intervention questionnaire.
Much information on IK	Inf	A characteristic of IK, vast amount of knowledge available.
Ignorance about including IK in curriculum	Ig	Lack of PCK to include IK into lessons.
Eager to incorporate IK	E	SLP motivating teachers to incorporate IK into lessons.
Human resource	HR	People as holders of IK who can be used to share their knowledge and expertise on IK.
Appreciation of IK	Ap	SLP served to generate an appreciation of IK that was not there previously.
Advantage of IK/ traditional medicine	Adv	To see the value of IK in communities.
Tolerant of other cultures	T	IK inclusion into lessons can increase tolerance of other cultures including Indian.
Fear of being insensitive	F	Including IK must be done tactfully so that there is no culture in the classroom that will feel undermined.
Challenges of including IK in curriculum	Ch	Tensions in the CHAT activity system that arise when IK is included in lessons.
Passion for teaching and learning	P	To examine SDL and teachers'/learners' desire to learn.
Time to teach	t	Another tension is the shortage of time to include IK in lessons.

Diversity in teaching	D	Including IK can introduce diverse teaching strategies and make lessons more interesting.
Lesson plans	LP	Lessons should be well-planned to ensure effective integration of IK.
Witchcraft	WC	IK might be confused with witchcraft.
Assessment	As	The role of assessments in integrating IK.
Learner performance increases	LP	Including IK can improve learner performance.
Indian IK	IIK	To see what aspects of Indian IK were picked up from SLP.
Prior knowledge	PK	Children come into the class with their own experiences which makes up their prior knowledge.
Teacher's PCK	PCK	PCK is an important component for successful integration of IK into lessons.

Twenty-seven descriptors relevant to the study were identified in both focus-group interview transcripts. These descriptors were then grouped into meaning units and then distilled into themes which will be presented in the ensuing section.

Provisional Theme 1: The SLP afforded teachers a more nuanced knowledge and appreciation for IK in general, and for Ayurveda in particular.

This provisional theme is similar to a category that developed from the analysis of Question 1 in the Limpopo SLP. The various responses made by the teachers during both the focus-group interviews at the Lenasia SLP, lead to descriptors such as, 'Much information on IK'; 'Human resource'; 'Appreciation of IK'; 'Advantage of IK/traditional medicine'; and 'Indian IK'. Teachers were sensitised to the value of IK and its integration into the curriculum after attending the SLP. Many realised that there was a lot more that they needed to learn about the topic thus making the notion of SDL more attainable.

Concurrently, the SLP informed them that there were many types of IK, not just African, prompting one teacher participant to mention, "*So when I saw that there is Indian and Dutch etc. IK, 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.*" Viewpoints

like this would inspire and develop a tolerance for other cultures, ultimately leading to nation-building.

Teachers came to grasp that learners can also learn more about their own culture by including more aspects of IK into their lessons than only what is prescribed in the curriculum document. This would also cultivate pride among learners about the value of their own culture. The teachers' responses indicated that the SLP showed them the wealth of knowledge that can be found in the older generation and who can be tapped into as a valuable resource during lessons. This can be seen by comments such as: "*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; going back to our roots has solved a lot of problems in my experience; the people back then would live to a 100, 120 years...What they used to eat? How they used to balance their dishes? That was maybe how they lived longer*". Instead of only using textbooks and worksheets, learners may enjoy learning from a more knowledgeable elder from the community who can narrate stories, remedies and other practices involving IK.

Many of the responses focused on the SLP increasing their knowledge about ethnobotany i.e. the use of traditional plants in various fields like medicine, cleansing houses (*imphepho*), building houses, and in food to treat certain ailments; as was explained during the Ayurveda section of the SLP. According to one remark, "*there is actually value in these plants ... So, yes, my opinion changed a lot*", which suggests that the SLP informed the participants about the uses of traditional plants and herbs. Another participant commented that "*we need to start at grassroots 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*", indicating the awareness after the SLP that conservation and use of traditional plants should be taught to learners from a young age.

Provisional Theme 2: The SLP aligned the NOIK with the NOS for teachers by enhancing their understanding of IK and science.

One of the aims of the SLP was to impart the tenets of the NOS and the NOIK to the participants. Although this was done on an implicit level during the two-day SLP, the

focus-group interviews revealed evidence of these tenets when one of the participants mentioned that natural resources are used to "*maybe treat your body and soul",* which speaks to the holistic tenet of the NOIK (Cronje *et al*., 2015:321, 322).

Reference was frequently made during the interviews to the relevance of IK and its changing characteristics. This alludes to the resilient but tentative NOIK since, according to Cronje *et al*. (2015:321, 322), IK is fluid, transformative and linked to people's experiences. Furthermore, the discussion highlighted such characteristics as the authenticity of IK being validated as a science as indicated by a participant talking about the Kirby-Bauer technique used in the SLP, "*we feel that Western medicine is the only thing that works … These remedies do work and we can use them*". This shows that once IK can be verified by scientific processes then they are more acceptable, in line with the empirical NOIK.

The social, collaborative and cultural NOIK was evident by the statements made to incorporate indigenous and Western knowledge, with one participant using the example of integrating Ayurveda into her lesson by making it relevant to learners' existing knowledge: "*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 Ayurveda 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*". This is a pertinent comment that also shows the functional application of the NOIK, another tenet listed by Cronje *et al*. (2015:321-322), is the contrast to the NOS, as IK is concerned with people's daily lives instead of with facts, theories and laws, which is what the NOS deals with.

The creative and mythical aspect of the NOIK also emerged during the interviews when teachers mentioned the negativity surrounding the use of certain herbs "*to wash away bad spirits*" but that this could be alleviated when such practices are verified empirically. Of the nine tenets of the NOIK listed by Cronje *et al*. (2015:321, 322), only four tenets have seemingly not been alluded to by the participants during the interviews, viz: empirical and metaphysical; inferential but intuitive; subjective; and

wisdom in the action of IK. Thus, it would appear that the SLP provided an implicit understanding of IK with the course material.

Provisional Theme 3: The SLP allowed teachers to engage in teaching and assessment methods that were more inquiry based, and could be used to stimulate learning and enhance integration of IK, thereby contributing towards teachers' PCK development.

This provisional theme was conveyed by participants discussing some of the teaching strategies they could use after attending the SLP, including the use of the different inquiry-based activities that were used, e.g., the Kirby-Bauer laboratory protocol, jigsaw method, De Bono's Hats and the poster-making to reflect on problem-solving skills. Teachers felt that these activities would enhance their own lessons, make them interesting and "*bring diversity into my teaching*", as described by a participant. This was more evident from the second focus-group interview which included several instances where teachers mentioned the methods they were going to use. A teacher responded that s/he would use such inquiry-based methods, including the cooperative learning technique of the jigsaw method, to help her learners prepare for the exams.

Mention was made in this study and the pilot study, about using and harnessing the learners' prior knowledge to be used in the classroom during lessons on IK. Indian Life Sciences teachers commented that they successfully used their learners' daily experiences to stimulate discussion on IK, as well as that Indian learners, may have an advantage if Ayurveda is taught as they have the requisite prior knowledge in the field. It is evident, therefore, that many teachers do share the view that learners have much to offer when IK is included in lessons.

The remark, "*they can research it and see what's going on so they will also know what to do and how to do it*" illustrates the notion of SDL which was one of the underlying aims of the SLP. Other participants spoke about the passion that would be generated when IK is introduced into lessons. They felt that this would show learners that IK is more than just a concept but is something to be appreciated because it has been practised the same way in the past as it is nowadays. One participant suggested that policymakers implement IKS as a separate subject in schools so that awareness and appreciation could be emphasised and another teacher expressed excitement that

current textbook content can be expanded to include the IK from "*other regions, e.g., Venda*".

Learning about different local cultures led the discussion to the idea that "*we should be broad-minded to change*" so that learning about IK would afford people the "*opportunity to learn about other countries' cultures*" and problems could receive a global solution if local ones are unavailable. Another part of the discussion revolved around the sustainable use of indigenous plants and that learners need to understand the importance of using these plants without damaging the supply for others. One of the participants suggested that learners cultivate their own indigenous plants in order to learn about plant sustainability, the rules for harvesting them while also selling them to generate funds for themselves and their community. In response to using inquiry-based methods for the inclusion of IK into lessons, one of the teachers made a pertinent comment that effectively sums up a key reason for exploring interesting pedagogies, "*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*".

Generally, this provisional theme illustrates that the SLP stimulated the teacher participants to start thinking about their own teaching methods and how they could use IK to improve them and ultimately, increase learner performance in Life Sciences.

Provisional Theme 4: Teachers at the SLP believed there were many challenges that would impede the integration of IK into the curriculum.

As in the Limpopo SLP, discussed earlier in this chapter, the focus-group interviews after the Lenasia SLP also showed that teachers had a few reservations about integrating IK into their lessons thus leading to the emergence of the fourth theme. One of the teachers said, "*we are sitting with a wealth of information but we don't know to use it so that we can make it part of our curriculum*", which indicates that he feels insecure about how to access the vast repository of IK for integration into his lessons, illustrating a lack of pedagogical knowledge. Perhaps future SLPs in the next cycle of this DBR methodology can provide more guidance to teachers in this regard.

The perennial challenge of whose IK should be emphasised in the curriculum also emerged during the first focus-group interview but other participants offered a possible solution to this dilemma: since nowadays there is an abundance of information easily available on the internet, IK can also be shared among all cultures and people can use solutions that are relevant to their specific problems. This view was captured by a participant who said, "*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*". In both focus groups, the conversation steered towards the fear of being insensitive to the different cultures in one classroom and that teachers needed to guard against being "*politically…or socially incorrect;...you need to be careful in conflict situations*". One of the participants said that the use of detailed case studies about various IK practices could safeguard teachers from this challenge. It also emerged during the interviews that there may be reluctance from some IK holders to divulge their information while, on the other hand, some people may be unwilling to accept such knowledge easily.

The discussion moved towards challenges that lay in pedagogy with three concerns raised:

1. Implementation of the jigsaw method in single period lessons.

One of the participants expressed the value in using this method but was unsure that it would not work in the designated time constraints. However, s/he also explained that by listening to the discussion during the SLP, a solution would be to break up the activity into two parts so that the home groups could be done in one period and the expert groups in another period. This scenario illustrates the second stage in the ZPTD (Warford; 2011), where teachers are able to develop their teaching strategies by using expert opinion, assistance from their peers and knowledge from the facilitators who scaffold their existing pedagogy.

2. Not every topic in Life Sciences is suitable for the inclusion of IK.

This was mentioned by a novice teacher who had under a year of teaching experience. Perhaps, s/he would change her view after developing more experience.

3. Teaching strategies must accommodate the multiple learning styles in a classroom.

This was a concern raised by a teacher who had the theoretical knowledge about different learning styles and was able to apply this to her own learning style as a student. S/he disagreed with some of the theory learnt while studying and asserted that teachers must become aware of the different learning styles of their learners. This observation shows the importance of SDL among teachers who need to continually upgrade their knowledge to refine their practice. It was also acknowledged that IK provides the ideal platform to cater for multiple learning styles, due to its holistic nature.

In unpacking provisional Theme 4, more light is shed on one of the research questions: "What are some of the tensions, if any, that arise when Indian IK is integrated into the SA Life Sciences curriculum?" Further analysis of these and other tensions will be made using the CHAT model to compare two activity systems that arise, viz., the expectations from the SLP; and the actual implementation of what was learnt as observed during class visits after the SLP. The next section will look at these class visits and the portfolios that were submitted after the Lenasia SLP.

4.6.5 Class visits after the Lenasia programme

At the end of the two-day SLP in Lenasia, it was necessary to conduct class visits to observe teachers' lessons a month later in order to evaluate the transfer of knowledge and skills from the SLP to the actual classroom, in keeping with my research question: **"**What transfer of Indian IK takes place in schools after the short-learning programme (SLP)?" Authors De Beer and Kriek (2018?:18) claim that "transfer of competencies to the classroom is the capstone experience of any PD intervention". Hence, it is an essential part of my study to examine the degree of implementation in the classroom.

It is disappointing to report here that from the 18 teachers who attended the SLP, only seven volunteered for classroom visits; however two of the seven teachers discouraged further communication. Five teachers were observed over a period of six months from the time the SLP was conducted in Lenasia. These class visits were observed using the RTOP instrument conceived by Sawada *et al.*, (2002). Brief, unstructured individual interviews were also conducted with each teacher after their lesson was observed. After subjecting the data from these brief interviews and class

visits recorded on the RTOP tool, to Saldana's coding method, three provisional themes emerged. Extracts from this section were also used in a paper submitted to the ISTE 2018 Conference with the researcher as the main author (Reddy *et al.,* 2018b). (The RTOP instruments for three of the five lessons observed are provided in Appendix J as examples).

Provisional Theme 1: Having the necessary expertise, qualifications and subject knowledge were insufficient to enable more integration of IK into the lesson, or to use inquiry-based methods for this integration.

The teachers observed had qualifications to teach Life Sciences ranging from a Bachelor of Science to a Masters in Science degree and should have, therefore, been able to use their PCK to answer learners' questions while drawing them towards the topic under discussion. Four observed teachers were unable to use their existing knowledge and expertise to bring in the IK learnt during the SLP in an authentic way, e.g., structuring the lesson around a guiding question embedded in IK.

One teacher was able to expertly steer class discussion from the topic of mitosis towards cancer and the use of indigenous herbs and remedies for treatment. S/he probed learners' everyday home experiences by asking the right questions to elicit their responses. S/he was also able to use learners' prior knowledge with specific reference to the content related to the topic that was taught earlier during this discussion. One learner mentioned that s/he had heard of some people who eat lemons when they have cancer, the teacher used this as a gap to introduce the concept of IK to the Grade 10 class by defining it for them and explaining that a great deal of this knowledge has been lost as it has not been transferred to younger generations. S/he then encouraged the learners to find out more from their grandparents about cancer treatment before modern medicine existed.

Although his lesson was able to integrate IK into the topic of mitosis, the teacher did not use any inquiry-based methods to do so and the only teaching aids used was the prescribed textbook and notes on a data projector for learners to copy during the lesson. The lesson was, therefore, transmission-mode chalk-and-talk pedagogy albeit with ample learner participation by answering questions posed by the teacher. During the interview afterwards, s/he indicated support both for the integration of IK and

Ayurveda into the curriculum, explaining that the latter would allow learners in multicultural classrooms "*to know what different people are doing*" and to be able to compare Indian and African IK.

This specific teacher echoed the views of the teachers from the Limpopo SLP who regarded the older people of the community as a valuable resource with the information they have to share about indigenous remedies and practices. In addition, s/he mentioned that "*urban schools should do a few visits to rural areas to interact with older people, see herbal cures and get ideas to grow their own medicinal garden*". The idea of involving other resources in the integration of IK has been dealt with by De Beer and Kriek (2018?:1) who argue for a "third partner in the value chain between schools and universities, in teacher education", the same partnership can also help schools integrate IK into the curriculum. Based on this teacher's outlook about IK and the lesson content, s/he can be considered a keystone species in the community of practice, for other teachers to use as 'expert other assistance' in the ZPTD (Warford; 2011).

Another teacher attempted to infuse some IK into the lesson on mammalian tissues by introducing the topic of biotechnology which s/he defined as using plants and animals to make medicine, then directed the lesson towards complementary alternative medicine (CAM) and asked about traditional remedies. Learners responded about their personal experiences at home with "*flu remedies (honey and ginger), turmeric as an antiseptic; aloe gel to soothe wounds and for acne treatment*". The teacher then introduced information on the African Potato (*Hypoxis hemerocallidea*, or the *inkomfe* (Zulu), *lotsane* (Sotho)) as this was in the syllabus; a few learners indicated that they had heard about this at home. Although s/he tried to incorporate elements of IK into the lesson, there were no inquiry-based methods used, it was chalk-and-talk with learner involvement in the lesson. The lesson had potential for meaningful inquiry activity where learners could have researched evidence for this plant's traditional use to treat benign prostatic hypertrophy (Van Wyk & Gericke, 2018).

None of the other lessons included IK as the teachers stated that the topics they were teaching (nervous system, gaseous exchange and Photosynthesis, respectively) were not suitable for the inclusion of IK. However, the resource books provided to teachers

at the SLP provided ample examples that could have been used. For instance, when dealing with the nervous system, a plant such as *Sceletium tortuosum* (kougoed) could have been used. This is a powerful mood-altering drug, which elevates mood and decreases anxiety, stress and tension (Van Wyk & Gericke, 2018). The active constituents are alkaloids, and learners could have done some desktop research on the pharmacology of *Sceletium*.

These teachers had an under-developed PCK by not integrating IK into other Life Sciences topics. Their shortcoming in not being able to integrate IK also points to a weakness in the design of the SLP, and for Cycle 3, there should be an activity where participants are expected to take a more explicit look at the curriculum and how IK can be infused into it. In support of this supposition, De Beer and Kriek (2018?:17), explains that teachers should be allowed to develop their own learning/PD goals so that "in facilitating such learning, the facilitators should then assist the individual teachers in identifying both the resources and strategies to achieve the identified learning goals".

Provisional Theme 2: Most teachers struggle to incorporate IK into their lesson due to time constraints and a content-laden curriculum.

This provisional theme emerged primarily from the analysis of the individual interviews held with the teachers after their lessons were observed. Upon reflection, however, the teacher-centred, transmission-mode in which all the lessons were conducted, are also indicative of this problem that teachers face. They felt that inquiry-based methods infusing IK would be too time-consuming and, therefore, resorted to the traditional method ('chalk-and-talk'). One teacher stated during the interview that "*given a choice, I would infuse more IK to make the topic more relevant*" the "*curriculum is too packed to allow for much more infusion of IK*".

In fact, this has also been an area of focus in a paper by De Beer and Mentz (2018:15) which compares the Limpopo SLP (representing Cycle 1 in the DBR methodology) with the Calvinia SLP (Cycle 3). These authors realised that teachers feel pressured for time by the pace-setters and "revert to familiar chalk-and-talk approaches, which are seen by them as being more effective in achieving the intended outcomes". They suggest a possible solution for future SLPs, which entails giving the teachers a chance

to compare a traditional transmission-style lesson with an inquiry-based method using PBL, in order for them to see that the latter does not necessarily take up more time than the former.

The keystone teacher discussed above also mentioned time is a challenge for teachers to integrate IK into the curriculum. However, s/he realised it would be up to the teacher to ensure it is taught in some form or the other. Having said this, s/he was able to successfully incorporate aspects of IK into the lesson by expertly drawing on learner inputs during the lesson. As a 'keystone species', s/he can motivate and inspire other Life Sciences teachers to be more creative in integrating IK into topics despite time constraints.

The challenge of not being able to integrate IK into lessons due to insufficient time at school is a recurring one that surfaced in the earlier investigations with other participants. Time limitation seems to be preventing teachers from implementing what was learnt at the SLP. Teachers interviewed after the lesson observations indicated that time was short since their focus lay on completing the curriculum to comply with departmental regulations rather than on spending time on the different learning techniques shown at the SLP. The pace-setter document referred to earlier, often forces teachers to 'teach-to-the-test' at such a hectic pace that the curriculum is covered merely for learners to write common assessments rather than to enable cognition.

Time pressures could be a valid reason, for the lack of response by the other participants.

Provisional Theme 3: Regardless of the teacher-development programmes that the teachers observed, they continued to teach in the same manner in which they were taught.

This provisional theme emerged from the observations due to traditional teaching styles used; resources; and the rigid arrangement of furniture in most of the classes. As mentioned above, the teaching styles observed mostly involved teacher-centred, chalk-and-talk methods with very limited inquiry-style techniques that were demonstrated during the SLP. The resources used in all the lessons observed

included textbooks; worksheets; PowerPoint slides and white-boards; and in one case, hand models – according to the teacher, showing the parts of the brain (see Figure 4.8 for photographs of these hand models). Except for the last three resources, the other resources and seating arrangement seemed to be outdated and not relevant to the learners or current climate. This phenomenon, where teachers teach the way they were taught is based on Lortie's (1975) [cited by Mewborn and Tyminski (2006:30)] "apprenticeship of observation" where he states that teachers' practices are based on the imitation of their own teachers.

Even though the observed teachers were exposed to inquiry-based and cooperative teaching and learning methods to integrate IK during the SLP, once back in their classrooms, they continued to teach in the same way they taught before the SLP. This shows that the influence of their own experiences at school had left an indelible impression on their own teaching style, regardless of what teacher development courses try to instil in them.

Another reason for the reversion to transmission-style of teaching can be explained by the "wash-out effect" put forward by Zeichner and Tabachnick (1981:7) and cited in De Beer and Mentz (2018); this occurs when skills and knowledge picked up during teacher development courses "are often 'washed out' at the coalface of teaching in the classroom" (De Beer & Mentz, 2018:7). In the case of the teachers observed, this coalface is governed by the systemic pressures of syllabus completion within a limited time; and the pressure to ensure adequate learner performance such that the pass rate of learners remains high.

The failure of implementation of indigenous knowledge using inquiry-based teaching methods could also be attributed to a two-day professional development (PD) course being too short to make any significant difference. However a comprehensive study by Lauer, *et al*. (2014:218) reveal "that short-term PD efforts with effective design features can result in positive participant outcomes." The authors continue to explain that their "finding contrasts with prior research emphasizing that PD needs to be longer than 30 hours (Guskey and Yoon 2009) and suggests that what happens during PD is as important as or more important than the time allotment."

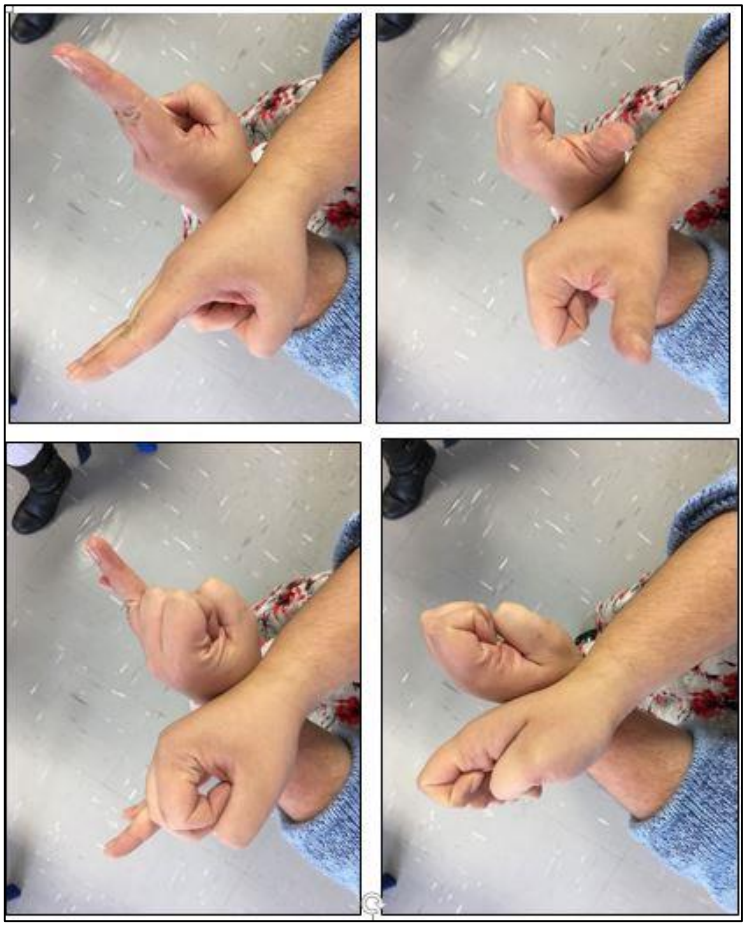


Figure 4.8: Photographs of hand models used by teacher during lesson observation to illustrate human brain anatomy

4.6.6 Using CHAT as a lens to compare information transfer between the Lenasia programme and the classroom

After the SLP in Lenasia, teacher participants were excited and eager to implement what they had learnt with regard to the integration of IK using the various inquiry-based methods of teaching.

However, this enthusiasm quickly waned when class visits were done. Noted was the absence of knowledge and skills transfer from the SLP to the classroom, a phenomenon not unique to the Lenasia SLP. De Beer and White (2017) observed the same in earlier SLPs that were part of Cycle 1. CHAT was used, as a research lens to examine the tensions that arose when teachers failed to implement the methods learnt at the SLP. These tensions refer to the systemic pressures of time constraints on teachers to complete the syllabus within a stipulated time and the need to maintain satisfactory learner performance, as discussed above.

Mentz and De Beer (2017:90) believe that it is preferable to juxtapose two activity systems in order to provide deeper insights into more complex issues facing education and teacher development in SA (p.92). They support Engeström's (1987) view that since we live in an interconnected world, it is more useful to consider a minimal unit of analysis as two interdependent activity systems. Two interlinked activity systems are, therefore, used to illustrate the contradiction between the SLP (Activity System A) and teacher implementation [transfer] in the classroom (Activity System B) (see Figure 4.9).

Activity System A represents the two-day SLP where the Life Sciences teacher participant is the SUBJECT who was part of a COMMUNITY consisting of the facilitators of the SLP and other teacher participants. The course facilitators used TOOLS such as the Kirby-Bauer technique; IK artefacts; inquiry-based methods involving PBL and CL strategies in order to inform teachers about Ayurveda; resources such as learning guides, textbooks and HIV-test kits; the NOS; and the views of the nature of indigenous knowledge (VNOIK) – all in an attempt to increase their PCK, and an enhanced understanding of IK to successfully implement Ayurveda principles in the CAPS topics – thus forming the OBJECTIVE of the activity system.

During the SLP, certain RULES had to be adhered to as set out by the tenets of the NOS; NOIK; the fundamental principles of PBL and CL, as well as aspects of SDL. The DIVISION OF LABOUR in this activity system was achieved by the SLP presenters who encouraged the participants to use the inquiry-based methods while pursuing SDL to better inform themselves about IK and Ayurveda. This was intended to ultimately lead to the teachers becoming reflective practitioners who would continually refine their teaching practices to enhance learning. The DIVISION OF LABOUR node also refers to the different roles/hats of the teacher (as SUBJECT), viz., the teacher as a facilitator of learning; the teacher as a curriculum designer; the teacher as an assessor; the teacher as a reflective practitioner; and the teacher as an agent of change.

Activity System B is a mirror-image of Activity System A and depicts the actual classroom implementation of techniques learnt at the SLP by the teacher participants whose lessons were observed. In this case, the common feature is the SUBJECT

which remains the Life Sciences teacher, although in this case in the classroom context. The teacher is now governed by a different set of RULES laid down in the pace-setters, curriculum documents, assessment programmes of the school, and the "apprenticeship of observation" described by Lortie (1975) and cited in Mewborn and Tyminski (2006:30). The DIVISION OF LABOUR in the classroom situation is achieved by the need for teachers to 'teach-to-the-test' where lessons centre on training learners to write examinations. The COMMUNITY, in this case, is made up of the school management, other teachers in the Life Sciences department, the community of practice in which the teacher fits, and the Department of Education.

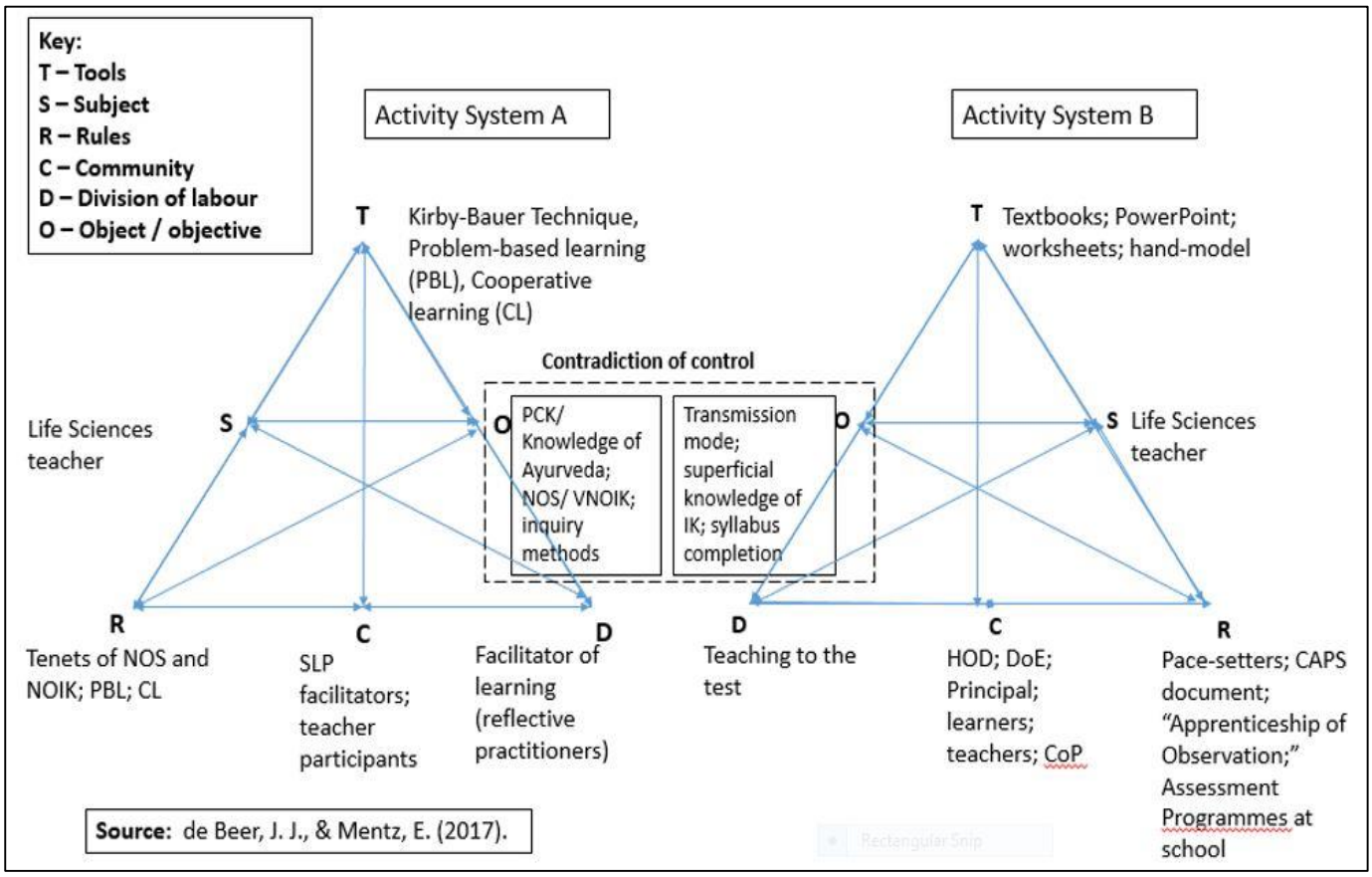


Figure 4.9: Two juxtaposed activity systems to illustrate the contradiction of control between them

TOOLS include textbooks, PowerPoint slides, whiteboard and a hand model as a learning aid in one classroom observation. The hand model was not part of the SLP and resulted from the teacher's own research to enhance the lesson. This shows some SDL, even though this was not an inquiry-based method of learning, s/he merely demonstrated the various hand formations to her learners while pointing out the

different parts of the brain they represented. The OBJECTIVE of Activity System B is the chalk-and-talk method of teaching emphasising syllabus completion, and a superficial knowledge of IK that the teachers displayed.

Comparing the OBJECTIVES in each activity system shows that they are in conflict with each other resulting in a contradiction of control (McNeil, 2013 cited in Mentz and De Beer, 2017:95). The RULES in Activity System B were controlled by the time constraints, the apprenticeship of observation and the rules of the school/department of education where certain topics in the pace-setter had to be reached within a certain time to enable the prescribed assessment to proceed. The NOS and NOIK were seldom included in the lessons observed.

The TOOLS in each activity system point to different objectives: in Activity System A the focus is on inquiry-based learning whereas in Activity System B the emphasis is on completing the syllabus. These show the contradiction of control emerging between the objectives in each Activity System. This contradiction concerns the conflict between the intended outcomes during the SLP for improved teacher development with the actual implementation in the classroom, primarily as a result of the systemic pressures facing South African public schools.

In conclusion, this contradiction of control represents a dissonance between the intended aims of the SLP with the actual implementation in the classroom, brought to light using CHAT as a research lens to analyse the two juxtaposed activity systems. Weaknesses in the Lenasia SLP then served to refine the next cycle in the DBR methodology, which is a SLP developed for Calvinia in the Northern Cape but was not the subject of my study. In other words, gaps in the design for Cycle 1 interventions (viz. Limpopo) were rectified for my study (viz. Lenasia), and which then served to reveal flaws in the design process that were addressed in the next cycle (viz. Calvinia).

4.6.7 Analysis of portfolios from Lenasia participants

Teachers who attended the Lenasia SLP were required to complete portfolios and submit them electronically via email or the E-fundi website. One of the design flaws in the Limpopo SLP was that participants were asked to submit hard copies of their portfolios which may have led to a poor submission rate. Hence, the submission

method for the Lenasia SLP was changed to make it easier for teachers, thereby envisaging an increased submission rate. However, only six portfolios were submitted out of an expected eighteen, which contained ample data from the requisite reflections and lesson plans as specified in the SLP manual. These were analysed to distil three provisional themes:

Provisional Theme 1: Teachers from the Lenasia SLP achieved the incorporation of IK and Indian IK into their lesson plans.

The received portfolios showed integration of IK and Indian IK into the lesson plans, resulting in a few interesting examples. One such lesson plan involved the use of different fruits in an otherwise conventional experiment to show enzyme action in various pH environments. As food combinations were dealt with during the Ayurveda part of the SLP, the teacher showed the learners how proteins can digest faster and more completely when eaten with certain fruit. The lesson plan also provided an explicit link to IK by stating: *Fruits were being recommended by our elders, and were even collected from the wild due [to] there [sic] benefits to our body. The most medicinal component in them is the acids found in them (Thabo; 2013).*

The second ensuing lesson plan, involved a detailed description of the jigsaw method to teach cancer treatment using four indigenous plants. The one challenge encountered in the lesson was that some learners struggled to pronounce the scientific names of the plants. A suggestion, the teacher could ask the learners to use the common names that they are familiar with from their communities, with the scientific names being available for information purposes only.

A second example, also using the jigsaw method, was based on plant anatomy; the teacher used examples of plants both from the CAPS prescribed textbook and from the reference book on IK plants. The second ensuing lesson plan, was on a healthy diet and incorporated aspects of Ayurveda learnt at the SLP: A third portfolio dealt with the topic on plant anatomy in a similar manner where the jigsaw method was used to complete a table as the end-result. In this case, the teacher divided the class into four expert groups, three dealing with a different part of a plant, while the fourth group looked exclusively at indigenous medicinal plants.

Introduction:

This lesson shows us how much Natural Science and Ayurveda agree with each other. They both agree that our human bodies are very active. Our bodies need a huge variety of different nutrients and substances in order to perform all these processes. We obtain these nutrients from the food we eat. The human body needs a balanced, healthy diet to keep functioning property.

Lesson phase:

Let us also bear in mind that every fruit and vegetables has particular healing properties. The fifth principle on which Ayurveda is based is that of Agni (digestive and metabolic fire/energy). Ayurveda places great importance on food and its digestion and proclaims that most illnesses are as a result of poor or incorrect nutrition and digestion. This is the major cause of vitiation of the doshas that ultimately leads to disease.

These teachers mentioned made extensive use of the resources that were given to them, such as the reference book and the resource DVD on Ayurveda that was given to all participants at the SLP. None of the portfolios submitted showed any evidence of using the other resources handed out at the SLP, such as the HIV-test kit.

Since all the portfolios had examples of the infusion of IK and Indian IK, it implies that there was some transfer of knowledge from the SLP to these written submissions. This finding is in contrast to the portfolios from the first cycle (Limpopo SLP) in this DBR methodology, where the researchers De Beer and Kriek (2018?:17) reported that there was very little evidence for the incorporation of IK in the science classroom, to the extent that “where IK was incorporated, the teachers … paid only lip service to it, for example by referring to a few medicinal plants”. Hence, there was an improvement from Cycle 1 to Cycle 2 in terms of the knowledge and skill content of the SLPs which in turn, improved the quality of portfolios submitted.

Provisional Theme 2: Teachers from the Lenasia SLP used inquiry-based methods in their lesson plans to keep their learners actively engaged.

Each of the six submitted portfolios showed use of the inquiry-based methods that were work-shopped at the SLP, confirming that there was some degree of successful

transfer of knowledge from the SLP activities to written lesson plans produced by these six participants. The jigsaw method which illustrates CL; PBL culminating in designing a poster; De Bono's Thinking Hats; and the Kirby-Bauer technique were all incorporated into each lesson plan. Comparing this result to portfolios received after the Limpopo SLP (Cycle 1) (De Beer & Mentz, 2018; De Beer & Kriek, 2018?); there is a marked improvement since none of the Lenasia lesson plans presented traditional transmission-mode lessons. In terms of the DBR methodology, therefore, improvement in this next cycle was noticeable because of the use of these different inquiry-based methods.

One well-conceptualised lesson plan (Task 6 – Lesson plan) exemplifies the use of several inquiry-based methods, making use of De Bono's six thinking hats to teach the topic 'human impact on the environment'. This lesson plan mirrors the activity used in the SLP which showed participants how to use De Bono's Hats to handle controversial topics in Life Sciences involving decision-making. It is a strategy that allows learners to view a situation/scenario from multiple perspectives. At the SLP, this topic was based on whether IK and Western knowledge can co-exist.

The participant designed this lesson plan making use of many inquiry-based methods. Firstly, a case study was presented to the learners containing a dilemma for indigenous people in an area (Mapungubwe National Park). Followed by role-play where the learners were divided into groups and each group represented one of these roles, e.g., National Parks Board representative, farmer's representative. Then each group had to engage in a discussion that supported mining in the national park or not, this used De Bono's Hats. Finally, the outcome of each group's discussion was presented for the whole class to evaluate and decide for or against mining, thereby using CL as well.

Task 6 – Lesson plan
THEME: HUMAN IMPACT ON THE ENVIRONMENT
SCENARIO: THE INFLUENCE OF MINING ON THE ENVIRONMENT AND COMMUNITY

INTRODUCTION: The following topics were treated before this lesson: treating deforestation, desertification, human impact on water quality, food security and loss of biodiversity. Introduce the learners to the activity by reading to them about Mapungubwe National Park (or having them read it aloud as part as English across the curriculum strategy). The activity is attached below.

LESSON PHASE

Give them the instructions and divide them in groups. Each group is given a name, they will be one of the following:

- Representative from National Parks board
- Community /villagers representative
- Mining company representative
- Farmers ' representative
- Department of Arts and culture representative

There could be more than one group representing the same viewpoint.
Each group has to prepare a presentation on their point of view.
After 20 minutes, the groups have to present their present.

CONCLUDING PHASE - The lesson is wrapped up and the different point of views are summarised by the teacher. The learners have to vote who the winning group is.
How to do differently: Give each group member a De bono hat so that they have to give an argument for their presentation.

ACTIVITY (30 min):

1. Read the following case study:

Mapungubwe National Park - Mapungubwe National Park and the surrounding areas are based on big coal reserves. South Africa needs coal to generate electricity and to produce fuel, and there is a pressure to mine the coal fields around the National park and build a power station to generate energy. There is currently an application to establish Vele Colliery to mine coal in both open cast and underground operations, located only seven kilometers away from the National Park. The South African National Parks Board is opposing the development of coal mines and a power station around Mapungubwe.

The mine promised thousands of jobs and what would our lifestyle be without electricity? The neighboring community has few options. Many villagers depend on family members who worked for the National Park or worked on nearby farms. Life is tough here. People get hungry and are sometimes tempted to hunt animals in the National Park for food. But the management of the park holds regular meetings with representatives of the community to discuss their issues.

There are over 400 archaeological sites, with the main sites Mapungubwe Hill, K2 and Schroda. There are 98 rock art sites in the Mapungubwe National Park & World heritage Sites which were painted by the San hunter-gathers and Khoekhoe herder. Large populations of lions, leopards, elephants, cheetah and spotted hyena occur in the area. The permanent pools of the Limpopo offer refuge to crocodiles and hippopotamus and a variety of indigenous fish. Tourist pay fees to visit the park which contribute towards the cost of maintaining the park. There are over 400 species of birds. A well number of preserved fossils, including wild flowering plants and whole bodies of insects were found in the mudstone. *Adapted from EnviroTeach Volume 18 (2009)*

2. Discuss the chosen representative's arguments for his/her case. You need to prepare a presentation on whether you support the mining in the national park or not.

3. Present your arguments to the rest of the class. After all presentations were completed the class will vote on the winning presentation and whether they should go ahead with the mining.

During the reflection part of this portfolio exercise, many teachers commented on how the inquiry-based methods succeeded in engaging learners and helping them to actively learn concepts.

The lesson plan also shows that the multiple methods kept learners actively engaged in meaningful learning throughout the lesson. A teacher remarked: "*Problem-based learning (PBL) is definitely a brilliant approach to use in order to engage learners in their own learning*". The teacher who had submitted the lesson plan on 'cancer treatment' (discussed earlier), commented: "*Learners could interact with each other, discussing nicely during their expert group. This helped to rule out the weak and silent learners because each learner was given a task (theme) to complete or read about hence made the [sic] to be active thought the whole lesson*". Another teacher reflected, "*Learners were actively engaged*" during the activity. These comments speak to the success of the SLP in showing teachers the benefit of using inquiry-based methods.

An observation made in the analysis of these portfolios is the reflection made by one of the teachers on how much time was saved in using inquiry-based methods: "*For my lesson on the musculoskeletal system I used the jigsaw method which was very exciting for the learners and very exciting for me as the educator because I caught up with my pace-setter very fast! I managed to cover a substantial amount of work within these two periods compared to if I had to teach each topic in the classroom*".

Concurring with De Beer and Mentz (2018), if teachers are given the opportunity to compare a transmission-mode lesson with an inquiry-based lesson, they would see that the latter does not take up more time. This teacher's comment indicates that inquiry-based methods can be used under time constraints. The teacher included some pictures which verify that the lesson took place as planned – see Figure 4.10 for a few of these photographs that are reproduced here with the written consent of the learners.

Figure 4.10: Learners engaged in cooperative learning (Jigsaw Activity)

In conclusion, provisional Theme 2 revealed that teachers at the Lenasia SLP were able to devise lesson plans that involved effective use of inquiry-based methods. Those teachers who implemented these lesson plans reported the benefit in saving time and keeping learners fully-engaged during the lesson.

Provisional Theme 3: Teachers from the Lenasia SLP demonstrated reflective practice in their portfolios.

De Beer (2018:2) posits that “research indicates that reflection is essential for teacher professional development (PD)”. The requirement for teachers to become reflective

practitioners was included in Cycle 1 (Limpopo SLP), although De Beer and Mentz (2018:16) report that this did not take place as there was no "evidence of critical reflective practice in their portfolios". It seems, according to these authors, that insufficient guidance was provided to teachers at the SLP to develop the skill of being reflective practitioners. The facilitators for Cycle 2 of the DBR methodology, i.e., the Lenasia SLP, therefore, focused on the participants' reflection. The portfolio also required more reflection but this was structured reflection after each activity.

This revision in the SLP seemed to bear harvest as the six portfolios all had evidence of a more nuanced level of reflection compared to the first cycle. Participants were guided by three questions: "What went well during the lesson?"; "What did not?"; and "How would you approach future lessons differently?" at the end of each activity that they had to complete for the portfolio. The participants were able to describe in detail the reaction of their learners to the lesson as well as what went wrong and how to resolve the issues next time. These questions forced the participants to reflect on their lesson, which they were not usually accustomed to.

Reflections elicited in response to the first question included: "*The learners were very interested and fascinated by the lesson. Especially that they realised that they are familiar with some plants. They also enjoyed the jigsaw method. They were excited about the lesson and realised that Natural Science is more informative and broad than they thought; learners had an opportunity to do experiments. Learners were in high spirits because of the knowledge Ayuverda [sic] brought to them.*" Very often teachers deliver a lesson without giving it much thought thereafter, this exercise helped participants to analyse their lesson and to identify the positive aspects, therefore, promoting learning.

The aim of the second question was to encourage teachers to engage critically with their lesson to identify pitfalls and other weaknesses. One of the teachers wrote: "*Problem-based learning (PBL) was attempted in my lesson on? The impact of exercise of heart rate. Unfortunately, this lesson was unsuccessful in my classroom. Possibly due to the context, learners were never exposed to practical work before I started teaching them so this task was very unsettling and confusing. They could not establish their own ways of exploring the task and looked for structure or distinct*

guidance. I ended up teaching them in groups instead of letting them explore the topic because they absolutely struggled and started drifting from the topic".

However, the participant was also able to offer a possible solution to alleviate this problem in future: "*Maybe as learners do more structured practical tasks they may gain more confidence in exploring ways of doing practical tasks on their own, they need to be taught skills which have been left out by the previous teacher in Term 1. They need to be taught about what controlled, independent and dependent variables are, how and why a hypothesis must be formulated, the different graphs which are used to represent different kinds of data, and how to tabulate results. There are many gaps in their prior knowledge which needs to be identified and bridged before they can attempt problem-based learning (PBL) activities*".

Similarly, reflections from the other portfolios also demonstrated such nuanced levels of reflection and seemed to get teachers thinking about their practice. Ultimately, this provisional theme showed that there was some transfer of information from the Lenasia SLP to the portfolios.

4.6.8 A final analysis of the Lenasia short-learning programme

A pilot study; pre- and post-intervention questionnaires; a SLP; focus-group interviews; class visits; teacher portfolios and individual interviews were the various sources of data that were presented and analysed in Section 4.5 to produce several provisional themes. The use of multiple data-gathering methods established the necessary validity and reliability to ensure a high level of research rigour. These provisional themes were compared with each other to elicit common threads among them and resulted in the 25 provisional themes being distilled into six major themes which form the findings of my study.

Major Theme 1: All teachers who were part of the SLP agreed that the integration of IK and Ayurveda into the curriculum would have significant value for learners.

The SLP was able to provide teachers with a more nuanced understanding of IK and knowledge of Ayurveda. This in turn, showed the participants the positive aspects of IK integration into the curriculum such as: learners in multicultural classrooms might become more tolerant of other cultural groups; the performance of Indian learners

might improve if their own IK is highlighted; and learning about Ayurveda could lead to good health, which prevents diseases rather than treating symptoms as in Western medicine. The teachers agreed that both IK and Indian IK have a place in the curriculum.

Major Theme 2: The inquiry-based and cooperative learning (CL) methods used in the SLP stimulated the teacher participants to aspire towards using them in their own lessons, thereby increasing their PCK for IK integration.

Most of the teacher participants were exposed to the inquiry-based and CL methods for the first time at the SLP, highlighting the existence of a teaching strategy that would enable meaningful learning in their classrooms. The positive feedback at the SLP incorporated wanting to use these methods and once implemented, would increase their PCK. The participants enhanced PCK would subsequently give them more confidence and skills for infusing IK into the lessons.

Major Theme 3: The naïve understanding of the tenets of the NOS and the NOIK of the teachers attending the SLP persisted in practice in the lessons observed, despite them receiving explicit information at the SLP on these two constructs.

Before the SLP, teachers had a poor understanding of the constructs of the NOS and NOIK; there was insubstantial evidence after the SLP from the lessons observed during class visits that this had been sufficiently addressed at the SLP. Analysis of the responses to the pre- and post-intervention questionnaires discussed earlier and represented in Graph 4.1 shows that where 80% of teachers had uninformed (UI) views of IK in the pre-intervention questionnaire, more than 80% had informed (I) views after the SLP (post-intervention questionnaire). In theory, therefore, teachers had more nuanced views of the NOIK after the intervention. Furthermore, the six teachers demonstrated, in their portfolios, that they infused IK in their lesson plans. In practice during the class visits, however, this was not observed.

Major Theme 4: The teacher participants identified an overloaded curriculum and a shortage of time as two of the primary challenges for the integration of IK and Ayurveda into the classroom using inquiry-based methods.

Teachers felt that they would be unable to integrate IK and Ayurveda successfully using inquiry-based pedagogies because of the systemic pressures in school

education. Implementation of the curriculum document (CAPS) is a challenge due to limited time in which a content-laden curriculum must be covered to enable learners to write common examinations, provincially (Grades 10 and 11) and nationally (Grade 12). However, one of the teachers in the study discovered that using inquiry-based methods actually saves time by allowing more content to be covered in this way. This also highlights a design flaw in the SLP that should be addressed in future cycles – an aspect that will be discussed in Chapter 5.

Major Theme 5: The transfer of knowledge and skills learnt at the SLP were not always translated into practice once teachers returned to their schools, due mainly to systemic pressures facing public education in South Africa.

Class visits showed that the knowledge and skills learnt at the SLP were not always implemented in the classroom and the observed teachers, reverted to the traditional transmission mode of teaching. According to these teachers, this was mainly because they felt pressurised to cover content before exams and were of the opinion that inquiry-based methods would be too time-consuming. While at the SLP they indicated there is a place for both IK and Ayurveda in the curriculum, but their lessons showed very little integration of either. The portfolios received however, told a different story, as lesson plans made several references to IK and Ayurveda. There were also interesting lesson plans that incorporated some of the inquiry methods learnt at the SLP.

Major Theme 6: Teacher professional development (PD) courses, such as this SLP, that introduce teachers to inquiry-based methods of teaching do not always succeed in changing the way teachers teach.

Lesson observations, via the method of class visits, revealed that teachers often do not change their teaching methods after attending SLPs because they habitually resort to the 'apprenticeship of observation' (Lortie, 1975). They would imitate the way their own teachers used to teach them when they were at school because this is familiar to them. Inquiry-based methods, on the other hand, are new to them and the participants probably lack the confidence or knowledge to implement them. However, the portfolios showed that teachers acquired the knowledge and skills to effectively include IK in their lessons. One of the limitations of this study, which will be further discussed in

Chapter 5, is that only a limited number of classroom observations were made. I, therefore, acknowledge that generalisations should not be made.

4.7 CONCLUSION TO CHAPTER FOUR

My study set out to investigate the integration of Indian IK (Ayurveda) into the Life Sciences curriculum. Data was obtained from different sources: a pilot study, pre- and post-intervention questionnaires at a SLP, the submission of portfolios by the participants and lesson observations thereafter to evaluate the transfer of knowledge and skills from the SLP. These various data sources gave rise to several provisional themes which were then further distilled into six major themes. Figure 4.11 is a flowchart summarising the different data sources and the provisional themes that emerged from each.

These themes suggested that while all the participants in the study agreed that IK and Indian IK is invaluable and must have a place in the curriculum, many of the participants have an under-developed PCK to teach these topics through integration into lessons. The SLP itself was well-received by the participants but none of the observed teachers were able to put into practice what was learnt once they were back in their classrooms. There was a difference in the submitted portfolios, where evidence was provided of authentic IK inclusion, and the lesson observations made.

Perhaps an alternative to SLPs would yield a more positive response from teachers. An example could be the Ohio Schools Project which was conducted over three years from 1990. Here, teachers' inquiry-based teaching methods were enhanced while providing teachers with "real-world experiences whilst connecting to the environment by providing hands-on practice of science" (Pretorius, 2015:54). In this project, "teachers attended pedagogical workshops introducing them to effective in-class and online strategies, which they integrated with the laboratory experiences, adapting and implementing the curriculum materials to classroom contexts" (ibid). Since this was done over a longer period compared to the SLP, teachers developed problem-solving, rational thinking and note-taking skills which they in turn imparted to their learners. Teachers had an enhanced understanding of science by linking their knowledge with the community – similar to Mode 2 Context sensitive knowledge (Gibbons, 2000).

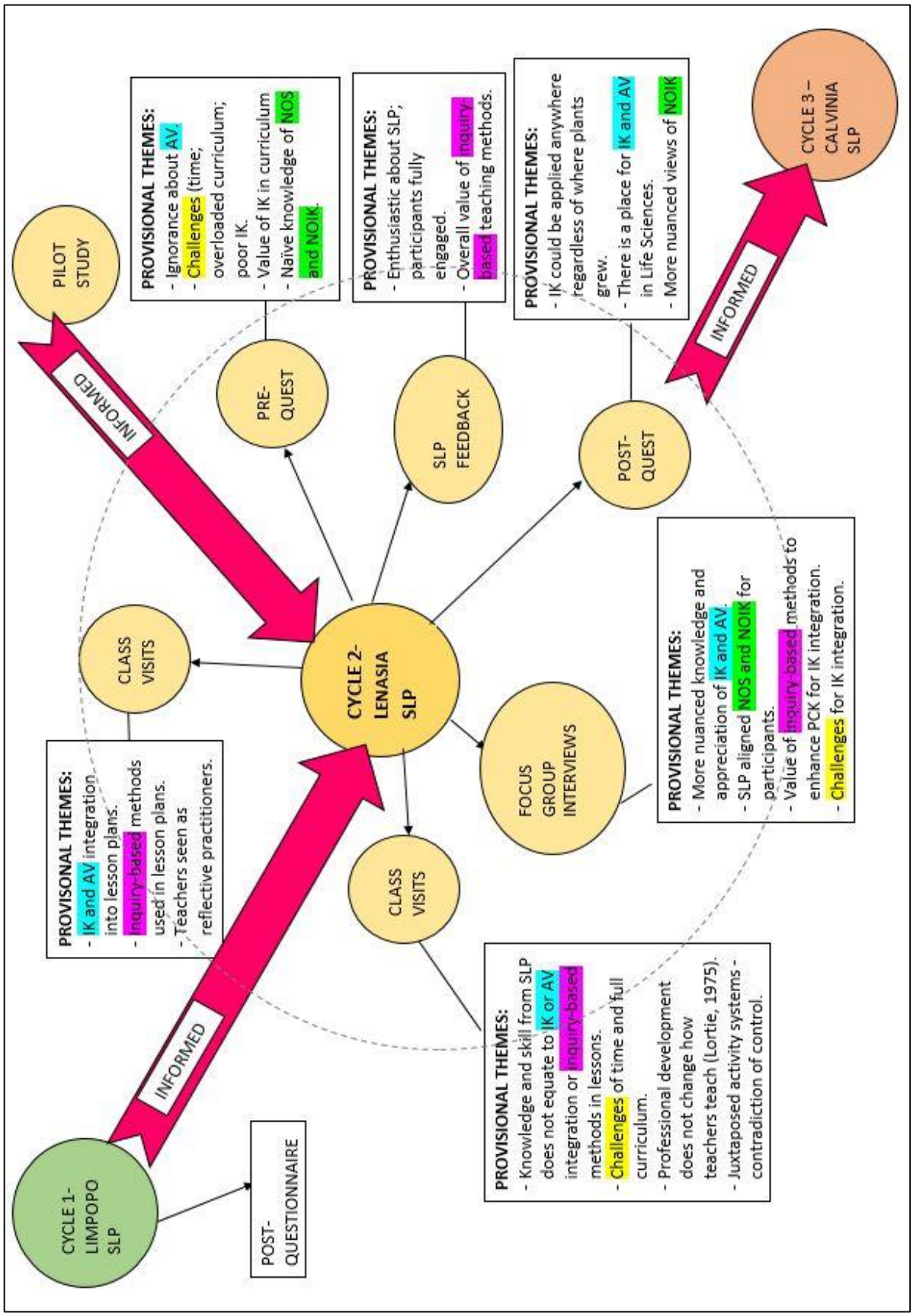


Figure 4.11: Flowchart summarising the different data sources and the provisional themes that emerged from each

Using CHAT as a research lens, two activity systems arose at this point, viz. Activity System A which refers to the SLP, and Activity System B which refers to implementation in the classroom. Since there was a dissonance between the objective of the SLP and the objective during implementation, it created a contradiction of control as there was little or no transfer of information from the SLP to the teachers' pedagogy. Most probably, if the SLP (Activity System 1) was juxtaposed with the portfolios submitted (Activity System 2, indicating an 'envisaged' classroom lesson) there would have been less 'contradiction of control'.

This contradiction can be explained using Lortie's (1975) apprenticeship of observation where teachers teach the way they were taught, through imitation. Zeichner and Tabachnick (1981:7), cited in De Beer and Mentz (2018:7) employ the term "wash-out effect" to explain the reversion to the transmission mode when teachers return to their classrooms and all the skills and knowledge gained at the SLP are abandoned. The primary reason for this appears to be the systemic pressures placed on teachers to prepare their learners to write external examinations by completing a content-laden curriculum within a prescribed time. Teachers are under the impression that inquiry-based methods to integrate IK will take up more time than a transmission mode of teaching and they are not willing to sacrifice lesson time to try learner-centred inquiry-based teaching methods; further reflection on this is in Chapter 5, as it also holds a design principle for future SLPs.

The portfolios, on the other hand, contained lesson plans that incorporated both IK and Indian IK using inquiry-based activities. Teachers also demonstrated that they were reflective practitioners by writing a good account of what they thought and felt about the SLP and the lessons they had planned in the portfolios. Unfortunately, however, these particular lessons were not observed to assess whether the lesson plans were actually implemented in the classroom.

My study is part of Cycle 2 in the DBR methodology which was informed by Cycle 1 and in turn, informed Cycle 3 which will not be dealt with here, though I will reflect on Cycle 3 in the next chapter. In addition, the study is situated under a major research project on SDL, which effective teachers ought to have, to be more informed about topics that are not covered adequately in the curriculum, such as IK.

This concludes the presentation and analysis of data. The next and final chapter will describe the findings, contribution to knowledge, future research, limitations and recommendations from my study. Among others, I will reflect on how the insights of my study have resulted in a revised SLP during Cycle 3 (that took place in the Namaqua district in the Northern Cape).

CHAPTER FIVE CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This research set out to investigate how Indian indigenous knowledge, with a focus on Ayurveda, could be integrated into the South African Life Sciences curriculum. Indigenous knowledge is currently included in the CAPS curriculum but with an exclusive focus on African indigenous knowledge. The rationale for conducting this study was that Indian people make up a significant part of the South African demographics and their indigenous knowledge should also be part of this curriculum. This would also pay justice to the notion of inclusivity and diversity in the country. In doing so, it was envisaged that Indian learners would find Life Sciences more relevant because it contained elements of their own culture; and more importantly, learners in multi-cultural classrooms in South Africa would be introduced to the indigenous knowledge of a different culture, thus fostering tolerance and contributing to nation-building. Several research questions were formulated to guide this study.

1. How can Indian indigenous knowledge systems be integrated into the SA school Life Sciences curriculum?
2. How does the Indian indigenous knowledge system of Ayurveda and Yoga concur with the tenets of the nature of science and the nature of indigenous knowledge?
3. What are Life Sciences teachers' views about the nature of science and the nature of indigenous knowledge?
4. What transfer of Indian indigenous knowledge takes place in schools after the short-learning programme?
5. What are some of the tensions, if any, that arise when Indian indigenous knowledge is integrated into the SA Life Sciences curriculum?
6. What are Life Sciences teachers' lived experiences of participating in the short-learning programme (SLP), and teaching indigenous knowledge in the classroom?
7. What is the role of such an SLP in providing teachers with more nuanced understandings of Ayurveda as an indigenous knowledge system?

Social constructivism provided the over-arching theoretical framework that guided my research; and the data collected was analysed using cultural-historical activity theory (CHAT) as a research lens. The conceptual framework of my study contained various

constructs such as self-directed learning (SDL); embodied, situated and distributed cognition (ESDC); conceptual change; pedagogical content knowledge (PCK); as well as the nature of science (NOS), the nature of indigenous knowledge (NOIK) and how these relate to each other. The notion of conceptual change was discussed in relation to how children could incorporate scientific knowledge into their indigenous or everyday knowledge.

An extensive account of indigenous knowledge generally, and Ayurveda specifically, completed the conceptual framework. To obtain an authentic and personal experience of the ancient science of Ayurveda, one of my promoters and I attended a condensed ten-day course at an Ayurveda hospital in Kerala, India. The course gave us the fundamentals of Ayurveda, which we used to make relevant links to the South African Life Sciences curriculum.

The PCK of teachers with regards to indigenous knowledge and, in particular, Indian indigenous knowledge formed part of the literature review since Life Sciences teachers were the focal point of this research. Since my study forms part of the Self-Directed Learning Research Focus Area at the NWU, the aspect of self-directed learning was a central consideration. In the SLP the facilitators showed teachers how the holders of indigenous knowledge used SDL to survive (De Beer & Mentz, 2018), and that SDL provides, therefore, an appropriate context for an intervention that deals with epistemological border-crossing between indigenous knowledge and Western Life Sciences.

Teachers will need to use SDL when teaching indigenous knowledge to enable them to continually improve their pedagogy and content knowledge, thereby becoming more effective teachers. The concept of ESDC was part of the literature review because the study aimed at a specific cultural group; and children come to school with this embodied knowledge, which can be distributed to others during lessons dealing with indigenous knowledge.

A qualitative design-based research (DBR) methodology, using a short-learning programme (SLP) infused with Ayurveda as an intervention for Life Sciences teachers, was used to gather data.

Focus-group and unstructured individual interviews with the teachers, as well as portfolios and lesson observations, were used to gather data after the SLP. These different data sets were analysed using a coding method according to Saldana (2009), which led to the generation of the major themes that constituted the findings of this study. These themes are summarised in the next section. This summary also indicates how they relate to the research questions.

5.2 SUMMARY OF FINDINGS OF THE STUDY IN RELATION TO THE RESEARCH QUESTIONS

This section provides a summary of how the research questions were addressed by the six major themes that constituted the findings of this study. Table 5.1 provides an overview of this relationship. The research questions appear as row headings and the themes as column headings.

The first major theme identified was: **All teachers who were part of the SLP agreed that the integration of indigenous knowledge and Ayurveda into the curriculum would have significant value for learners**. And that problem-based learning and cooperative learning hold affordances in this regard, addressed the first research question: **To investigate ways in which Indian indigenous knowledge systems can be integrated into the SA school Life Sciences curriculum.** Therefore, this SLP did show teachers that the integration of Indian indigenous knowledge into the Life Sciences curriculum was possible (the result of the Ayurveda studies attended in Kerala, India by my promoter and I). Teachers were then expected to apply self-directed learning principles to enhance what they had learnt during this SLP in order to refine this integration.

Table 5.1: Table showing link between major themes with research questions

RESEARCH QUESTION	MAJOR THEMES					
	1. All teachers who were part of the SLP agreed that the integration of indigenous knowledge and Ayurveda into the curriculum would have significant value for learners.	2. The inquiry-based and cooperative learning methods used in the SLP stimulated the teacher participants to aspire towards using them in their own lessons, thereby increasing their PCK for indigenous	3. The naïve understanding of the tenets of the NOS and the NOIK by the teachers attending the SLP persisted in practice in the lessons observed, despite them receiving information at the SLP on these two	4. The teacher participants identified an over-loaded curriculum and a shortage of time as two of the primary challenges in the integration of indigenous knowledge and Ayurveda in the classroom using inquiry-	5. The transfer of knowledge and skills learnt at the SLP were not always translated into practice once teachers returned to their schools mainly due to the systemic pressures facing public education in South Africa.	6. Teacher professional development courses such as this SLP that introduce teachers to inquiry-based methods of teaching, do not always succeed in changing the way teachers teach.
1. To investigate ways in which Indian IK systems be integrated into the SA school Life Sciences curriculum	√				√	
2. To examine whether the Indian IK system of Ayurveda and Yoga concur with the tenets of the nature of science and the nature of indigenous knowledge.	√		√			
3. To look at Life Sciences teachers' views about the nature of science and the nature of indigenous knowledge.			√			
4. To examine whether the transfer of Indian indigenous knowledge takes place in schools after the short-learning programme?					√	√

5. To identify some of the tensions, if any, that may arise when Indian indigenous knowledge is integrated into the SA Life Sciences curriculum.				√	√	√
6. To delve into Life Sciences teachers' lived experiences of participating in the SLP, and the teaching of indigenous knowledge in the classroom?	√			√	√	√
7. To investigate the role of such a SLP in providing teachers with more nuanced understandings of Ayurveda as an indigenous knowledge system.	√	√				√

Researchers such as Ogunniyi (2004:303); Lelliott *et al*. (2009:56); Yishak and Gumbo (2012:185); and Ngman-Wara (2015:168) support the view that integrating indigenous knowledge into school curricula brings about positive results in learner performance and understanding of science. My study, however, did not focus on learner performance as a result of indigenous knowledge integration, but instead revolved around teacher pedagogy. The data shows that lab protocols such as an adapted Kirby-Bauer technique, problem-based learning and cooperative learning are valuable pedagogies for the infusion of Ayurveda into CAPS themes.

The second major theme: **The inquiry-based methods used in the SLP stimulated the teacher participants to aspire towards using them in their own lessons, thereby increasing their PCK for indigenous knowledge integration**, emerged during the SLP itself when teachers expressed excitement and were enthusiastic about wanting to implement the teaching methods learnt. Their lesson plans in the portfolios submitted incorporated these inquiry-based methods, indicating that teachers were able to devise their own lessons using the skills and information learnt at the SLP.

The third major theme: **The naïve understanding of the tenets of the NOS and the NOIK by the teachers attending the SLP persisted in practice in the lessons observed despite receiving information at the SLP on these two constructs**, addresses the second and third research questions regarding the NOS and the NOIK. Although the SLP included activities that dealt with the NOS and the NOIK, these were not properly transferred to actual lessons observed. However, the portfolios contained

good examples of lesson plans that showed the integration of the tenets of the NOS and the NOIK quite effectively. In principle, therefore, there was positive feedback as evidenced by the lesson plans in the portfolios.

A CHAT research lens was used to identify a few tensions that emerged during the implementation phase after the SLP. This CHAT analysis produced the last three major themes (Themes 4, 5, and 6 and indicated in Table 5.1). These themes spoke to the systemic pressures of time together with an overloaded CAPS curriculum that prevented the integration of Indian indigenous knowledge and the use of inquiry-based teaching methods. Regardless of the methods used during the SLP, teachers observed during class visits reverted to the traditional transmission-mode teaching that they were exposed to as learners. However, as mentioned, there was good evidence of transfer in the lesson plans submitted in the portfolios.

Research Questions 5 and 6 were addressed by these themes. Research Question 5 deals with tensions that may arise during the integration of Indian indigenous knowledge into the curriculum; and Research Question 6 asks about the lived experiences of Life Sciences teachers. Interestingly, as indicated in the literature review, researcher Hsiao-Lin Tuan (included in Abd-El-Khalick *et al.*, 2004) made a similar observation with Taiwanese teachers who felt pressured to complete content for examinations and therefore sacrificed inquiry-based methods for lecture-style pedagogy.

As shown in Table 5.1 and the discussions here and in Chapter 4, my study investigating the integration of Indian indigenous knowledge into the Life Sciences curriculum has addressed the various research questions, although this has not been without shortcomings. The culmination of my study has, therefore, opened the way for recommendations for future studies. These recommendations are dealt with in Section 5.3. In Section 5.4, I briefly reflect on the contribution my study made to Cycle 3 (a SLP in Calvinia, in the Namaqua district in the Northern Cape), although this particular data was not part of my study.

5.3 RECOMMENDATIONS ARISING FROM THE STUDY

The findings from my study have revealed certain recommendations pertaining to the integration of indigenous knowledge, in particular, Indian indigenous knowledge, into the Life Sciences curriculum in South Africa. The recommendations are as follows:

5.3.1 Integrating Indian indigenous knowledge into the curriculum

The present CAPS Life Sciences curriculum requires indigenous knowledge to be included in various topics, but examples provided in CAPS are limited to African indigenous knowledge, at the expense of inquiry-learning approaches and considering the tenets of the nature of science. My study shows that the indigenous knowledge of the Indian minority group in South Africa should also be integrated into the curriculum, especially since this group have a wealth of information that can benefit all learners in the country.

The basic principles of Ayurveda and Yoga have relevance to many topics in the Life Sciences curriculum, as explained in Chapter 2. This relevance was demonstrated during the SLP, thereby guiding teachers in the integration of these aspects into lessons. Perhaps an electronic repository of this type of information should be established, where teachers can post indigenous knowledge exemplars and activities to facilitate the sharing of resources. This would serve as a database of information and resources on indigenous knowledge and Ayurveda that teachers can access to enhance their lessons.

The application of various Ayurvedic principles and regimes can also educate learners for life beyond the classroom so that they can improve their mental, physical and, ultimately, spiritual wellbeing. Parallels between African and Indian indigenous knowledge, especially with regard to the doctrine of signature, make a stronger case for the inclusion of Indian indigenous knowledge into the curriculum.

From a methodological point of view, it would be interesting to examine whether research methods could be constructed based on Ayurveda knowledge or whether this knowledge could be used to re-examine traditional Western methods. According to Singh (2010:92), Ayurveda has been evidence-based “since antiquity” and uses the reductionist nature of conventional science to create “a close and transparent interface

between Ayurveda and contemporary science" (Singh, 2010:94). This author therefore recommends that new methodologies be developed to research Ayurveda such that its basic principles can be used instead of the conventional science strategies.

5.3.2 Inclusion of inquiry-based pedagogy in in-service teacher education courses

Present science teacher education courses need to have greater emphasis on inquiry-based teaching methods to promote more meaningful learning among learners. Most teachers who have completed their training are either not able to implement inquiry-based teaching methods, or seemed not to have learnt it during their studies – this was evident during the SLPs when teachers expressed awe at the cooperative and problem-based learning activities used, and some admitted never to have encountered these before.

These inquiry-based methods need to be explicitly included in teacher education courses so that teachers are confident when applying them to their lessons. This will avoid the tendency for teachers revert to their 'apprenticeship of observation' (Lortie, 1975) where they simply imitate the teachers who taught them as learners.

5.3.3 Explicit inclusion of the tenets of the NOS and the NOIK in the curriculum

The CAPS curriculum should include the tenets of the NOS and, by extension, those of the NOIK explicitly if the Specific Aims of integrating indigenous knowledge are to be achieved. Currently, the CAPS curriculum specifies the inclusion of indigenous knowledge, but does not indicate how this is to be done. If the tenets of the NOS and the NOIK are included in CAPS, it could be easier for teachers to implement.

Explicit rather than implicit inclusion is also more effective as other studies have shown (as discussed earlier). The use of the Kirby-Bauer technique in the SLP gave participants clear insight into how a scientific method could be used in lessons. Positive teacher reactions to this activity showed that they were more convinced about the value of including indigenous knowledge into lessons (traditional plant remedies) since they could prove this for themselves rather than simply reading about it in a book. More such explicit activities should therefore be specified in the curriculum. This

should also be addressed in teacher professional development interventions. SLPs should, therefore, be underpinned by pedagogies that could enhance teachers' understandings of the nature of science.

5.3.4 Shoestring science to be included in teacher education courses

Many schools in South Africa are under-resourced, attested to by teachers at the SLP who complained that the lack of resources impeded their ability to teach effectively. Teacher-education courses should, therefore, train teachers to improvise with cheap, easily available resources from the environment. This is known as 'science-on-a-shoestring' or 'frugal science' (De Beer & Mentz, 2018).

Such an intervention in teacher education courses could contribute significantly to providing teachers with an alternative to using expensive laboratory equipment and chemicals. In this way they could implement inquiry-based pedagogy and the tenets of the NOS and NOIK more readily. Developing teacher agency should, therefore, be a goal of future SLPs.

5.3.5 CAPS to become less content laden and more learner centred

Teacher responses from the SLP showed that the systemic pressures of a content-laden curriculum, insufficient time, and external examinations all impede meaningful teaching and learning. Findings from my study suggest that CAPS should be re-visited by policy-makers to make provision for science teachers to implement more meaningful learning strategies such as inquiry-based methods, as discussed earlier. In a challenging 21st Century the focus in education should be on the development of 21st century skills (and enhancing self-directed learning), and not on transmission-mode education.

The presence of the pace-setter should be used as a guide to syllabus completion, rather than as the primary driving-force behind curriculum coverage. This document forces teachers to merely complete topics by specified dates, without consideration for meaningful learning.

5.3.6 Cycle 3: The SLP in Calvinia (Namaqua district)

The absence of inquiry- and cooperative-learning approaches in the observed classroom lessons during Cycle 2 prompted the SLP designers to consider more effective ways of scaffolding teachers. For this reason classroom action research (CAR) was introduced during Cycle 3. Classroom action research is described by Mettetal (2002) as a midpoint between teacher reflection at the one end and educational research at the other. CAR is more data-based and systematic than reflection, but less formal and controlled than educational research (Gravett & De Beer, 2015). This strategy paid off.

In general, the portfolios received in Cycle 3 were of a much higher standard than those submitted in Cycles 1 and 2. De Beer and Mentz (2018) indicate that teachers were very innovative in the projects and research questions that they engaged in, as part of CAR. Teachers, for instance, facilitated research projects in which learners engaged, for example, in ethnobotanical surveys. Teachers also provided evidence of more nuanced and deeper reflection. One of the teachers reflected in an interview (translated from Afrikaans): *"Despite the fact that I wanted to get hysterical at times about this ethnobotany study, it was also a big highlight. The Grade 10 class is actually a difficult class…..It was amazing for me to see how they cooperate, and how they get excited about it. This gave me pleasure*". (De Beer & Mentz, 2018).

5.4 CONTRIBUTIONS OF MY STUDY

A study of this nature is required to make contributions to the field of research into education, Life Sciences education and the indigenous knowledge project. These contributions are listed and explained briefly below:

5.4.1 Gaps in existing literature addressed – going beyond 'just' African IK

Up to the time of this research being undertaken, none of the literature consulted reflected on the indigenous knowledge of Indian people. There was also no South African study undertaken on Ayurveda inclusion into school Life Sciences curricula.

In addition, the South African context does not include the indigenous knowledge of the Indian minority group. My study showed that there are several reasons why it should be included in the curriculum together with African indigenous knowledge. My study, therefore, contributes by introducing Ayurveda to the literature on indigenous

knowledge, as well as raising awareness that this ancient science has a place in the South African Life Sciences classroom.

5.4.2 Promoting/ enhancing the debate on decolonisation of the South African curriculum

My research began at a time when South Africa higher education students were calling for the decolonisation of the curriculum, and for more prominence to be given to indigenous knowledge. Although this debate was not well conceptualised at the time, it nevertheless drew attention to decolonisation, albeit only to the inclusion of African indigenous knowledge.

My study, therefore, contributes to this debate by presenting an additional dimension – that of the inclusion of Indian indigenous knowledge. The inclusion of Ayurveda into lessons can inform learners that other cultural groups also have their own indigenous knowledge to share, thus contributing to tolerance and nation-building in the country. This is especially necessary at a time when social issues such as xenophobia and race crimes are mounting in the country. Also, my study has highlighted the shared tenets between African and Indian indigenous knowledge, e.g., the doctrine of signature.

5.4.3 Epistemological contribution – the value of including Indian indigenous knowledge systems into the curriculum

My study contributed to an improved understanding of the value of including Indian indigenous knowledge in the curriculum. Teacher participants at the SLP all agreed that indigenous knowledge systems are immensely valuable when included in the curriculum. Of additional significance, is the inclusion of Indian IK into the indigenous knowledge network.

While the value of Ayurveda in the Life Sciences curriculum is limited to the South Africa context in my study, it could perhaps prompt further such studies in other countries. This makes a valuable epistemological contribution since there is now a substantial resource showing how the basic Ayurvedic principles relate to different aspects of the curriculum (see Chapter 2) and the presentation on Ayurveda made at the SLP (see Appendix L). My study also generated four research papers that were

presented at ISTE and SAARMSTE conferences from 2016 to 2018 and these each contributed different perspectives to the field of indigenous knowledge inclusion into the Life Sciences curriculum. (These papers are listed in Appendix M.)

5.4.4 Methodological contribution – DBR and the unique use of CHAT

The methodological contribution of my study is two-fold: firstly, it forms Cycle 2 in the design-based research study, such that the results and shortcomings from the Ayurveda-infused SLP were used to inform Cycle 3 (as discussed in Section 5.4).

Secondly, in the analysis of results, my study was able to use CHAT in a unique manner by juxtaposing two activity systems to compare teacher responses during the SLP with the classroom implementation of what was learnt at the SLP. This approach, advocated by Engeström (1987) and De Beer and Mentz (2018) has not previously been used in post-graduate theses, and provides an exemplar of how CHAT can be used in a more rigorous way. This juxtaposition of two activity systems in this study resulted in a contradiction of control, since the objectives in each activity system were in conflict with one another and led to the identification of several tensions in the activity systems that impeded effective implementation in the classroom.

5.4.5 Practical contributions to teacher professional development

The SLPs in all the teacher interventions in each cycle of the DBR contributed to in-service teacher development, thereby enhancing the PCK of the teachers who attended. In particular, my study was able to raise awareness about the introduction of Ayurveda into the curriculum, a topic that was previously unheard of by the participants.

As explained elsewhere, my study formed Cycle 2 of the DBR process, and extensive resources were produced for teacher development. These included videos that were posted on YouTube showing the processes and reactions of teachers during the various phases of these SLPs. (Links to these videos are included in Appendix N.)

Since my study forms part of a larger research project on self-directed learning (SDL), it also contributed to the aims of SDL by motivating the participants to conduct their own further research to continually improve their PCK and become more effective

teachers. Their engagement as self-directed learners also mirrors the actions of many indigenous people who use SDL to amass their knowledge and impart it to the rest of their community. Thus SDL also contributes by practically demonstrating to teachers how indigenous knowledge has formed over generations.

5.5 THE LIMITATIONS OF MY STUDY

A study of this magnitude is not without its flaws. In hindsight, a number of limitations emerged that could be addressed should the need arise to conduct similar studies in future.

5.5.1 Small number of participants

Although the SLP in Lenasia was conducted with the full permission of the GDE (Gauteng Department of Education), even including officials from the DBE (Department of Basic Education), many teachers were reluctant to attend. The reason may be that the SLP was held during the winter school holiday. Another reason may be that the SLP was initially confined to teachers in Lenasia – in an attempt to attract Indian teachers predominantly.

When we did not get the desired response, it was decided to extend the invitation to teachers from the larger Gauteng area. Hence, the number of participants was smaller (18 participants) compared to the SLPs held in other parts of the country (e.g. Limpopo and Calvinia). There was also a mixed group of teachers from different cultural groups. Ultimately, this proved to be advantageous since Ayurveda was introduced to a diverse group, and it was very well received by all of them. In retrospect, therefore, the SLP should have been open to all teachers from the start and held in a more central location to increase the number of participants.

Even though there was a small number of participants, there was a certain level of data-saturation since they all responded positively to the SLP; all the portfolios submitted showed adequate reflection and use of inquiry-based strategies; and all the lessons observed were devoid of the skills and information learnt at the SLP.

5.5.2 Poor submission rate of portfolios

This was disappointing since, when more than six months had elapsed, many of the participants had not submitted their portfolios, despite them knowing it would have earned them 16 credits. It is unclear why only six teachers decided to submit their portfolios.

Perhaps, in future, the duration of the SLP could be extended to provide teachers with the time to plan or even submit their lesson plans and reflections during the SLP, rather than teachers having to do so long after the SLP ends, and many of them possibly forgetting about it. This is, however, not a problem unique to the Lenasia SLP. According to De Beer and Mentz (2018), the poor submission rate was also encountered during Cycle 1 (Limpopo SLP) in spite of the very positive feedback from the teachers after the SLP.

On a positive note, however, all portfolios submitted exhibited evidence of inquiry-based teaching methods and the integration of Indian indigenous knowledge.

5.5.3 Unwillingness of participants to have lessons observed

The biggest limitation of this study was the small number of lessons that I was able to observe after the SLP. Surprisingly, there was an extremely poor response from participants willing to have their lessons observed. As indicated in Chapter 4, some of the participants who had volunteered at the SLP for lesson observations were unresponsive to communication from the researcher when the time came to have these done.

It is possible that they were under pressure to complete the syllabus and thus unable or unwilling to implement any of the inquiry-based methods learnt at the SLP. The lessons observed did show a lack of inquiry-based approaches and a reliance on traditional lecture-style teaching. Individual interviews with those teachers observed confirmed this. They stated that they were under pressure to complete the syllabus and felt that the traditional style would save them time.

It is, therefore, very difficult to determine the full extent of transfer after the SLP into individual classrooms due to the relatively small number (5) of lessons observed.

In future, it is suggested that class visits be secured by making it a compulsory part of the portfolio for points; or for additional resources to be given to these teachers after the lesson observation. However, this might pose problems with Research Ethics Committees (RECs), as most RECs emphasize the principle that participation in research should be voluntary, and that teachers have the right to participate in SLPs, even if they do not agree to participate in the research agenda.

5.5.4 Longitudinal, systemic interventions vs 'flash-in-the-pan' short-term interventions

After Cycle 1 (in Limpopo) one of the design principle distilled was that systemic longitudinal interventions are needed. The CDE (2011) indicates that short-term workshop-type professional development is not very effective. During Cycle 2 the facilitators attempted to establish an online community of practice, with sustained support to participating teachers from Lenasia. Unfortunately this did not materialise. Although it is a design flaw of the SLP, and not an inherent problem in the design of this study, it did limit the data obtained.

5.5.5 Limitation of solely involving teachers, and not learners, in this study

It would have been valuable to research the affordances of indigenous knowledge in the conceptual development of learners. In this study, several teachers commented that IK could serve cognitive outcomes in the classroom. Although I have provided context in terms of embodied, situated and distributed cognition, which might support such predictions, no actual data supported these claims, as learners were not involved in the study.

5.5.6 Methodology limitations

Questions in focus group interviews were closed ended and needed to be more open-ended so that participants were at liberty to express themselves more freely. In addition, validity of my study could have been increased if the questionnaires were more widely shared among other experts (science educators) who would provide their input into the questions asked.

5.5.7 Disclaimer

Despite the limitations listed above, I am of the opinion that the multiple data sources and triangulation provided 'rich description' (Geertz, 1973) for the study.

5.6 FUTURE RESEARCH

5.6.1 Addressing epistemological border-crossing in pre-service teacher education

One of the avenues for future research should be on the integration of indigenous knowledge in pre-service teacher development programmes using inquiry-based teaching-and-learning techniques. There also exists a need for the explicit inclusion of the tenets of the NOS and the NOIK in these programmes to allow student teachers to develop these pedagogies from the start. This could then possibly lessen the effects of the 'apprenticeship of observation' (Lortie, 1975).

5.6.2 A revised Life Sciences school curriculum

Another avenue for further study could be to revise the content of the current CAPS curriculum for explicit reference to indigenous knowledge, including Indian indigenous knowledge, taking cognisance of the tenets of the nature of science and indigenous knowledge. We need more than 'lip service' to indigenous knowledge (i.e. reference to examples). Rather learners need to engage in the process of science (e.g. the Kirby Bauer technique to test antimicrobial properties of *muthi* plants) thus also addressing the so-called 'scientific method'. Designers of teacher development programmes could work together with policy developers to enable a smooth transition of policy into practice so that the contradiction of control in juxtaposed activity systems can be removed.

5.6.3 More nuanced understandings of the tenets of indigenous knowledge systems

There could be more detailed studies on the parallels between African and Indian indigenous knowledge (and other indigenous knowledge systems as well), to better contextualise the integration of indigenous knowledge into the curriculum. My study hints at the relationship between these two fields of indigenous knowledge in Chapter 2 where there is discussion on the doctrine of signature. A study dedicated to this comparison could prove valuable in cementing the link between them, giving credibility

to the inclusion of Indian indigenous knowledge in the South African Life Sciences curriculum, and contributing to tolerance among African and Indian people.

5.6.4 The affordances of indigenous knowledge for learners' conceptual development and scholarly achievement

In my study, several teachers predicted that a focus on IK would improve the conceptual development of learners, and possibly improve their performance in summative assessment. However, this was not part of my study. For future research, I suggest a study where the focus is on how the infusion of indigenous knowledge in CAPS themes could facilitate conceptual development of learners. 'Controversial conceptual development' might be a more appropriate term in this respect.

According to Piaget and Vygotsky (in Howe, 1996:38), children come into the classroom with their own culture and social background, which influence conceptual change. They also bring their prior knowledge, 'everyday' or spontaneous concepts to school where they have to learn non-spontaneous or scientific concepts. Ngman-Wara (2015:168) indicates that this link between learners' prior knowledge and classroom knowledge results in more meaningful learning since learners try to understand what they are being taught in the context of what they already know. Embodied, situated and distributed cognition (discussed in Chapter 2) suggest that indigenous knowledge holds affordances for the cognitive development of learners. However, most studies done in this field (my own, as well as those of De Villiers (2018), Jacobs (2018) and Cronje (2015) have only focused on teachers' perceptions.

5.6.5 Validating the VNOIK instrument: Rasch modelling

Since the publication of the VNOIK instrument (Cronje *et al.*, 2015) several studies have utilised the instrument to determine teachers' views of indigenous knowledge (Akerele, 2016; De Villiers, 2018; Jacobs, 2018). Due to the number of respondents who have completed this questionnaire, it might be beneficial to engage in Rasch modelling to determine construct validity. This psychometric model, used to analyse categorical data, should be beneficial in identifying items that do not fit.

5.6.6 Researching teachers' engagement in classroom action research

As reported in Section 5.4, CAR was introduced during Cycle 3. It is recommended that a study is conducted on the value of classroom action research on teacher professional development.

5.6.7 The inclusion of yoga in the Life Sciences curriculum

Although my study mentions yoga as a type of Indian indigenous knowledge that could be included in some topics in the curriculum, this was not addressed here. Instead, the focus was almost inclusively on Ayurveda. Future studies could be undertaken in order to explore specific ways in which yoga could become part of Life Sciences lessons.

5.7 CONCLUSIONS TO MY STUDY

My study started with the observation that Indian indigenous knowledge was not included in the South African Life Sciences curriculum. Several research questions were then formulated in order to study the integration of Indian indigenous knowledge into the curriculum. The findings that emerged from this investigation were discussed at length in the first part of this chapter where it was shown that the research questions were sufficiently addressed by the data obtained.

An extensive description of Indian indigenous knowledge as well as explicit links to the Life Sciences curriculum was given in the literature review in Chapter 2. This attempted to fill some of the gaps in the existing research literature on indigenous knowledge. The findings of my study showed that Indian indigenous knowledge was positively received by teachers attending SLPs, but they were unable or unwilling to implement this methodology when they returned to their own classrooms, although the portfolios received did show some integration of Indian indigenous knowledge into their lessons. By using two juxtaposed activity systems, it was shown that systemic pressures in the South African education system were a stumbling block to actual implementation. Together with this, the lack of resources in many schools and the under-developed PCK of many teachers prevented them from improvising with more readily-available resources from their surroundings. The juxtaposed activity systems also highlighted design flaws in the SLP.

My study also showed that many teachers do not change the way they teach simply by attending a once-off SLP. In addition, professional development courses should include more explicit teaching methods for inquiry-based teaching; the tenets of the NOS and the NOIK; and indigenous knowledge itself. This would lead to a more nuanced application of what was learnt during the SLP. During the SLP, teachers were also encouraged to embark on SDL in order for them to teach more effectively. Teachers should also become more reflective as practitioners if they want to make science learning more meaningful for their learners.

5.8 MY REFLECTIONS AS A RESEARCHER

It is necessary for me to include a section in this chapter on my own reflections as a researcher and a Life Sciences teacher, since one of the principles of my study is that a good teacher ought to be a reflective practitioner. Apart from the findings gathered from my study and the epistemology generated as a researcher, my own knowledge and skills as a Life Sciences teacher have improved with regards to concepts such as the NOS and the NOIK, and indigenous knowledge itself.

The extensive reading into social constructivism and activity theory allowed me to understand these models more clearly, which enabled me to apply them as the over-arching framework in my study on Indian indigenous knowledge. In addition, I needed to conduct detailed research into all the intermediate concepts making up my conceptual framework. This enabled me to gain a deeper understanding into concepts such as SDL which was new to me, but which made a great deal of sense once I could relate it to indigenous knowledge. It also linked very well to other concepts of the NOS and the NOIK, especially where these could be taught using inquiry-based techniques. These concepts all seemed to be interconnected and were relevant to my study on Ayurveda, which also dealt with holistic treatment and wellbeing.

In addition, as a researcher, the methodology used in this study introduced me to design-based research, a concept that was new to me. This study, therefore, necessitated a wide reading on this methodology to give me a clearer grasp of how my study formed an important part in a larger project. It also made me see that my study with the SLP in Lenasia had much room for improvement and that this could be made in Cycle 3 of the longer DBR study. I realised, therefore, that there was

opportunity for more immediate modification of weaknesses from one study to the next in a DBR methodology. My domain as a researcher was also expanded immensely by providing me with the experience of writing and presenting papers at conferences.

A poignant reflection for me as a South African Indian was the research I did on the indentured labourers who were my forefathers. Although I had a basic knowledge of how I came to be in South Africa as a fourth generation Indian, I had never previously delved into these details to such an extent. Conducting this study made me feel closer to my roots and gave me a greater understanding of why so many Indians decided to stay on in South Africa, as well as the struggles and hardships they had to endure in order to establish themselves in their new country. This gave me a newfound appreciation of my forefathers and the phenomenal successes achieved by the Indian people in South Africa since then.

Of equal significance to me was the incredible journey I took to India with one of my promoters to learn about Ayurveda. This was truly an unforgettable experience. There I learnt about Ayurveda while being completely immersed in an environment in which this ancient science originated. Not many post-graduate students experience learning a new topic or field with their promoter and I feel proud and honoured to have been able to do so. Learning about Ayurveda itself was insightful and I felt that I learnt much more from the course in India than I would have reading about it in books. The Ayurvedic doctors who taught us provided a new dimension to this knowledge since they also shared their own experiences – something not available in books. Learning Sanskrit terms during this visit was a remarkable learning experience in itself, and one that I thoroughly enjoyed. Books would have been unable to provide pronunciations of these terms given by the doctors, making the experience in India more rewarding.

I was also able to make several links between what I had learnt in India to what I was exposed to growing up in an Indian home in South Africa. I realised that most of the practices inculcated in me by my grandparents, specifically, were actually Ayurvedic practices. I now understand their reasoning, rather than viewing these practices as superstitious beliefs imposed on me by the older generation.

This study gave me greater insights into improving my practice as a Life Sciences teacher. I realised that inquiry-based methods can actually save time in the race to complete the curriculum and that traditional methods can be replaced successfully to enable meaningful learning. As a teacher myself, I was also of the opinion that the former pedagogy was more time-consuming than the latter, and I was reluctant to use it. However, after conducting this study and looking at some of the portfolios received, it is evident that inquiry-based methods may achieve more success in Life Sciences among learners.

Based on my reflections, it is evident that this study allowed me to develop on different levels: as a researcher; as a Life Sciences teacher; and as a South African citizen of Indian origin.

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APPENDICES

APPENDIX A: AYURVEDA CERTIFICATE FOR RESEARCHER AFTER COMPLETION OF THE COURSE

VAIDYARATNAM
AYURVEDA FOUNDATION

'CENTRE OF EXCELLENCE IN AYURVEDIC MANAGEMENT OF CHRONIC JOINT DISORDERS'

Recognized By: Ministry of AYUSH, Govt. of India

An Academy for Ayurvedic Studies

Thaikkattussery, Ollur, Thrissur - 680 306, Kerala, India

Awards this certificate to

CAMANTHA REDDY

in recognition of successful completion of

'AYURVEDA AWARENESS PROGRAMME based on ASHTAVAIDYA TRADITION'

during the period from 10th April 2017 to 21st April 2017

Dr. Sudeesh Kumar S.
Course Director

Prof: Dr. K. Muraleedharan Pillai
Medical Director

Ashtavaidyan E.T. Narayanan Mooss
Managing Trustee

APPENDIX B1: GENERIC ETHICS CERTIFICATE

NORTH-WEST UNIVERSITY
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Private Bag X6001, Potchefstroom,
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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 B2: ETHICS CERTIFICATE FOR THIS STUDY

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

Fakulteit Opvoedkunde / Faculty Education
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Suid-Afrika / South Africa 2520
T: 018 299 4656
F: 086 661 8589
http://www.nwu.ac.za

16 October 2018

To Whom It May Concern

I hereby confirm that the ethics application, as stated below, was approved at the Ethics Committee meeting of the Faculty of Education of 26 July 2018.

Ethics number: NWU-00358-18-A2

Project head: Prof JJJ de Beer

Project team: C Reddy, Dr N Petersen

Title: The integration of Indian Indigenous Knowledge into the SA Life Sciences curriculum

Period: 1 June 2018 – 1 June 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

APPENDIX C: PERMISSION LETTERS

NORTH-WEST UNIVERSITY
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School for Natural Sciences and Technology for Education
Tel: 018 285-2626
Email: josef.debeer@nwu.ac.za

8 June 2017

Mr HM Mweli

Director-General of Basic Education

222 Struben Street

Pretoria

0001

email address: mweli.m@dbe.gov.za

Dear Mr Mweli

INDIGENOUS KNOWLEDGE COURSE FOR LIFE SCIENCES TEACHERS

I trust that you are doing well! Camy (Reddy) is registered for her PhD degree at the NWU, and the focus of her studies is on how we could infuse Indian indigenous knowledge into the teaching of CAPS Life Sciences. In an educational era where the 'decolonisation of the curriculum' or the 'Africanisation of the curriculum' receives a lot of attention, it is important to not only consider indigenous knowledge from an African perspective. South Africa, often touted as a Rainbow Nation with its diverse cultures also has a large Indian population, with their own rich indigenous knowledge system, notably that of Ayurveda, an aspect not previously considered as warranting integration into the South African Life Sciences curriculum.

Camy and I embarked in April 2017 on a two-week long course on the basic principles of Ayurveda, offered by the Vaidyaratnam Ayurveda Foundation in Thrissur, India. We have infused these insights into a three day Life Sciences courses (accredited, and worth 16 credits, provided that the teachers submit an evidence-based portfolio). The short course shows teachers how IK can be implemented in the CAPS curriculum, utilizing the processes of science. (For example, teachers engage in an adapted Kirby-Bauer technique in the laboratory, testing the anti-microbial properties of muthi plants). The NWU has offered this 3-day course since 2016, and we have received excellent feedback from both teachers and subject advisors. (We offered the course in May to teachers in Kimberley, with the help of Mrs Ria van Wyk). If you click on the following link, you can watch a short 10 minute video on the IK course: https://youtu.be/hrA3_MpsA2Q

Camy and I would like to offer this course to Indian teachers in the greater Johannesburg (Lenasia) area, and to other (non-Indian) teachers who might also be

interested. The course normally costs R4000 per person (teachers also receive resources for their classrooms), but due to sponsorships that we have received from the NRF and the Fuchs Foundation, we can offer it free of charge. However, in order to warrant this expenditure, we need at least 15 teachers who enrol for the course, and the maximum number of teachers that we can accommodate is 40. We would appreciate it if you could kindly assist us in this regard. Teachers who register (since it is a 16-credit course, teachers will receive NWU student numbers) will receive the following (free of charge):

- A learning guide
- A resource CD with short videos and learning resources
- A book, Medicinal Plants of the World (A Briza publication, full colour, with retail value of R 500)
- Somerset science kit for their classroom
- Two days of lectures and practical work, with lunch daily.

We are hoping that we can conduct this training from the **3-4th July 2017** at a school in Lenasia so that it is convenient for the teachers attending. We would appreciate your help in arranging for teachers to join in and benefit from this training.

Thank you in advance and looking forward to hearing from you!

Kind regards

(Prof) Josef de Beer

Original details: (22024042) C:\Users\22024042\Desktop\KANTHAN- INDIGENOUS KNOWLEDGE COURSE FOR LIFE SCIENCES TEACHERS.docx
26 May 2017

NORTH-WEST UNIVERSITY
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School for Natural Science and Technology for Education
Tel: 018 285 2626
Email: josef.debeer@nwu.ac.za

24 July 2017

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 and Life Sciences teachers recently attended a short course that the North-West University Potchefstroom Campus developed on infusing indigenous knowledge in the teaching of the Curriculum- and Assessment Policy Statement.

In order 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 study 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.

Yours sincerely,

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24 July 2017

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 and Life Sciences class that your child attends has 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.

We would appreciate your consent that we could do these observations, as this research project aspires to assist teachers in making the teaching of Natural and Life Sciences more meaningful for children. You are more than welcome to contact me, if you need more clarification.

Yours sincerely

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 D: LIMPOPO SLP POST-INTERVENTION QUESTIONNAIRE

Data from SLP in Limpopo (27-29/06/16) CR

Coded ✓

5. Would you say there is a place for teaching of IK in Life science classroom?

1	2	3	4
1	5	24	32
1.64	8.20	39.34	52.46

7. Did this short course change your views on the use of cooperative learning methods in the Life Scienc

1	2	3	4
0	2	23	37
0.00	3.28	37.70	60.66

8. Did this short course change your views on the use of problem-based learning methods in the Life Sci

1	2	3	4
0	3	34	25
0.00	4.92	55.74	40.98

1 – No

2 –

3 –

4 – Definitely Yes

- emphasis on Q^L data.
- mixed methods (sequential design) - Cresswell
- generic Q^L design
- Methodology:

Analysis of Data:

- Saldana: codes
  code, code > category
  code, code > category
  } theme.
- need 3–4 themes for study
- every theme needs to be supported by data.
- need strong conceptual framework + literature
- use Abstract as a starting point.

Q1

4. How would you describe indigenous knowledge?

Is a knowledge based on culture that was not based on medical test but proven to be working. It was used by our fore-fathers.

It's cultural or traditional knowledge of certain people or group.

Traditional way of getting knowledge.

Indigenous knowledge refers to the use of previous knowledge/ traditional way of doing things with the help of knowledge learned from the past.

Begin knowledgeable about different plants, materials, methods and rituals of different cultures and what qualities they have that can be helpful to modern society.

Is the knowledge of certain people about their earth, it is a way of life and it really shows how they relate to the earth and thing (living both plants and animals around them).

Information gathered by inhabitants of a particular area, that information is gathered though in Interactions between inhabitants and the environment.

Knowledge from our forefathers where in it helped then survive different life threw at there. It is passed from generation to generation.

Knowledge through which learners learn by acquiring what is imported from elders that was learnt through discoveries, viewing.

Indigenous knowledge is about development of traditional and cultural activities.

Our cultural and traditional activities, to gain knowledge.

It help me with the knowledge of the nature. It help more knowledge about their using natural science.

The way indigenous products where used by human being who lived many years before present and how this knowledge can be used in the classroom situation.

Knowledge passed on by our ancestors through generations.

The knowledge that or elders has acquired in the long years back.

A knowledge that comes from different localities. It goes hand in hand with the belief and religion.

Very useful knowledge that one need to bridge between mortal science and western science.

Is the local knowledge that is unique to a given culture or society.

It is the knowledge acquired naturally in our life.

Indigenous knowledge is about understanding how our forefathers maintained their lives through their activities and practise.

It is a knowledge that is used in a particular community or internationally. It can be localised or also nationalised.

Knowledge of applying science in a natural way.

Is the local knowledge that is unique to a given culture or society.

It is the way in which old people use to do things which is passed from generation to generation.

Knowledge developed from the interaction amongst the environment and the people for survival.

As the knowledge of various cultural groups' way of training and where their procures are and how they are related to science education.

Knowledge that is specify to a certain community.

It is knowledge from interaction and experiences with natural resources and that helps to construct or build what human beings requires to make their lives easily but without putting or giving a negative impact to the natural resources.

Knowledge gained from past generation which is gained through experience, rather than formed education.

It is knowledge that is specific to a certain community or society. Knowledge that hardly changes.

Knowledge used by people in the past to heal diseases using natural plants.

It is a way of knowing things by not using scientific methods, but beliefs, supernatural power and/or being gifted from their ancestors.

Q2

5. Would you say there is a place for teaching of IK in Life science classroom? Motivate your answer.

Indigenous knowledge does not evolve and materials are ~~really avoidable~~ readily available and cheap.

If it was recorded, it would then be taught very smooth. — challenge

Most leaners 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.

Learners learn best when they can relate to the content being learnt.

There are indigenous activities not taken into consideration.

It helps the learners. — how?

So that this local knowledge be in practice it become meaningful in our daily lives. how?

Environmental studies. — ??

Most chapters e.g. Plant growth hormones need the infusion of indigenous knowledge. Link to LS ©

Integrating life science will give best results.

Because in term 4 life. Science we deal with environmental studies.

I don't believe one should incorporate IK in every topic. It should be used as a perspective to keep learning interesting.

Relevant to daily life.

Occasional use of IK [O]

Life science in the classroom is taught based in CAPS. It should be catered for first in CAPS curriculum.

When teaching grade 12 learners evolution. One will have to talk also about fossils.

Learners need to understand more about IK as it is related to the natural life things around the universe.

No. some believe it is witchcraft and do not believe it.

This will make learning easier.

It has myths and unpredictable, where science is pure.

Learners need to understand how things came about, without applying western science.

Learners mostly do not relate with the scienctific knowledge so IK will contribute to their learning process.

Life science is something tangible.

Learners will understand better with this type of knowledge.

IK can only be incorporated into some science chapters.

It is not everything that can be introduced in the class, e.g. some plants are not found in other areas.

The other information in contrary to the rules and regulations of God our Creator, our Father, for example Jesus Christ heals. Other people uses antichrist believes. So it does not fit into Christianly.

Most of IK go hand in hand with our curriculum.

Make science more interesting.

Fusion of content and relevance to society.

Knowledge will not die and will be transported to the next generation.

Everything from IK cannot be involved, since we no longer have elders who know that.

Yes, because in the classroom we can use chemistry for testing those plants or medicine.

There are indigenous tree in out garden where learners can experience.

IK is what they experience in their daily live.

Because IK deals more on nature of science, of which do not supported by opinions.

Learners may understand better if they hear what they have heard from their elders.

It bridges the gap between the west and local community.

Time allocated for a period in school.

Using indigenous plants & animals as resources materials in a classroom.

It will help out learners to know that there is nothing different between what they are doing at home to cure diseases what they are what is done in the laboratory.

When learners learn from their environment, learning becomes meaningful.

Relevant for CHAT - tensions

Q3

6. What are the difficulties that you anticipate in teaching indigenous knowledge in your lessons?

I

Learners being not interested with the topic, some feel out of space as it will sometimes talk about witchcraft. Some feeling shy because their parents grandfathers practicing it. PS

Different belief systems might bring a lot of misconceptions when dealing with this topic.

Now I don't see any difficulty after this short course.

Misconceptions, religion, believes and origin of human.

Confusion because most of the time it encompasses knowledge known within a community and that knowledge may be known only to tribal elders or people from the rural areas.

The indoctrination and the fact that most learner are made to believe that IK entails witchcraft and other myths. PS

We are a diverse nation and you find that different places differ so this makes it a little difficult.

Cultural diversities might disadvantage or advantage others. Whose IK?

It is because of lack of recourses.

When we teach learners those knowledge it helps a leaner not to discourage about things that comes with nature. ?

It is not documented and thoroughly researched. lack of info.

Attitude of learners.

Where sometimes examples are given, other plants cannot be accessible. local K

Teaching IK need one to have a sound knowledge of culture and traditions of people of IK for the practical implementation thereof. SDL - T is to L on own.

Reference is the difficulty, something we have been only told and have never experience or seen before. ?

There are learners from various cultures in our school, I think it will be difficult to find a common ground in incorporating IK. Although I don't think this problem cannot be overcome. Incorporation of IK will be perfected with trial and error.

Learners were told different from their respective home. As a teacher, you first have to clear the myths and misconception about IK. Cultural background - ascertain prior K

Learners have never been exposed to that before and moreover is not in line with the CAPS policy document. mis

None being well conversant with the part of interest to be used in the lab.

Due to the religion background teaching IK in my class is not that easy. Beliefs.

Learners may not be open and free enough to communicate what they've been taught by their elders before. Inferiority alt own culture.

I have never taught IK. PCK

Some of learners are not familiar to the IK. They don't understand the cultural part of the lesson.

Learners may ask questions what the teacher mat not be able to response to.

It will need a lot of time to prepare for it and to do some research in t.

Some of the teaching aids will not be available.

When elderly people may not be willing to share. Conflict in religion as some things are confidential when research.

Learners of today are difficult to accept theory explanation. They want proof and answers so I have to answer many questions.

The resources to use or demonstrate in classroom while teaching this IK.

None, there things is that I never thought of it, but as from now on I will definitely use IK in my classroom.

Learners may not be interested.

Learners do not have much knowledge of IK from the community.

The kind of assessment used is common this doesn't include IK. Doesn't allow learners to apply what they have learned in the classroom then the approach becomes meaningless.

7. Did this short course change your views on the use of cooperative learning methods in the Life Science classroom? Motivate your answer.

It nearly incorporate the past and the presence practice of science.

Methodology of grouping learners, case I just let learners group themselves.

I learned new strategies that I saw are effective and I will use.

It changes because all along I did not involve learners directly.

Cooperative learning is just not only about people working in groups. The participant interdepend ently.

It help all learners to participate in the classroom.

Help learner's different abilities to understand all levels of topic in classroom.

I will be able to us IK to enhance the understanding of the learners.

Team work is mostly productive because opinions came from different learners in a group.

I will definitely use cooperative learning strategies.

With cooperative learning can share ideas, clear misconceptions and help them understand content better.

I gain more on how to use cooperative learning methods. I will apply it to my lessons.

Yes → As long as it is applied in the class to suit their learning programme.

Q4

SDL - relevance

15. Based on your experiences these three days, is it necessary for you to formulate any professional development goals for yourself? (e.g. did you identify any knowledge- or skill gaps that you would like to address in the following themes?)

Themes/category	No development goals – I do fine:	I identified the following professional development goals:
Knowledge on IK systems. Valuing IK (7) V B I Imp C SL MC		Valuing the IKs in the curriculum. V Knowing the content. K Initiate IK in my teaching. I I would like to learn more! ↑L Knowledge of IK from other cultures. MC I didn't know that we can in cooperate that in the classrooms to add meaning to the lesson. Learners should firstly acquire this knowledge in a community. – SL I really need to do some research on IK and learn a lot because those is more to reach. R There is still more to be learnt. Our curriculum must make room for IKs. C I've developed an understanding in the IK. B One can never know enough. – R
Lab/Tring Skills (6) obs M Eq SM Grp Safety	Plants – old K Plants – Artefacts Plants	Bridging the gap between traditional herbs and western medicines. G The way in which our forefathers lived practises and activities. G Plants that can heal diseases that I wasn't in the know of G Pottery making, African Beer creativity. G No identification on professional development. This is a gap, workshops such as this can make a difference. B Identifying different plants and their functionalities. G
Own L'ing: (3) K ↑L R		Integrating IK with scientific process in my classroom. I Find out about more in my area. ↑L Linking class activities to home and communities. I
Gaps in SLP: (2) NL G	Plants	Wend definitiewe pogings aan om te sien of dit iewers in die sillabus inpas. The importance of including indigenous knowledge in class. I Knowing more plantations that could replace traditional p. sciences lap apparatus like (indicators) and organic compounds.

Q4 MU & Themes

Laboratory skills (anti-microbial activity lab)	I do fine.	Conduit and carryout the experiment effectively. The approach is very good. Improvise for enhance learners activities. Observation skills. I would like to learn more. Laboratory skills, microbial activities. Using lab equipment. I need so assistance going forward. In our school we do not have lab of that standard. I firstly need to understand and do more research on it and also prepare myself or know the content subject deeply by reading further so I can use this method. We need labs at our schools and to pies which involve this on our curriculum. Being able to formulate hypothesis and stick to the procedure for them to be reliable. How to handle some lab equipments. Conducting experiments. Anti-microbial that kill the bacterials. Handling of apparatus, observational skills, group work/socialize. Observation, experimenting and get more data. Safety be infused. Begroting en veiligheid is 'n probleem. Kombinasie met videoclips + elementêre prakties. Some bacteria cannot grow in small space. Perfecting experimental solutions.
PBL approaches		How to approach a problem without difficulties. Prepare learning activities differently. De Bono's hats. Working together and sharing ideas with other teachers. There is room for improvement. To use it in order to let learners learn to do things for themselves and be responsible. You need to make a combination of smart and slow learners. As educators we need more training in order to implement the approach thoroughly. Know how to pose questions that will identify areas of focus for learners. Writing a report to report on scientific research. Guiding learners in approaches. Student centred. Designing rubrics and experiments for learners. Very goods methods of learning were learners come up with solution. A lot was learned & it will be applied.

APPENDIX E: PILOT QUESTIONNAIRE

PILOT STUDY – QUESTIONNAIRE – INTEGRATION OF INDIAN INDIGENOUS KNOWLEDGE (IK) INTO THE SOUTH AFRICAN LIFE SCIENCES CURRICULUM:

1. How many years have you been teaching Life Sciences for?

2. Are you CAPS Trained for Life Sciences FET phase?

3. How do you see Indigenous Knowledge?

4. Do you think there is a place for Indigenous Knowledge Systems in the Life Sciences classroom?
   4.1. Why/Why not?

5. Have you ever incorporated Indigenous Knowledge into your Life Sciences lessons?
   5.1. If so, explain what pedagogy you will use when teaching Indian indigenous Knowledge. E.g. When looking at Indian medicinal plants, a teacher might decide to engage the learners in chromatography or in using agar plates to test anti-microbial properties.

6. What are your views on the teaching of Indian Indigenous Knowledge amongst Indian learners in South Africa?

7. The Life Sciences CAPS document states that the examples of IK chosen "for study should, as far as possible, reflect different South African cultural groups" (DoE, 2011:17).
   7.1. Are you in a position to implement this requirement?
   7.2. What problems do you experience when implementing this requirement?

8. What do you know about Ayurveda?

9. Would you say there are any links between the current Life Sciences curriculum and Ayurveda?
   9.1. Explain further.

10. How do you think the performance of Indian learners who learn about Indian Indigenous Knowledge would be influenced compared to those learners who do not learn about it?

11. What do you understand about the Nature of Science (NOS)?

12. Do you see any difference between the NOS and Ayurvedic principles?
    12.1. Please explain your response.

Thank you for your time and effort, it is sincerely appreciated!

Your name: _____ (optional)

Functioning Email address: _____

School Name: _____ (optional)

APPENDIX E 1: ONE OF THE RESPONSES TO THE PILOT QUESTIONNAIRE

(7)

QUESTIONNAIRE – INTEGRATION OF INDIAN INDIGENOUS KNOWLEDGE (IK) INTO THE SOUTH AFRICAN LIFE SCIENCES CURRICULUM:

1. How many years have you been teaching Life Sciences for?

   28 years

2. Are you CAPS Trained for Life Sciences FET phase?
   Yes

3. How do you see Indigenous Knowledge?
   This refers to knowledge systems peculiar to the different cultural groups IK-

4. Do you think there is a place for Indigenous Knowledge Systems in the Life Sciences classroom? Yes

   4.1. Why/Why not?

   There is definitely a great deal to be gained from Indigenous Knowledge systems. We have multicultural classes. Learners and educators can learn from one another and hence respect one another's cultures C

5. Have you ever incorporated Indigenous Knowledge into your Life Sciences lessons? Yes

   5.1. If so, explain what pedagogy you will use when teaching Indian indigenous Knowledge. E.g. When looking at Indian medicinal plants, a teacher might decide to engage the learners in chromatography or in using agar plates to test anti-microbial properties.

   IIP Examine different herbs and bulbs and draw on uses made of these. The medicinal and health advantages of using herbs and other storage organs e.g. ginger and garlic have long been known to the different cultural groups

6. What are your views on the teaching of Indian Indigenous Knowledge amongst Indian learners in South Africa?

   C
   It is an excellent idea, since learners will understand and appreciate their rich cultural backgrounds. The knowledge gained can be used in daily life. Many Indian learners do not have any idea or very little idea of their culture A

7. The Life Sciences CAPS document states that the examples of IK chosen "for study should, as far as possible, reflect different South African cultural groups" (DoE, 2011:17).

   7.1. Are you in a position to implement this requirement? Yes PCK+

   7.2. What problems do you experience when implementing this requirement?

   ESDC
   The knowledge that learners bring into the classroom have meaning for them alone. We have learners from different backgrounds so this is something that we have to take into consideration when teaching IKS PCK+

8. What do you know about Ayurveda?

   Type of healing system and a way of life that originated in India IK-ve

9. Would you say there are any links between the current Life Sciences curriculum and Ayurveda?

   9.1. Explain further. yes

   IKS are used in both PCK-

10. How do you think the performance of Indian learners who learn about Indian Indigenous Knowledge would be influenced compared to those learners who do not learn about it?

    Both groups would benefit but Indian learners may be more advantaged because of their prior knowledge albeit not so much ESDC

11. What do you understand about the Nature of Science (NOS)?
    The NOS refers to ideas, principles, theories and laws that describe science mis NOS

    2 diff. types of K.

12. Do you see any difference between the NOS and Ayurvedic principles? Yes

    12.1. Please explain your response.

    NOS is based on scientific principles misNOS-

Thank you for your time and effort, it is sincerely appreciated!

APPENDIX F: PROGRAMME FOR THE LENASIA SLP

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

APPENDIX G: PRE-INTERVENTION QUESTIONNAIRE – LENASIA SLP

Addendum

PRE-QUESTIONNAIRE RESPONSES – LENASIA:

[23 participants attended the SLP, 15 pre-questionnaires received]

1. How many years have you been teaching LS for?

Lee-Anne: 4
Phindile: not yet in practice – student teacher
G: 12
Olehile: 22
Andries: 8
Tracey: 20
Princess: 6 months
Abigayle: 4
Muzz: 6 months
Whitney: 2
Samuel: 23 years
Ilze: 3 months
Jessie: 24
Mota: 5
Buhle: starting on 25/07/2017

0-23yrs.

2. Are you CAPS trained for LS FET phase?

Lee-Anne Rautenbach: Yes
Phindile: yes
G: Yes
Olehile: yes
Andries: yes
Tracey: yes
Princess: no
Abigayle: yes (university based)
Muzz: Yes
Whitney: yes
Samuel: yes
Ilze: using a Platinum (CAPS) but not trained
Jessie: yes
Mota: no
Buhle: yes

12/15 CAPS Trained

3. Do you think there is a place for IKS in the LS classroom?

Lee-Anne: Yes, as part of the botany section to enhance exposure P

Phindile: definitely, this is where decolonisation can first be achieved in curriculum/ through curriculum. D

G: Yes, it contextualises content, making it relevant to learners. C

Olehile: there is a place, but very minimal. Some teachers don't even cover section on IK

Andries: Yes. Teaching the topic of life and living that would be related to the life style of the children and environmental studies topic where learners need to know on how they could interact with their environment knowing different plants. C

Tracey: definitely. IK empowers students and facilitates comprehension. It does also helps them appreciate their environment. E U

Princess: Yes, because most things in science originate from IKS.

Abigayle: Yes, the generation of learners have moved away from pure theory and require a broader perspective of practical knowledge to add relevance to the theory C

Muzz: Yes, an appreciation of different cultures and their beliefs T

Whitney: yes – it helps learners develop knowledge on systems practices by grandparents better.

Samuel: Yes, because we need to know medicinal plants and how they can be used to alleviate suffering. P

Ilze: Yes, I think that we as teachers need to do practical teaching because doing think kenitics (?) helps improve learnings. U

Jessie: Yes, there is. All South African cultures have 1 T

Mota: yes, because we are teaching about plants cell. Is where you can fit in IKS

Buhle: 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 D

4. Have you ever incorporated IK into your LS lessons classroom? Why/Why not?

Lee-Anne: No. Not part of CAPS, nor mentioned in-depth in study books.

Phindile: as a student in my 3rd year LS class we were asked to develop a chapter that we think should be included in LS curriculum and my topic was IK (focusing on traditional medicine) – it was approved by mrs Willemson, as an interesting topic to look at. T

G: No

Olehile: yes I have in teaching cancer C treatment, the use of African medicine ie African potato etc. I have used it in the teaching of health medicine especially in grade 10 and 11.

Andries: Yes. When teaching environmental E studies topic and learners to be able to identify different types of plant and how they can be used as some are herbaceous that they can be used as herbs.

Tracey: Yes. When dealing with the conservation E of plants and animals. Ways in which the aspect of fotems(?) and how it spared animals from becoming extinct.

Princess: yes when I taught learners about cancer C in grade 10 and STD's in grade 12.

Abigayle: Yes, lessons, excursions, practicals, Case studies, Research projects

Muzz: No, not yet

Whitney: Yes – as prescribed by CAPS. We focused more on traditional medicines vs modern medicine. I allowed learners to debate.

Samuel: Yes, because there's a section on biomes and plant diversity. Weltwischia treats cancer. African potato, Hoodia and the rest zeroed in on how plants were used traditionally

Ilze: No

Jessie: 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.

Mota: No. some time we were not aware of this IK

Buhle: Yes, when teaching energy transformations to sustain life

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

Lee-Anne: IK is learnt by "forefathers" and taught within families/ communities through generations. Western knowledge is more scientific, based on laboratory experiments.

Phindile: it is the knowledge that comes from the value of culture or tradition, which has been existing since ancient times/ before or during our forefathers.

G: as a "westerner" I feel we also have IKS, where plants, honey, etc are being used as medicine. I think that there are some links that could be made between the two knowledge systems

Olehile: It is the knowledge of how important is the plants that originate in our areas, naturally produced there, how they can be of help in terms of our health and how they can be protected and kept or preserved.

Andries: indigenous will be knowing and understanding eg natural resources on how they occur, what role they may be contributing to core detail of such resources and how they can be used.

Tracey: IK is one that is native to the area or society. Western knowledge is one that is adopted from the West and incorporated into the system via educational systems on social media.

Princess: it is rich, pure knowledge that has been passed down through generations and there is so much that can be learnt. Western knowledge is sometimes based on this.

Abigayle: IK is a natural theoretical perspective found within everyday life of various cultures. This knowledge can be medicinal, spiritual or used in other ways. Often it is passed down through the generations

Muzz: Knowledge of a certain people/ group. Something sacred they believe in, knowledge that defines a group's culture

Whitney: traditional knowledge is practices developed by people of the same tradition as us but lived 100's of years ago. What makes it different is that it did not evolve to its optimum to our current generation.

Samuel: this is knowledge that is passed on from parent to offspring orally. It is different because we do not rely on hard copies but valuable information is passed on orally, through traditional ceremonies or events ie full moon, etc

Ilze: I think indigenous can change a "believe" systems

Jessie: Its origin cannot to accredited to a particular individual hence it's not treated. Not journalised/ published etc. western knowledge is accredited, published and in a journal.

Mota: it is because most of the traditional knowledge the western knowledge belief that is not healthy for the health of people and they don't encourage people to take it even if you went to the professional DR they don't prescribe it.

Buhle: IK is knowledge that is unique to a culture or society

6. Practitioners of indigenous knowledge (e.g., elders, herbalists, traditional healers) observe nature to generate knowledge. Do they do experiments and tests in order to verify or validate this knowledge?
   - If yes, explain how they test or validate their knowledge
   - If no, explain why not

Lee-Anne: Yes, perhaps not scientifically but I do believe they verify their tests. Trial and error plays a role.

Phindile: Yes, validation is done on the basis of has it worked over the years (ancient times). They study the plant; however, its validation is questionable.

G: Yes, and No. I think that their knowledge comes from years of applying it and seeing whether it works or not. It comes from experience, from knowledge being passed from one generation to another.

Olehile: yes, they do test, they literally test by using the herbs when they heal or treat their patients. If they use it and see it's not working, the resort to another method of healing or treatment. They go to their type of school where they are validated.

Andries: elders and traditional healers that are less informed may be just using their discretion without a clear understanding of test, but recently since they can now be registered practitioners it does help.

Tracey: Yes. The knowledge is validated through administering to the clients. Normally the clients (if traditional healer) gives feedback after using it.

Princess: [no answer]

Abigayle: Depends, they use knowledge of various combinations to formulate medications. They may even test it on themselves. Yet it depends on culture and the knowledge they have and if they are actually trained in the practice

Muzz: No, for instance in a rural tribe or inaccessible clan, they may not have the facilities or expertise to test indigenous plants/ substances } western influence.

Whitney: No. They rely on spiritual instinct which is not safe if you look at it from a microbiology and physiology perspective.

Samuel: Yes, experiments are done but are done on human beings. Not enough clinical tests are done

Ilze: No, in the older days there was no experimental way of testing

Jessie: Yes, over many many years – some observations were not personally observed but passed on by the elders to the family

Mota: No, because they belief from the past that they heal people without any test. They just tell you how to use it or cook it.

Buhle: No, usually traditional healers are given a vision through dreams by their ancestors as to which plant heals which ailment and during their initiation period before being a healer their "Gobela" teaches them.

7. 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

Lee-Anne: Some stays the same because of traditional beliefs but there is also change. Change gives better results or different results. Depending on background, culture, level of understanding there will be change.

Phindile: Knowledge stays the same but information changes over time. The other thing that could change is ways to use/ implement it but science knowledge is dynamic it changes with time.

G: yes, they learnt from their elders and views as the ultimate truth. (not sure actually)

Olehile: no, it does not stay the same, it changes due to new findings and tests that are regularly performed. Technology also plays a part in changes observed.

Andries: yes, it does stay the same but since they could be tested a slight change occurs since now they could be mixed up and be modified.

Tracey: no, it does not stay the same to its being infused with western knowledge.

Princess: yes, new things are discovered all the time so old methods of doing things are improved, new discoveries are added to old IK and things are improved.

Abigayle: Yes – certain practices still work over the decades and is common practice. No – new practices may come around from new diseases or illnesses.

Muzz: No, some aspects of the medicine may get lost in the translating or transferring of the knowledge. The techniques could be refined over the years.

Whitney: It changes, reason being nature evolves all the time. For example an antibiotic from IKS that worked then might not work today since microbes evolve all the time.

Samuel: the knowledge does not remain the same because the society is dynamic, it changes with time and so does knowledge as well. Changes can be due to technological changes and advances.

Ilze: Yes, because that is the way it is learned from elders

Jessie: [no answer]

Mota: No, because people now they serve their own interest and they make money out of it.

Buhle: The knowledge changes over time because with the changing of times and evolution of diseases, such changes are made to adapt to the current times

8. *Hoodia gordinii* 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?

Lee-Anne: firstly, by chance and then duplicating their "test." Trial and error.

Phindile: I think that they come to know through the experiment maybe if they ate it on a certain day, it would sustain them for more days.

G: they accidentally came across one of those plants. Someone cut it open and saw that it contained a lot of liquid. Another "brave" soul tasted it and survived – that is how history was made.

Olehile: the only way to know how something works is to put it in practice. The tested by drinking or taking it, up until they realised its effects. It's not or was not a once day thing.

Andries: it could be that maybe the plant was the one that was dominant in their area, changing the thickness and how it retains most of its water.

Tracey: it could have been through dreams when visited by ancestors and they are shown which plant to use s if they hunted in sacred forest.

Princess: by tasting it and considering it as a food source

Abigayle: they would have observed nature and the animals using it/ a medicine man may have contacted the spirits and be enlightened/ they could have tried it out in small doses to observe the effects.

Muzz: Trial and error. Knowledge passed on from generation to generation

Whitney: Honestly I have no idea. Maybe through trial and error.

Samuel: Trial by error, Khoi-Sans used it by accident as they lived off wild plants and fruits

Ilze: [no answer]

Jessie: [no answer]

Mota: because they use it to eat

Buhle: Hoodia is a succulent so they probably ate the plant for it water properties then found that it was an appetite suppressant.

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.

Lee-Anne: within their cultures they have their own methods and knowledge, as well as indigenous to their area plants carried forward within their own family to family.

Phindile: I think IK is universal to a certain extent, it is only restricted by the availability of that plant growing in that area.

G: Yes, the hoodia is an example of a IKS used in a specific community to survive. Plants occur in certain biomes where certain communities live and it is used in that community for specific purposes.

Olehile: Culture plays a huge role in the use or in practicing IK. Rastafarians believe that dagga has always been a medicine (effect of Cannabis oil in curing cancer).

Andries: yes, it does, specifically with the black Africans that are still using herbs to treat other health problems from generation to other.

Tracey: yes. Through the example of IK people expose their cultures value through sharing

Princess: [no answer]

Abigayle: No, various cultures and communities may be influenced by other factors such as media, better understanding of medicines etc that may change between each level of society and community.

Muzz: [no answer]

Whitney: Yes. For example, the *Hoodia gordonii* – it reflects the hunting culture of the Khoi San people. Cultures that do not hunt would not use it.

Samuel: IK does reflect social and cultural values of a certain people. Mopane worm is food, a good protein source – people get food and employment.

Ilze: [no answer]

Jessie: [no answer]

Mota: I think it is good for our local community to believe in it if they have rituals in their family, use impepha

Buhle: Yes

- 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.

Lee-Anne: it 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.

Phindile: different plants growing in different parts of the world may perform the same function in different areas/ communities.

G: could be used globally → Rooibos is being used worldwide. Tea tree oil, eucalyptus tree oil is being used worldwide as well as Echinacea

Olehile: it depends on policies or legislation in other countries. Certain plants are not allowed to be used in other countries (Cannabis oil)

Andries: it can be used globally with the modern technology. Engineering of plant that can be packaged and be sold out.

Tracey: I believe it should be used in specific areas to solve problems to avoid it being watered down.

Princess: they can be used in other areas or globally because communities don't only experience problems in isolation in a global community.

Abigayle: Globally, as many plants and animals have chemical factors (active ingredients) that are used in medications globally eg aspirin from the willow tree

Muzz: it can be used globally if research has shown it has medicinal properties. Then why not share the knowledge.

Whitney: It can be used everywhere, depending on those people's openness to the knowledge.

Samuel: IKS is not confined to a specific area but can be used to benefit others or solve problems elsewhere.

Ilze: [no answer]

Jessie: [no answer]

Mota: It can be used in other areas or globally to solve the problem because it can help to cure many illness or prevent it

Buhle: it can be used in other areas eg how cancer patients are travelling to India to get treatment

AYURVEDA

10. What are your views on the teaching of Indian Indigenous Knowledge amongst Indian learners in South Africa?

Lee-Anne: [not answered]

Phindile: for learners specifically Indian learners will be more able to understand because they will contextualise

G: I don't have any new view (unknown to me)

Olehile: They are Indians and surely have to know about their origin and plants and animals associated with them.

Andries: that would give a clear and more understanding

Tracey: I believe it should be so that it does not become extinct. It also ensures that they remain connected to their roots.

Princess: just like African learners it would create excitement and interest in science knowing that it relates to their culture and what they grew up with.

Abigayle: It may differ between various cultures and communities but many learners can relate.

Muzz: Limited at this moment

Whitney: It should be implemented. They must know their cultural way.

Samuel: it's not been well done. There has not been such in-depth teaching, due to few schools and a restricted syllabus

Ilze: I believe we all can learn from each other

Jessie: [no answer]

Mota: I think it is very important because it encourages them to eat healthy and their spice are very good. X late!

Buhle: We need to accommodate their IK systems as they are also part of South Africa

11. The Life Sciences CAPS document states that the examples of IK chosen for study should, as far as possible, reflect different South African cultural groups (DoE, 2011:17). Are you in a position to implement this requirement? What problems do you experience when implementing this requirement?

CHAT

Lee-Anne: No problem implementing IK in the class. However, CAPS and learner books contain very little reference to IK.

Phindile: teacher by profession but not in practice at the moment.

G: once again time syllabus is overloaded

Olehile: I teach according to the textbooks. I have a challenge in finding examples of some indigenous plants to show to the learners

Andries: less resources at our schools

Tracey: yes. Problems would be biased and also cultural diversity leading to some authorities valuing some IK at the expense of others.

Princess: I would be able to implement this

Abigayle: Yes, however we incorporated IK into the SAGS curriculum as we are semi-private. Only problem is time restriction

Muzz: [no answer]

Whitney: I am willing, but IKS knowledge is not strong. So I rely on things I have read but never experienced.

Samuel: Yes, different cultures will react differently to IK studies. Parliament must be involved. This will make it easy for us to harvest our natural medicinal plants and putting them to great use.

Ilze: Info – overall

Jessie: [no answer]

Mota: ?

Buhle: [no answer]

12. What do you know about Ayurveda?

Lee-Anne: no knowledge about Ayurveda

Phindile: nothing at the moment but willing and interested to learn

G: nothing

Olehile: I haven't heard about it but I know it is the treatment of chronic diseases using herbs.

Andries: none

Tracey: Nothing

Princess: it's an ancient Indian traditional way of treating and curing illness using natural remedies.

Abigayle: It is knowledge found within the largest Indian culture of South Africa

Muzz: Nothing, zero

Whitney: Nothing

Samuel: Indian name (A type/ branch of science that blends muti and clinical studies

Ilze: no

Jessie: [no answer]

Mota: is all about VATTA – movement; Pitta – infection; kapha – feeling of heaviness

Buhle: [no answer]

13. Would you say there are any links between the current Life Sciences curriculum and Ayurveda? Explain further.

Lee-Anne: no comment

Phindile: not sure since I do not know what it is

G: don't know

Olehile: There isn't, how I wish it could be.

Andries: nope, first I hear of it

Tracey: [no answer]

Princess: Yes, there are illnesses in Life Sciences that can be treated using Ayurveda

Abigayle: Yes, many aspects of plants are linked to medicinal uses as well as cultural practices such as turmeric/ borrie

Muzz: NA

Whitney: [no answer]

Samuel: Yes, on the section on plant and animal biodiversity

Ilze: [no answer]

Jessie: [no answer]

Mota: Yes, because is related to different types of animal tissues

Buhle: [no answer]

14. Do you think that learning about Ayurveda could benefit the learners? Explain.

Lee-Anne: no comment

Phindile: I believe it would

G: don't know

Olehile: It would benefit the learners a lot

Andries: [no answer]

Tracey: Yes, if it is going to ensure that the knowledge remains valued

Princess: It could, learners who cannot access medical treatment could safely use some of the Ayurveda remedies they learn about in Life Sciences

Abigayle: Yes, to incorporate a more inclusive learning environment as well as educate other learners on different cultural practices.

Muzz: NA

Whitney: [no answer]

Samuel: yes, they will be able to assist society and community with knowledge on medicinal plants

Ilze: Yes, they need to know about other cultures

Jessie: [no answer]

Mota: yes, because it will interact with tissues and also understand similarities

Buhle: [no answer]

15. What do you understand about the Nature of Science (NOS)?

Lee-Anne: physical, result-oriented, interactions

Phindile: these are the key principles and ideas which provide description of science and knowing and understanding science

G: Should teach learners to do practical investigations, think critical and analytical, and address the affective domain (contextualise your teaching).

Olehile: It is how science works, how it impacts on our lives and how science is important.

Andries: knowing and understanding the environment and the interaction that we have with—

Tracey: [no answer]

Princess: Science is accurate, reliable and ethical, it is ever-changing and can be tested.

Abigayle: Science is not theoretically based, but also requires a practical and emotional factor to understanding

Muzz: [no answer]

Whitney: ?

Samuel: Nature of science is a process of discovering unique compounds/ chemicals that can be used to treat diseases.

Ilze: [no answer]

Jessie: [no answer]

Mota: ??

Buhle: [no answer]

16. Do you see any difference between the NOS and Ayurvedic principles? Explain your response.

Lee-Anne: no comment

Phindile: with my understanding of NOS I believe there might be.

G: NA

Olehile: There is truly no difference, this is all science.

Andries: [no answer]

Tracey: [no answer]

Princess: No, Ayurveda has been tested and tried over centuries so it is also accurate, reliable and ethical to use, it also changes with time and can be tested.

Abigayle: No, it requires scientific understanding along with deeper, more meaningful understanding.

Muzz: [no answer]

Whitney: [no answer]

Samuel: Ayurvedic is more focused, whereas NOS is too general.

Ilze: [no answer]

Jessie: [no answer]

Mota: No I think it is the same. Because we use the natural things to prevent some diseases.

Buhle: [no answer]

APPENDIX H: POST-INTERVENTION QUESTIONNAIRE (LENASIA SLP)

Addendum

POST-QUESTIONNAIRE RESPONSES – LENASIA:

[23 participants attended the SLP, 18 post-questionnaires were received]

1. How did you experience this short course on indigenous knowledge?

Very bad- a waste of time	It had useful aspects, and made some contribution towards my development	Good- it definitely made an impact, and helped me in my professional development		It was fantastic, and I learned a lot. I can't wait to implement what I have learned in practice.	
1	2	3		4	
		2	**11.11%**	**16**	**88.89%**

2. Would you say that there is a place for the teaching of indigenous knowledge in the Life sciences classroom?

No- IK is pseudo-science and devoid of any substance. It does not belong in the classroom.	Maybe some aspects of indigenous knowledge could be introduced in the classroom.		Where applicable, indigenous knowledge should be brought in as a different perspective to the purely western view.		Definitely. Indigenous knowledge can make the learning of Life Sciences much more meaningful.	
1	2		3		4	
	3	**16.67%**	**7**	**43.75%**	**8**	**44.44%**

Motivate your answer.

Lee-Anne: provides learners with real-life situations

Phindile: learners would be able to contextualise

Olehile: To clear misconceptions about the use of herbs which is associated with witchcraft for conservation purposes

Andries: On an Environmental Studies topic

Abigayle: adds to a more inclusive and meaningful learning environment

Whitney: It will bring knowledge to learners and a desire to pursue a career in research SDL

Samuel: We need learners to come up with new ways of making medicine and treating of ailments PBL

Ilze: Just based on the jam-packed work

Jessie: break knowledge apartheid decolonise

Mota: Because it can be able to bring different cultures together – unity, nation-building

Sibonelo: I believe if the department can be able to consider people's views, yes it can be introduced.

Aisha: Only after we are well-equipped as teachers – intervention

Wadzis: Yes, but the class does play a factor

Sima: Yes, to promote tolerance and understanding

Mpho: because it shows that knowledge is nature, that all is integrated

Saidi: learners always practice this at home. Some, it will be easy to apply this in class

3. What are the difficulties that you anticipate in teaching indigenous knowledge in your lessons?

Lee-Anne: limited resources in CAPS and learner material currently on IK

Phindile: the process of having to learn and understand my learners background in order to accommodate them in my lesson by making content relevant. It might come across as time consuming

Olehile: Time of teaching, scope and aspects of IK to be taught practical investigation sin terms of number of its learners in the classroom, some parents may not allow their children to be taught these sections due to religious beliefs.

Andries: Less resources available. Not able to demonstrate to learners with a visible plant etc.

Abigayle: time constraints, willingness of other colleagues, types of classes

Muzz: A disinterest from learners, possible boredom, possible time constraints

Whitney: 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. I do not believe in tokoloshes

Samuel: cultural, religious beliefs of different learners

Jessie: racial, cultural, religious segregation, lack of trust, parental interference

Mota: Because of the most of the learners they are still stereotyped about this IK

Buhle: It could be time-consuming and we may move away from what the pace setter says must be taught for the day

Sibonelo: In my school we have a challenge of over-crowding classes and more repeaters. With that being said, it is a challenge to finish received content.

Aisha: First of all, it is not part of the curriculum so it might be as accepted.

Wadzis: Cultural diversity, time, class size

X: time constraints

Mpho: lack of interest from learners; getting carried away with the content; knowledge apartheid

Saidi: basing on religious aspects, some learners may not be interested in learning this. Can also be time-consuming

4. How would you rate the different activities, in terms of its usefulness towards your own professional development? How did it assist in your own professional development as a science teacher?

Activity	Bad	Average	Good	Excellent	Comments
Ayurveda lecture	0	1	4	13	Lee-Anne: interesting facts Phindile: insightful. I have learnt the kind/type of person that I am. Olehile: Provided knowledge of Indian indigenous plants Muzz: Interesting Samuel: eye-opening experience Ilze: love it Jessie: validated previously heard information Buhle: very insightful, made me realise there are other IK in the world Sibonelo: It was new to me so I have learnt Sima: It works as a daily personal route and knowing yourself. Saidi: good to apply and interested
Anti-microbial tests on plants	0	3	9	6	Lee-Anne: shows impact of IK Phindile: growing up and being exposed to traditional medicine practice has validated that they do actually work Olehile: Effectiveness of indigenous plants Andries: Abigayle: maybe make your own incubator Whitney: I did microbiology in my junior degree so I already knew about the technique Samuel: petri dishes should have been incubated at about 37°C Jessie: very interesting Buhle: due to the lack of the incubator – the intended results were not seen Sima: being able to relate all cultural muthi's and understanding of it. Appreciation of plants Saidi: can really aid in identifying the activity of plants on bacteria.
Problem-based learning	0	0	5	13	Lee-Anne: another mode of delivery to students to spice up teaching Phindile: It got my creative juices running. I never knew I was this creative Olehile: provided an opportunity to design an experiment using own material Samuel: I will have an opportunity to provoke learners to think Jessie: to incorporate this into my lessons

					Sima: be able to come up with a solution and helping weak learners Saidi: improves the thinking capacity
Jigsaw method	0	0	3	15	Lee-Anne: another mode of delivery to students to spice up teaching Phindile: my learners will be responsible for their own learning process Olehile: effective planning Samuel: a bit difficult but with time and practice it can be done. Jessie: to lure the learners who don't always speak Sibonelo: I normally use it in my classes Saidi: improves the interaction of the learners in learning
De Bono's hats	0	0	3	14	Lee-Anne: another mode of delivery to students to spice up teaching Phindile: creative way of teaching certain topics in Life Sciences Olehile: essay, structured lessons Samuel: creative way of educationg learners Jessie: to show question answering techniques, to evaluate their responses, it is factual, emotional Sibonelo: I feel like it is a powerful tool to deal with environmental impact in Grade 11 learners Sima: allows learners to break down the topic according to their understanding Saidi: opens the learners' mind

General Comments:

Phindile: I come here with a tool box that had all the tools that I had collected as an undergraduate, this programme has just added a new tool in my toolbox

Olehile: excellent presentations in general. All activities were inspiring and can be applied in the classroom

Andries: Excellent presentation, insightful

Abigayle: timing was a bit off – maybe do it over 3 days
Muzz: overall, an amazing course

Samuel: I like the diversity of variations in these activities. It's not monotonous but its real and exciting

Jessie: I was invigorated as an educator

Mota: I have learned a lot because it has lightened up my knowledge concerning the IK and made me aware how plants important in our health and lifestyle

Aisha: we need more workshops that will help us to be fully equipped

Sima: this knowledge will be helpful to me when I complete my degree and become an educator, will implement it to my learners

Mpho: new knowledge brings about new perspective. I got the opportunity to think and learn about new things that will improve my classroom.

Saidi: these activities should be used because they bring effective learning

5. Based on your experiences these three days, is it necessary for you to formulate any professional development goals for yourself? (e.g. did you identify any knowledge- or skill gaps that you would like to address in the following themes?)

Theme/ category	No develop-ment goals- I do fine	I identified the following professional development goals:
Knowledge on indigenous knowledge systems	1	Andries: How to use different plants on a dqaily basis Muzz: need to know more, would like to better my knowledge. Ilze: there is a lot to learn Jessie: yes Buhle: I need to do self-regulated learing fro other IK in iother cultures to be more accommodative of my learners X: explore in more detail IK of other cultures LeeAnne: knowledgeable on this topic. I will take through to classes Phindile: I need to read more about IK since my understanding was only on African IK Abigayle: more varied IK in my teaching Whitney: I would like to know more about the pharmaceutical effects of African medicinal plants Samuel: some of the custodians of information, not willing to share Sima: tolerance, creativity and knowledgeable Mpho: more about other IKS; how IKS is used
Laboratory skills (anti-microbial activity lab)	4	Andries: Learner-centered and practical Muzz: I would like more practice, hands-on understanding Jessie: yes X: doing microbial tests in a lab LeeAnne: skilled already in lab work, implement in class Phindile: how I could use everyday household products to conduct an experiments Samuel: need equipment like incubators, etc Sima: creative, hands-on participation
Problem-based learning approaches	3	Andries: Learner orientated Wadzis: need to employ more approaches to learning Jessie: yes Buhle: apart from the lab activities set out in the CAPS document, I'll look for alternatives to promote variety in my experiments.

		LeeAnne: new to me – will develop and implement Phindile: allow my learners to be in charge of their learning Abigayle: more creatively I have lost that will to create tasks outside the box Samuel: challenges are unique for every learner. Expose learners to more activities Sima: problem-solving and decision making Mpho: thinking of worksheets – scaffold learners
Cooperative learning techniques	5	Andries: Learner orientated Wadzis: need to work on these to engage students Jessie: yes LeeAnne: great technique to be implemented Phindile: affective domain Samuel: free-flowing of information among learners
Reflection	4	Andries: More time to be invested on. Jessie: New techniques are always welcome to teach you have to be willing to learn X: perhaps a little constructive criticism would allow one to see if I understand the concept correctly eg was my interpretation of the problem based on learning correct. LeeAnn: will encourage more in class Abigayle: I need to work on my teaching style with reflection Whitney: I hardly reflect on my lessons. If I had fewer classes as opposed to 9, I would practice this. Samuel: it was very informative, can lead one to want to do BSc in Ayureda

Comments:

Olehile: I have gained so much professionally

Muzz: Yes, I need to develop concrete goals and what I want to achieve

Whitney: The SA education system must be adjusted to allow such teaching methods to be incorporated successfully

systemic

Mota: I have learnt cooperative learning techniques

Sibonelo:

Wadzis: PBL and CL need one to plan effectively so that one does not derail from achieving the goals

X: what are the criteria to be considered in a PBL. Was scaffolding sufficient?

VIEWS ON THE NATURE OF IK

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

Lee-Anne: knowledge learnt/ carried down from generations within a community, not always scientifically based through experiments

Phindile: IK is the basis of most if not all western knowledge. It is knowledge that has existed ancient years ago.

Olehile: The use of traditional medicine, preservation thereof and different cultures in terms of their medicine usage. How effective the herbs are and how cheaper we can get

Andries: more focus on the history/ background of understanding the importance of plants and old system beliefs

Abigayle: IK is cultural knowledge that is passed down. It is particularly incorrect to separate wester knowledge from IK as both have links within each other

Muzz: A respect for your culture and understanding of the world we live in teaches one to view life more holistically

Whitney: IK is a knowledge system derived from different cultural practices towards the benefit of human developments

Samuel: information passed on from parent to offspring from generation to generation through folk lore or orally

Ilze: indigenous is more home-based. Here is SA and not from other countries. But overall it is the same

Jessie: it's not well documented can therefore not be referenced. Various cultures may not easily share information viewed as family heirlooms. Not trusted as its not found in books.

Mota: Because it is natural and acquired knowledge of many things and learn that every tree or plants are very important

Buhle: IK is knowledge that originates from a certain culture or society, it differs from other types of systems because what works in this system won't necessarily work in others. IK socially culturally based

Sibonelo: IK is more based on the everyday life, learners encounter every day and it makes it easy for them to grasp more information as possible, in contrast with the western knowledge where they are required to imagine everything taught

Aisha: It's going back to the NOS

Wadzis: this is knowledge that one has that relates to ones culture with regards to any topic (sciences). With this knowledge one can relate and contextualise it making comprehension and learning interesting

X: IK is knowledge of nature used in helping and healing people

Sima: IK is a way of each and every one of us to do things; it brings all cultures together and work together, also promotes understanding and tolerance of each other

Mpho: IKS is knowledge that has been transferred from generations to generations about surviving and making things better; IKS is different from Western in that it is different for each area; IK is the same.

Saidi: IK uses time available natural resources unlike the western style or knowledge. IK is cheap, easily accessed unlike the western knowledge

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

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

Lee-Anne: Yes, they will test to determine results. Not lab experiments but through trail and error they test

Olehile: they do b repeatedly administering, by increasing or decreasing their dose as well as the conditions in which they administer them

Andries: Yes/ no. Some are more practical and cannot be easily explained

Abigayle: yes, observation, understanding of plants, traditional practices and beliefs. Metaphysical aspects using the scientific processes

Whitney: Yes, they use basic scientific methods though their techniques may not be lab based, they have a form of experimental method that they use.

Samuel: some do, some don't. if a patient comes back with news the muthi is working. Very few clinical tasks are done. The dosage of the muthi is not known.

Ilze: they don't do experiments or tests, they do look at the plants and see what part of the body is the same. That is how they know.

Jessie: Yes, and no. information is passed on over many generations that could serve as an experiment with a proven outcome which is why it's used.

Mota: Because in the past people do believe in natural things irrespective of testing it. They know by means of measuring in terms of ML or cups not making it strong. They can be able to tell.

Buhle: during the initiation period of the traditional healer his/her "Gobela" teaches the healer which herbs cure which ailments and some healers receive visions in the form of dreams from their ancestors to, I suppose, this is how some of the knowledge is validated.

Sibonelo: Yes. They do tests especially when the medicine is given to the patient and works perfectly so however the problem is that the humans test what western knowledge which they use animals to test their skills and knowledge.

Wadzis: Yes they do by inquiring from their clients. However the only shortcoming is in the administering of dosages

X: I am unsure as to how the tests were done

Sima: Yes. I think that by using it according to the look and its name especially in out African culture

Mpho: No. because information has been transferred for many generations. What they know to cure stomach ache will cure stomach ache.

Saidi: No, because they obtain information from their elders so information is passed from generation to generation without alteration

8. 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

Lee-Anne: a lot of it stays the same but I do believe there is change for improvement purposes

Phindile: it changes over time because we are now existing in the new times so knowledge is becoming dynamic

Olehile: No, it changes all the time. New findings ae made as they improve

Andries: Yes, it does not stay the same, slight changes are those that are now scientifically proven

Abigayle: both – well established methods may stay the same for certain ailments whereas new methods may be needed for new illnesses or strains

Muzz: No, word of mouth, may change from person to person. An Ayurveda IK may differ from an African IK

Whitney: no. it changes due to changes in the universe as a whole. Today we have issues like climate change, different other positions, different microbial adaptations

Samuel: the knowledge gets distorted as it cascades down due to preferences and values from the custodians of this knowledge

Ilze: The base stays the same but over time it can change

Jessie: stays the same. If there's faithful students, changes if students incorporate their observations

Mota: It change because of the constitution of the RSA and the laws of the country

Buhle: Changes take place over time due to the fact that it is transmitted over word of mouth so it is lost over time or changed. Some Diseases/ ailments evolve so in order to cure them the remedy has to be changed a bit, so how colds and flu were cured by the San back in the day may vary from how they cure them now because of the different strains iof flu

Sibonelo: No. It does not stay the same due to the fact that technology is taking over bit by bit so it could be developed and advanced.

Wadzis: The principles behinf=d the knowledges is the same, what changes is the manner in which it is used due to geographical locations

X: No. Oral transmission has problems – there can be omissions, additions and even alteration of information

Sima: Yes. To be used continually and for our origins, where we come from and for us not to forget where and who we are as people

10. 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.

G = global

Lee-Anne: social and cultural values are reflected within IK – it determines "who" we are. I do not believe it should be specific but shared to increase/ encourage learning and knowledge

Phindile: IK is only used in specific areas because it's relevant and accessible to the community existing their so yes IK reflects social and cultural values of a specific community. Different plants from different areas may perform different/ some functions in those areas

Olehile: It reflects everyone social and cultural values. Marijuana reflects Rastafarian culture an ad how they use the herb as both a drug and for medicinal purposes

Andries: Reflects most on popular ones eg Indians and Black Africans; can be used globally

Abigayle: Yes. They may be links to other cultures but most is passed down through the generations. Globally knowledge is interchangeable and IK can help various people who are in need of aid

Muzz: Yes. No – KhoiSan live off the earth and so appreciate it far greater than some western communities, the knowledge should g=be shared open y=to all, Ayurvedic operations sound far friendlier than western surgery so why not incorporate this IK

Whitney: IKS does not necessarily reflect a particular culture. Since most of this knowledge is commonly used in different cultures under different names. As a result, IKS should be used globally.

Samuel: yes, to a certain extent we are living in a global village now an that must change. The use of it must be selective so that it can only be used where the results are more positive

Ilze: I think IK can help everyone over the country if they are open to try it

Jessie: it is reflective of a community and it values Xhosas, Zulus, Pedi's, Khoisan, etc. But it can overlap to other cultures and beliefs. In our colonised state, information remains good in a certain group but since we are integrated integration of IK is necessary.

Mota: It can be used globally because looking at the time we are living in today many people are sick and some of IK can help to reduce numbers of people who are sick like in the past where our grandparents were using this IK there was no sicknesses like now

Buhle: yes, it can be used in a specific area to solve certain problems but in another area it could be used to solve a totally different problem. The placebo effect also plays a role in such a context.

Sibonelo: Yes. IK reflects social and cultural values due to the fact that our elders' knowledge will be sustained for new generations benefits. I believe it can be used globally if it can be implemented and

used wisely because are more interested to the Western knowledge. So to convince them needs great work.

Wadzis: it should be used globally so all can benefit and appreciate the importance of using the plant sustainably

X: yes it does, there's a spiritual aspect, however it can be used in other contexts eg yoga. There is a physical aspect as well as a cultural, religious link yto meditation

Sima: No. It covers all cultures/ people. No

Mpho: Yes, eg Ayurveda, Indian IKS; IKS can be integrated into different communities.

Saidi: yes, because each community (culture) have a specific way they use IK which may be different from another. However, it might be addressing the same problem. Can be used globally because each group or community have a specific knowledge they used before developments came up. Only integrity is needed.

AYURVEDA

11. What are your views on the teaching of Indian Indigenous Knowledge amongst Indian learners in South Africa?

Lee-Anne: no comment

Phindile: It will show much meaning and relevance to them so it is a good initiative

Olehile: it is good for them, it reflects on their culture and social community

Andries: will be insightful for the Indians and other learners in a multicultural class

Abigayle: I still lack enough knowledge to address most topics that are cultural norms amongst Indian learners

Muzz: they will be encouraged to ask and enquire about their own culture, learn about Indian and Ayurvedic roots/ origins

Whitney: It should not be amongst Indian learners only – it should be all SA learners

Samuel: it will be great; I I will learn a lot from them. It will break down cultural barriers

Ilze: this will improve life itself and how we see the world

Jessie: I think it's necessary. Learners need to reclaim their heritage

Mota: It is very good because they will start to understand how important they are

Buhle: it's actually important that we teach that IK so that they don't lose touch of who they are or where they come from

Sibonelo: I believe even Indian students needs to be taught the skill and knowledge, their forefathers used back then like other cultures were taught.

[redacted]: It is a good idea

[redacted]: It should be encouraged so that the appreciation and value of IK is not forgotten

[redacted]: It is a necessity and would acknowledge these learners

[redacted]: it will help them to know their origin

[redacted]: we can, however we must teach it across the spectrum

[redacted]: It is good because it helps the learners to know the ancient activities in regards to healing of the diseases.

12. How would you describe your knowledge of Ayurveda after this SLP?

[redacted]: limited to the information given at this course

[redacted]: insightful and I am excited to share this knowledge with my future learners

[redacted]: I am better informed and can teach other people

[redacted]: 8/10. More studies needed for more information SDL

[redacted]: empowered, informative and humbling as this has opened to a new level of information that can be integrated into the classroom

[redacted]: Much much better, eyes open to something truly interesting

[redacted]: I didn't even know what Ayurveda was until the 2-day course

[redacted]: Excellent and very useful

[redacted]: Ayurveda is not a belief system. This is a life change, a way of life

[redacted]: I heard a lot from my days as a learner in an Indian school. I didn't trust the information I know have validity to explore some of the information heard and gained.

[redacted]: I start to realise that they are many things that are don't know about myself and nature at large

[redacted]: I actually want to research more about it and maybe try it out. SDL

[redacted]: I have discovered my Doshas which is Pitta and Vatta which totally new things

[redacted]: I am well-enlightened to share it with others with confidence

[redacted]: Adequate

[redacted]: to me it is knowing yourself as a person

[redacted]: my Ayurveda knowledge understanding has increased.

[redacted]: Moderately an expert

13. Would you say there are any links between the current Life Sciences curriculum and Ayurveda? Explain further.

Lee-Anne: no comment

Phindile: yes, there are links because Ayurveda is Ayur / life, veda (knowledge/science) so it's knowledge of science

Olehile: No, there is nowhere in the curriculum IK is taught holistically

Andries: No. Pace setter does not include it

Abigayle: yes, plants and plant tissues, biochemistry all link

Whitney: the systems are different but the content is similar. Ayurveda is more practical

Samuel: Yes. Learners must practice critical thinking to make better muthi.

Ilze: Yes, for testing plants

Jessie: No. Most of the information received I've heard from the first time. I have not encountered it in the syllabus

Mota: Yes, there are link especially on the basic principles of Ayurveda eg Dhatus (tissues) it is Life Science related

Sibonelo: Yes, because Ayurveda is life knowledge, and most the things are coming from Ayurveda are not that away from Life Sciences

Aisha: Yes, they are both Life Sciences

Wadzis: not well versed in Life Sciences

Sima: yes. As much as you know your body, it links to Ayurveda

Mpho: No. Is content based. Ayurveda is strictly IKS it only has a section on IKS

Saidi: Yes, it deals with the science of humans which we teach learners

14. Do you think that learning about Ayurveda could benefit the learners? Explain.

Lee-Anne: no comment

Phindile: it would especially with the Doshas they will know who they are and why they behave in certain ways so they will be able to understand one another

Olehile: Yes, because they would not learn about medicine only but the treatment and the benefit health wise, holistic approach

Andries: Yes. About their relationships with the environment

Abigayle: Yes, inclusive education and since it is not religious based, it can allow learners to know about alternative medications

Muzz: Yes, possibly if they wish to become medical practitioners or have a broader view of a way to treat people

Whitney: a lot. It will even help them to manage their lives better

Samuel: Yes, Small ailments can be handled by the learners themselves without spending money

Ilze: Yes, it is "hands-on"

Jessie: Yes. Black, white learners might want to practice it's principles – this will discard the knowledge apartheid

Mota: Yes, in many ways looking at tissues especially as a foundation from grade 10. Also grade 12 eg digestive systems an d metabolic fire

Buhle: yes, they would/could learn that there are other knowledge systems besides the western one that our current education system is subjected to

Sibonelo: Yes, due to the fact that learners will learn alternative methods to deal with certain diseases and problems

Aisha: It is based on facts and is the most beneficial knowledge to have.

Wadzis: Yes, they would appreciate the benefits of being in good health to allay diseases and sicknesses

X: Yes, application of Ayurveda is beneficial to all.

Sima: Yes, they would be able to listen and observe how their body works

Mpho: Yes. It will show learners the relevance and knowledge

Saidi: Yes, because help in self-treatments eg nutrition (no need for medicine if you have good nutrition)

15. What do you understand about the nature of science (NOS)?

Lee-Anne: science is all around us and is living and changing continually

Phindile: it refers to key principles/ ideas which provide a description of knowing and understanding science

Olehile: How science works in the classroom

Andries: Indigenous and natural understanding of Life and sciences

Abigayle: science is testable, has a process, is subjective

Muzz: It is observable, practical

Whitney: science is too rigid. It follows certain specific rigid methods

Samuel: Is to disseminate information about conservation and how we, must look after our environment

Ilze: Nature is open form so much science and we have so much still to learn

Jessie: evolving, growing, non-static. There are new things to learn and discover

Mota: NOS is very important if people can stick to NOS it means nature is very good for our health

Buhle: It is tentative

Sibonelo: I believe that it is the knowledge that you get to know about the nature

Wadzis: this is the elementary sciences to get the pupils piqued so that they can study it further SPL

X: deals with the world around us, includes both living and non-living

Sima: study of living and non-living organs – environment as a whole

Mpho: WWW. Science occurring naturally without interference

Saidi: science that deals with life of organism.

16. Do you see any difference between the NOS and Ayurvedic principles? Explain your response.

Lee-Anne: no comment

Phindile: no difference because they are both based on principles which are their starting point.

Olehile: No, they are basically the same

Andries: Yes, science is scientific and proven, Ayurveda has more of history to the content

Abigayle: holisticness (?) of Ayurvedic principles over NOS

Whitney: Ayurveda is also method-based

Samuel: There are a lot of similarities

Ilze: Yes, nature is a wonderful place where plants can help us in medicines, etc...

Jessie: Ayurvedic – holistic; NOS - compartmental

Mota: No there is no difference

Sibonelo: No because since they discuss about the health of the plants which are the plants that are natural nor are plants and helps us to know that as humans we are dependent on the plants for many things

Wadzis: there's a difference. Ayurvedic looks at approaching life sciences holistically whereas with NOS it is in parts.

Mpho: No

Saidi: No, because Ayurvedic principle also deal with life of organisms.

APPENDIX I 1: FOCUS GROUP INTERVIEW 1

TEACHERS AFFECTIVE DEVELOPMENT DURING AN INDIGENOUS KNOWLEDGE PROFESSIONAL TEACHER INTERVENTION

FOCUS GROUP INTERVIEW 1 ✓ coded themed.

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. R

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.

C Indigenous knowledge in 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 I medication to the western 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 R ✓ in today's generation.

I think that as much as it has changed, it still is A very authentic, because at the end of the day we realise that we need to go back to I 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 K does not change but people are just taking another route whereby they try to neglect the other party of blame in the inner way but still it has its importance and if we can incorporate I it into this western life or medications, it can bring in, maybe, a better treatment. You see what is indigenous and fast treatment 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 cancer bush, 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 use 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 unlike 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 now living in a global village where information is spread 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 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.

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.

APPENDIX I 2: FOCUS GROUP INTERVIEW 2

TEACHERS AFFECTIVE DEVELOPMENT DURING AN INDIGENOUS KNOWLEDGE PROFESSIONAL TEACHER INTERVENTION

FOCUS GROUP INTERVIEW 2 coded

Welcome to the Focus Group Interview.

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, people look at you 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 plants 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 Ayurveda 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 imphepho is, I know what imphepho 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 UJ and I was taught by Prof De Beer so I know the De Bono's hats 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 think 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 indigenous knowledge 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

PCK CAPS.

learners learning style and incorporate all of them and as part of inclusion. We are going towards inclusive education.

APPENDIX J1: RTOP INSTRUMENT –LESSON OBSERVATION TOOL

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 _____

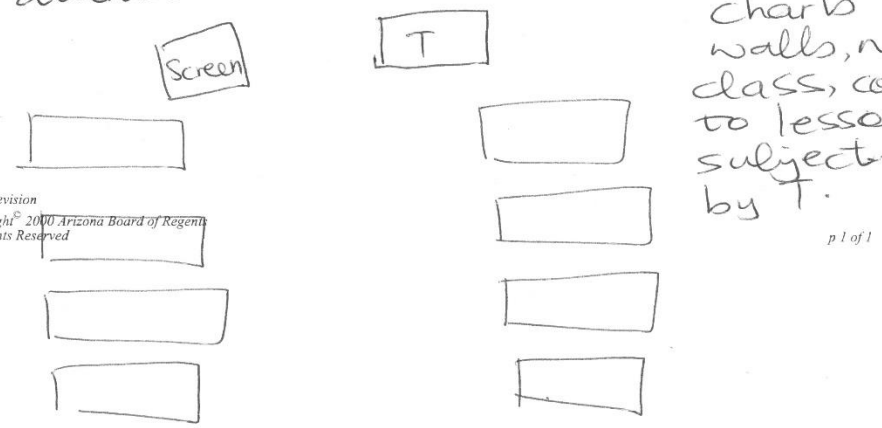
Observer _____ Date of observation _____

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.

Learners were greeted & asted to sit. A few Ls arrived late to class - lesson was just after break. T has good control over the class - Ls are attentive. 30 Ls present.



charts on walls, neat class, conducive to lesson & to subject taught by T.

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Record here events which may help in documenting the ratings.

Time	Description of Events
11:20	L's enter the class & are greeted. T in firm control of L's even with distractions & L's misbehaving but very minor issues.
11:30	T is explaining Mitosis – specifically significance of Mitosis as a way of introducing Cancer – topic. (AT) L's are attentive, some are writing notes from transparency notes on screen. No internet at the school today ∴ can't use laptop & data projector for aids. Most L's are listening, paying attention. (AT) Much reference is made to work related to lesson that will be covered in Gr. 12. eg. Genetic variation & Human reproduction (conception). Related to Mitosis (PCK) (EXP)
11:35	T asks if L's have any Q's – there are none.

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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

Refl

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Continue recording salient events here.

Time	Description of Events
11:40	Reference made by T to prior K + lessons already covered - DNA.
PK	T asks if L's have heard of cancer before. Active participation from L's -
P	they feel comfortable, T encourages this kind of dialogue. 1 ♀ L mentions that she has heard abt some people
IK	who eat lemons when they have cancer. T directed lesson towards this kind of interaction. (T asked what people did before they knew abt chemotherapy). T explains that this kind of information is known as IK + how people pass on this info. from 1 generation to another. T also says that a lot of IK has been lost as it has not been parred down - he encourages
IK	L's to chat to their grandparents to find out how they would treat cancer before modern medicine
11:50	T also refers to smoking - makes it relevant to L's by cautioning them abt hoping he is not talking to smokers!

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Relev. Also talks about X-rays + what have L's observe when they go to hospitals for X-rays - steers this towards cancer causes.

11:55 T demonstrates diff. bet. recreational drugs + medicinal drugs - links to carcinogens.

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)

+ve Interaction (L)

Additional comments you may wish to make about this lesson.

The vast experience of the T & his Masters qualification gives him the ability to control the class & direct the lesson towards what the aim of the topic was.
T also draws on K of History L's abt atomic bombs & their effect on mutations.

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APPENDIX J2: RTOP INSTRUMENT –LESSON OBSERVATION TOOL

(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

Location of class

Years of Teachin

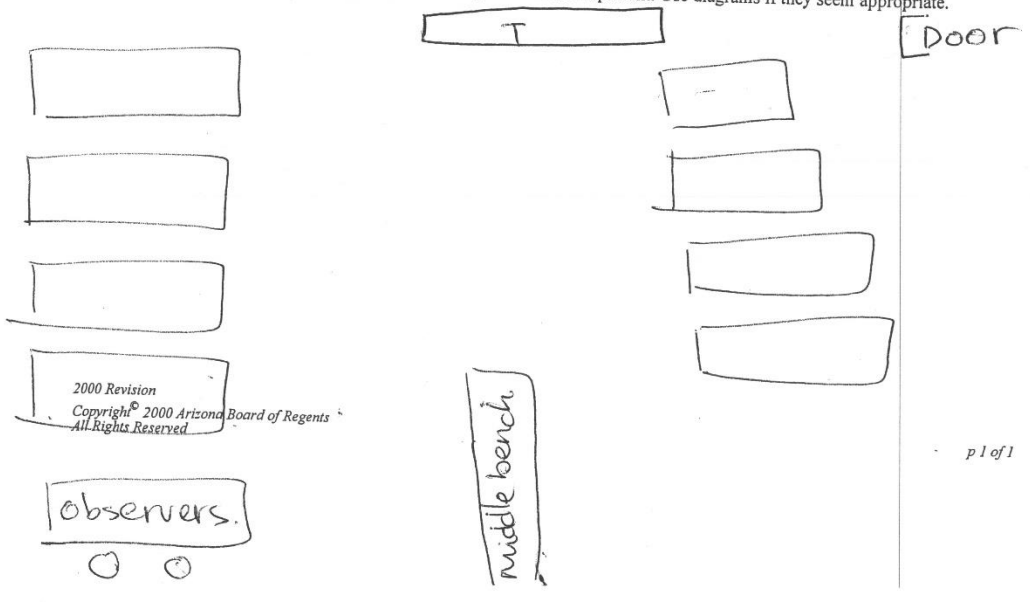
Subject observed LS (K-8 or 7-12) Grade level 10

Observer C. Reddy Date of observation 05/08/17

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.



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Lab technician → helps to set up pracs. Also manages & tends to greenhouse Some indigenous plants

Record here events which may help in documenting the ratings.

Time	Description of Events
9:26	L's enter class quietly & greet the T.
9:30	PPT on types of photosynthesis.
WK	worksheet given.
10:10	Dismissal – organised way. Announcement for Revision class after school.
	Q from L's on dogs urinating on grass & grass turning yellow. T explains possible reasons why.

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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

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Continue recording salient events here.

Time	Description of Events
	Students allowed (F) to interact by explaining flower is at home - after talking through what she was seeing, she came upon the name - Cerariums. Friendly atmosphere - Ls feel comfortable to interact, giving their answers with no fear of ridicule. T is able (E) to dispel misconceptions with explanations on photosynthesis (PS) with C3 & C4 plants. Impt. link PCK to relevance to Global warming. Also relevance of sugar-cane IK & its benefits for the health (IK - infusion). It grows in Dbn (Identified by Indian L). T explains ~~various~~ functions of Yellow Nut Sage (common clover) - does not. chewing on lower stem. (K) Poppy → invasive weed - alien - link to C4 type of PS → damages soil - uses up nutrients. 1 L eating crisps in class in full view of T. → T allows it.

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V. CLASSROOM CULTURE

		Never Occurred				Very Descriptive
	Communicative Interactions					
16)	Students were involved in the communication of their ideas to others using a variety of means and media. Yes – no.	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.

CAM plants – more ~~invasive~~ in Karoo (77% in Karoo) – deserts.

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APPENDIX K: EXTRACT FROM A PORTFOLIO SUBMITTED BY TEACHERS AFTER THE LENASIA SLP

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QUESTION 6 CL

THEME/AIM: EXPERIMENT TO DETERMINE THE ACIDIC NATURE OF SOME FRUITS

SCENARIO/ HYPOTHESIS: SOME FRUITS CONTAIN MORE ACID THAN OTHERS TO PROTECT THEM FROM INFECTIONS (DEFENCE MECHANISM).

INTRODUCTION

South Africa possesses a large diversity of indigenous food crops, including grains, leafy vegetables and fruit types. These crops are produced and found growing in the country under various weather conditions. Their production within the rural farming communities is on small scale and is mainly for subsistence purposes (Thabo, 2013). A number of fruits which are indigenous and exotic are grown, have a great benefit on the health of the people around the country, some of these fruits are acidic, neutral and alkaline. Fruits are the perfect food and are packed with vitamins, nutrients, anti-oxidants and phyto-nutrients (Van Wyk and wink, 2012). Some of acidic fruits include lemon, oranges, pineapple, tomatoes and others, others than the benefits mentioned above fruits have other unique benefits that's why they have been used traditionally for a long time, they include Protection of the body from Diseases, Protect Yourself From Disease, Lower Cholesterol as dietary fibres from fruits help reduce blood cholesterol, The soluble dietary fibres in fruits help maintain proper bowl function, reduce constipation, and reduce diverticulitis, fruits help in Fighting Colds and Flu and Making Healthy Babies Fruits are high in folate (folic acid) which helps the body form red blood cells, fruits aid in in the body getting Hydrated as Whole fresh fruits are naturally water-rich, containing the world's most purest form of water (Thabo, 2013).

LESION DEVELOPMENT:

APPARATUS/MATERIAL

- Fruits (orange, tomato, lemon, pineapple)
- Test tubes
- Pepsin
- Test tube rakes
- Droppers
- 6 beakers
- Trough
- Egg
- Water bath
- Sodium hydroxide
- Copper sulphate

LEMON

PINEAPPLE

TOMATO

ORANGE

Procurers

1. Wash the fruits in a trough separately with fresh water.
2. Cut the fruit and peel it off and crush the pericarp
3. Add some 50cm^3 of water to obtain an extract
4. Prepare a 50cm^3 of solution made of protein like using an egg
5. Repeat the procedure 1 to ^{3} for all the fruits
6. Add 6cm^3 of the each extract to the test tube and label the test-tube 1 to 5
7. Add the 3cm^3 of a protein solution
8. Put the test tubes in a water bath for 20min at a temperature of 35ºC to 37ºC
9. Remove then and 2cm^3 of sodium hydroxide followed by 2 to 3 drops of cupper II sulphate.

Observations

The learners should be able to identify that the colour of copper II sulphate will change depending how acidic the fruit solution will be. Either will be deep purple, slightly purple or remain blue due to the amount of protein which were found.

Conclusion

Learner should be able to relate the observation with the aid and their hypothesis like the deeper the purple colour the higher the amount of protein present and the lesser the acidic nature of the fruit.

CONCLUDING PHASE

Discussion

Learners should be able to discuss their results in this line; Pepsin work best in acidic conditions, if the fruit solution is more acidic, it will give pepsin a more favourable condition to work best hence more proteins will be converted to peptides (Clitheroem, *af el.*, 2014). (Less protein will remain) and the lighter the colour of copper II sulphate will be after being added to the testing fruit solution. The test tube were the no fruit solution was added acted as a control experiment as no protein was converted due to the medium was not favourable for pepsin to act on protein hence had the deepest purple colour after adding copper II sulphate solution.

a) Why do we need to know the acidic nature of the fruits?

The acids protect the fruits from pathogens or invaders, these acid are also beneficial to our body to work properly like ascorbic acid (vitamin C). Which can important for skin and immunity among others (Isaac, 2014[1]

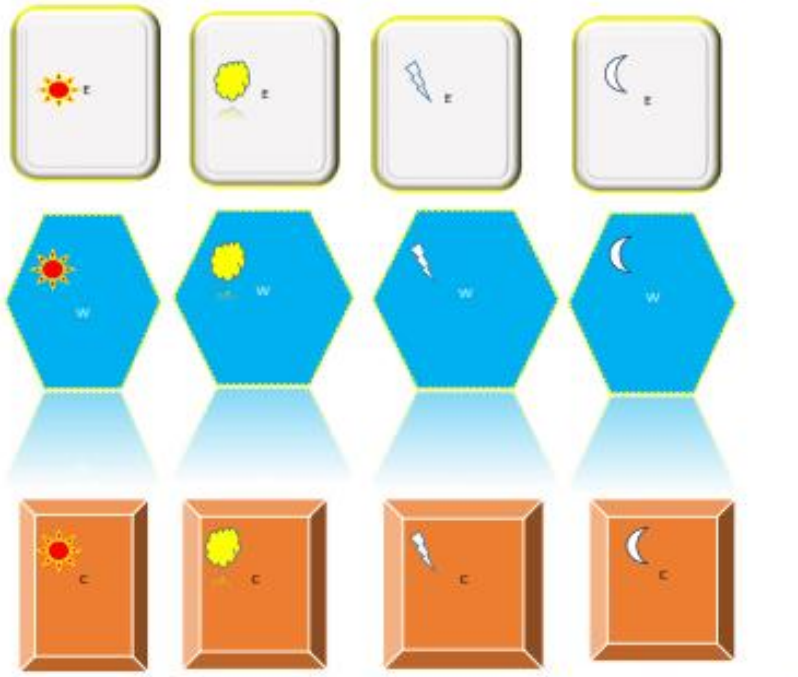
b) How is this related to the indigenous knowledge?

Fruits were being recommended by our elders, and were even collected from the wild due there benefits to our body. The most medicinal component in them is the acids found in them. (Thabo, 2013).

What went well?

- Learners were excite as they were dealing with the samples they know, they could see the colour changes and

CLASS ORGANISATION.



The expert group is identified basing on weather condition ie , , and

Home group will be based on the direction or position ie east (E) west (W) or central (C)

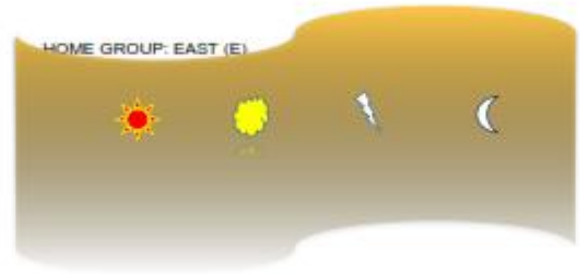
Those with read Camplotheca acuminata

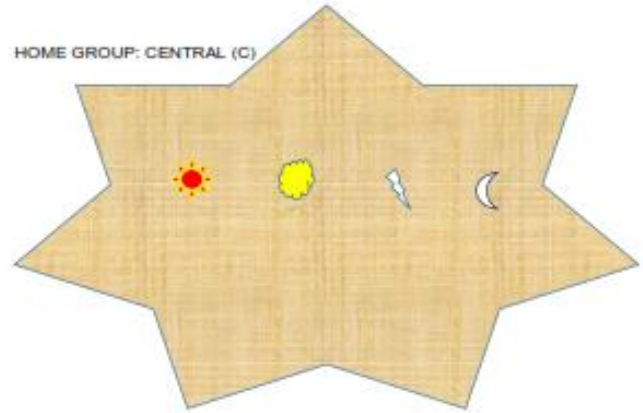
Those with read Sutherlandia frutescens

Those with read Aloe vera

And those with Tinospora cordifoli

After studying from their expert group go back to their home group for their discussion as follow.





APPENDIX L POWERPOINT PRESENTED AT LENASIA SLP

SHORT LEARNING COURSE – LENASIA:
Ayurveda – an ancient yet relevant Indian Indigenous Knowledge

Date: 3rd July 2017

Prof Josef de Beer; Dr Neal Peterson and Mrs Camantha Reddy

SDL

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

AN INTRODUCTION TO AYURVEDA

- An ancient system of medicine – originated in India almost 6000 years ago.
- Sanskrit – language in which Ayurveda has been communicated
- Originally transmitted orally from teacher to pupil, later on extensively documented in various texts.
- Oldest is in the Rig Veda; Charaka Samhitha and Susrutha Samhitha.

Ayur means life and Veda means science, precisely Ayurveda is ancient Indian life science. Practiced in India, China and ancient civilizations for over 6000 yrs. Ayurveda is not just a medicine, but life style. Even as the traditional system of healing finds more takers at home, people globally are realizing its benefits.

Ancient teaching method: oral transmission from Guru (teacher) to students

AN INTRODUCTION TO AYURVEDA

- Is not confined to Hinduism – Ayurveda is applicable to all of humanity (NOT linked to a religion!!)
- Meaning of Ayurveda: Ayur = life; Veda = knowledge → Knowledge of life/ Life Science
- A holistic practice (way of life) – emphasises prevention of illness instead of treatment of symptoms, goes to root of illness
- Does not profess to cure all diseases but can complement allopathy
- 8 branches of Ayurveda – internal medicine; surgery, paediatrics; reproductive health; head and neck; toxicology; rejuvenation; astrology

SCIENTIFIC BASIS OF AYURVEDA

Five basic principles on which Ayurveda is based:

1. Ayurveda is based on the premise that the universe and all living organisms are made up of five elements: air, fire, water, earth and ether.

- Referred to as the *Panchamahabhuta*.

Ayurvedic doctor performing surgery in ancient times

RELATION OF THE FIVE ELEMENTS TO THE THREE ENERGY PRINCIPLES IN THE UNIVERSE

STRUCTURE OF UNIVERSE		FUNCTIONS IN UNIVERSE
Ether (space)	WIND	Principle of propulsion, movement
Air (motion)		
Fire (energy)	SUN	Principle of conversion, transformation
Water (cohesion)	MOON	Principle of cooling, cohesion or preservation
Earth (mass)		

2. These elements occur in humans in different proportions resulting in the three "*doshas*", or energies: *Vata, Pitta* and *Kapha*. Called the Tridosha Theory – the crux of Ayurveda

Relationship between DOSHAS and ELEMENTS

Vatta - space and air	Pitta - fire and water	Kapha - water and earth

Doshas are therefore the biological expression of the 5 elements

DOSHA FUNCTIONS IN THE BODY

Functions	
DOSHA	**NORMAL FUNCTION**
Vatta	Energy, inspiration, expiration, actions, mechanism of impulse, proper functions of dhathus (tissues) and of indriyas (senses).
Pitta	Digestion, body temperature, hunger, thirst, taste, beauty, intellect, grasping power, courage, body softness.
Kapha	Stability, unctuousness (lubrication), strength of joints.

GENERAL PROPERTIES OF EACH DOSHA

The thridoshas

Vatha — dosha of degeneration

Pitta — dosha of sustenance

Kapha — dosha of generation

3. BODY TISSUES (DHATUS)

NAME OF TISSUE	FUNCTION	CONTROLLED BY
Rasa (CHYLE)	Nutrition	Kapha
Rakta (BLOOD)	Oxygenation	Pitta
Mamsa (MUSCLE)	Movement	Kapha
Medas (FAT)	Lubrication	Kapha
Asthi (BONE)	Support	Vatta
Majja (BONE MARROW)	Support	Kapha
Shukra (REPRODUCTIVE)	Reproduction	Kapha

4. METABOLIC WASTE PRODUCTS (MALAS)

- Ayurvedic principles also place great importance on the proper production and excretion of metabolic waste products.
- There are 3 main waste products: faeces; urine and sweat.

5. BIOLOGICAL POWER (AGNI)

- Ayurveda emphasises the role played by the 13 different types of energy in the body.
- Each tissue has its own energy (=7)
- Each element has its own energy (=5)
- The main energy is that controlling DIGESTION (=1)
- These energies are responsible for all the metabolic activities in the body.
- Ayurveda regards the role of food and its proper digestion as being paramount in determining one's health and well-being.

ILLNESSES IN AYURVEDA

- A healthy person, as defined in *Sushruta Samhitha*, one of the primary works on Ayurveda, is "one whose *doshas* are in balance, appetite is good, all tissues of the body and all waste products (malas) are functioning properly, and whose mind, body and spirit are cheerful..."
- Ayurveda is therefore a holistic practice that focuses on all aspects of a person – their mind, body and spirit.
- Ayurvedic texts → ailments or illnesses result from a vitiation of the doshas. (vitiation = disturbance).
- Vitiations can occur due to an accumulation of toxins; incorrect dietary or other lifestyle habits.
- Ayurvedic treatments attempt to balance the doshas for good health to be restored by advocating diet/ lifestyle changes or in more severe cases, various cleansing processes are administered.

Vatta	Pitta	Kapha
1. Controls basic functions eg cell division; mind; breathing; blood flow; heart function; ability to get rid of body waste through the gut.	1. Controls digestion; ability to break down foods (metabolism); certain hormones linked to appetite	1. Controls muscle growth; body strength and stability; weight; immune system
2. Disrupted through: eating dry fruit; eating too soon after a previous meal; fear; grief; staying up too late	2. Disrupted through: eating sour/ spicy foods; fatigue; spending too much time in the sun	2. Disrupted through: daytime sleeping; eating after stomach is full; consuming salty or watery foods/ drinks; greed
3. Tendency to develop: anxiety; asthma; heart disease; nervous system disorders; rheumatoid arthritis; skin problems.	3. Tendency to develop: anger and negative emotions; Crohn's disease; heart disease; heartburn a few hours after eating; high blood pressure; infections	3. Tendency to develop: Asthma and other breathing disorders; cancer; diabetes; nausea after eating; obesity

ILLNESSES IN AYURVEDA (contd...)

- Besides food, good health is also achieved by following specific **rituals daily and according to the season**. This will be discussed later.
- If there is an accumulation of toxins in the body, then a cleansing process known as *panchakarma* is recommended to purge these unwanted toxins. This fivefold purification therapy is a classical form of treatment in Ayurveda. These specialized procedures consist of the following:

1. Therapeutic vomiting or emesis (*Vaman*)
2. Purgation (*Virechan*)
3. Enema (*Basti*)
4. Elimination of toxins through the nose (*Nasya*)
5. Bloodletting or detoxification of the blood (*Rakta moksha*)

?

Shiro Vasthi

An Ayurveda treatment – *Nasya*. Inserting drops of oil into the nose to treat headache, insomnia and other diseases of the head

AYURVEDIC OIL MASSAGE

DAILY ROUTINE - *DINACHARYA*

- Appropriate daily regimes should be followed the Ayurvedic way for good physical, mental and spiritual health.
- *Brahma muhurta* - The best time to wake up every day to gain knowledge – fresh, pleasant air and the best time to attend to natural urges; do not avoid answering nature's call!
- Advisable to drink a glass of warm water to activate sluggish bowel.
- Ayurveda prescribes how teeth should be brushed, tongue scraped and mouth gargled daily to prevent build-up of Kapha and ensure mouth is fresh; tongue swelling is reduced and taste is enhanced.
- Medicated smoke inhalation – reduces excess kapha and clears head – recommended for headaches and insomnia
- Exercise: daily walks increase lifespan, strengthen intelligence, enhances peristalsis and digestion, increases health of sense organs; yoga – postures to tone and strengthen muscles and joints
- Abhyanga (oil massage) – nourishes the 7 body tissues; improves skin and muscle tone. Can be done for self; warm sesame oil is best.

DAILY ROUTINE – *DINACHARYA (continued)*

- Benefits of oil massage – delays ageing process, promotes skin rejuvenation, decreases Vatta diseases; increases blood circulation and skin complexion; good sleep results.
- Benefits of foot massage – removes muscle stiffness/ numbness of legs; prevents cracking; relaxes and strengthens feet; prevents sciatica and cramping of feet
- Head massage – coconut oil with curry leaves massaged into scalp promotes hair growth, prevents premature greying and hairfall. Gives good complexion of face and skin. Wash off after 20 minutes to prevent dandruff and stickiness.
- Herbal dry powder massage – eliminates Kapha and can be done to lose weight and for treatment of varicose veins; dilates blood vessels, prevents rashes and itchiness. Usually done before oil massage, but can also do after to remove excess oil. Some powders used: dry ginger, triphala, cassia plant.

AYURVEDA DRY POWDER MASSAGE

Ayurvedic plant	Scientific name	Health benefits
Triphala (mixture of 3 plants – amla, myrobalan (Harada) and belleric myrobalan (Bihara) – fruits are dried and then powdered together)	*Emblica officinalis, Terminalia chebula and Terminalia belerica*	Anti-oxidant and immune-enhancing properties. Used in treatment of infections caused by drug-resistant pathogens, diabetes and recurrent rhinitis.
Guggul	*Commiphora mukul*	Arthritis, hemorrhoids, and urinary tract infections. Guggul is also publicized as a remedy for acne, as well as a weight-loss stimulant.
Fenugreek	*Trigonella foenum-graecum*	Type 2 diabetes, arthritis, inflammation, alopecia, muscle pain, gastrointestinal disorders, and skin ulcers
Turmeric	*Curcuma longa*	Stimulates digestion, boosts liver function, and regulates menstruation; can help prevent cancer; arthritis; eczema; heartburn; ulcers, gallstones; kidney stones.

Triphala

Guggul

Fenugreek (Methi) Leaves and Seeds

AYURVEDIC DIETARY GUIDELINES

- **Eat according to your body type/dosha:**

Choose foods that have the opposite qualities to the dosha that you want to balance. Thus if you have a prominence of Vata in your nature (cold, dry skin, restlessness, worry, light sleep, etc) it is necessary to keep Vata in balance by favouring warm, moist, oily, heavy, sweet, sour and salty foods and by reducing (but not eliminating) cold, dry, light, pungent, bitter and astringent foods.

- **Examples of foods of the six tastes (rasas):**

Sweet: Sugar, milk, bread, rice, wheat, pasta.
Sour: Yoghurt, cheese, sour fruits, tomato
Salty: Salt.
Pungent: Spicy foods, cumin, ginger, peppers, chillies
Bitter: Green leafy vegetables.
Astringent: Beans, lentils, pomegranate, some apples.

Turmeric

Eat by your Body Type / Dosha

Dosha	Decrease/balance	Increase/aggravate
Vata	Warm, moist, oily, heavy, sweet, sour, salty	Cold, light, dry, pungent, bitter, astringent
Pitta	Cool, heavy, oily, sweet, bitter, astringent	Hot, light, dry, pungent, sour, salty
Kapha	Warm, dry, light, pungent, bitter, astringent	Cold, moist, oily, sweet, sour, salty

Dosha specific recommendations: Vatta diet

Dairy products: All dairy products pacify Vata. Do not take milk with a full meal. Cheese should be soft and fresh.
Fruits: Favour sweet, heavy fruits, such as avocados, grapes, cherries, peaches, melons, berries, plums, bananas, sweet oranges, pineapples, mangoes and papayas. Avoid or reduce dry light fruits such as apples, pears, pomegranates, cranberries and dried fruits. (Dried fruit can be taken first soaked in hot water. Dates are best taken with ghee).
Sweeteners: All sweeteners are good for Vata (but not in excess).
Beans: Avoid all beans except for tofu, (soybean curd) and mung dhal (split mung beans).
Nuts: All nuts are good.
Grains: Rice and wheat are very good; reduce barley, corn, millet, buckwheat, rye, and oats.
Oils: All oils pacify Vata.
Spices: Cardamom, cumin, ginger, cinnamon, salt, cloves, mustard seed, and small quantities of black pepper pacify Vata.
Vegetables: Beets, carrots, asparagus, cucumber, and sweet potatoes are good, but they should be cooked and not raw. The following vegetables are alright in moderate quantities, if cooked and especially cooked with ghee (clarified butter) and Vata reducing spices: peas, green leafy vegetables, broccoli, cauliflower, celery, courgettes and spinach (small quantity). It is best to avoid sprouts and cabbage.

Dosha specific recommendations: Kapha diet

Avoid large quantities of food, especially at night.
Dairy products: Avoid aged cheese. Avoid or reduce other cheeses and yoghurt. Low-fat milk is better. Always boil milk before you drink it, and take it warm. Do not take milk with meal or with sour or salty foods. You may add one or two pinches of turmeric or ginger to whole milk before boiling.
Fruits: Favour lighter fruits such as apples and pears. Reduce heavy or sour fruits such as oranges, bananas, pineapples, figs, dates, avocados, coconut, and melon.
Sweeteners: Honey is good (but do not heat it above 400C). Avoid sugar products.
Beans: All beans are fine except tofu (soya bean curd).
Nuts: Avoid all nuts.
Grains: Most grains are fine, especially barley and millet. Restrict use of wheat, rice and oats.
Oils: Reduce or avoid all oils. A small amount of ghee (½-1 tsp/day) is fine.
Spices: All spices are good but restrict the use of salt.
Vegetables: All are fine, except tomatoes, cucumber, sweet potatoes and courgettes.

Dosha specific recommendations: Pitta diet

Dairy products: Ghee (clarified butter), milk, cream, and cream cheese, are good. Avoid salty butter and sour milk, e.g. yoghurt, aged cheeses.
Fruits: Sweet and astringent fruits are good e.g. grapes, pomegranates, bananas, avocados, mangoes. Avoid sour fruit, e.g. most citrus (a little lemon is alright).
Sweeteners: White or semi-refined sugars are good. Avoid molasses and brown sugar. Honey can be taken in small quantities.
Beans: Mung dhal and soybean are good.
Nuts: Avoid all nuts except coconut.
Grains: Wheat, rice, barley, and oats are good. Avoid millet, corn, buckwheat and rye.
Oils: Ghee is best for pacifying Pitta.
Spices: Coriander, cumin, ginger (small quantities), turmeric, saffron, fennel, cinnamon, cardamom. Avoid black pepper, mustard seed, cloves, and chillies.
Vegetables: Asparagus, courgettes, cauliflowers, broccoli, cabbage, green beans, potatoes, sweet potatoes, peas and peppers are good. Reduce beets & carrots and avoid tomatoes.

Special advice

Milk: It is not recommended to take milk with a meal made up of mixed tastes especially salty and sour foods. It can be taken with sweet foods including grains. Milk is easier to digest after being boiled with spices such as ginger, black pepper, turmeric, and saffron.
Honey: Do not heat honey above body temperature (400C). Doing so decreases the benefits of honey and actually causes it to have a negative impact on health.
Food best avoided: Minimize heavy foods (e.g. meats, especially red meat, fish, eggs, aged cheese), refrigerated and ice-cold foods and drinks (they depress digestion), raw vegetables (easier to digest when cooked) and alcohol.
Tea and coffee: Minimize tea and coffee consumption. The negative effects of both can be reduced by adding a little cardamom powder.
GMOs: It is strongly recommended that you avoid food that has been produced using genetically modified ingredients. Genetic modification of food disrupts the intelligence of the food and is very likely to produce subtle deleterious effects in the long-term.
Organic agriculture: Organic food is strongly recommended. It has more sattva – balance producing quality.

Food preparation

- Eat freshly prepared food, preferably organic. Avoid GM food, leftovers, pre-cooked and fast food.
- Food is best if warm and well cooked.
- The food should look good and taste delicious.
- Food prepared by a happy settled cook in a pleasant environment will have the greatest nutritional value!

A few spices and herbs to be used in food preparation to enhance taste, appearance and digestion.

When and how to eat

Ayurveda emphasizes the great importance of a good digestion for health and holds that how and when you eat is as important as what you eat.

It recommends.....

- Eat in a settled atmosphere and savour your food – sit, don't stand and avoid TV, radio and reading. Let your attention be on the food.
- Be regular in your meal times and eat your main meal in the middle of the day when the digestive fire is at its strongest. Eat lightly in the evening at least 2 hours before bedtime.
- Do not eat until the previous meal has been digested.
- **Eat moderately:** avoid overeating and do not skip meals.
- Avoid sour foods (yoghurt, soft and hard cheese, buttermilk) at night. (Lassi is ok)
- Walk for 10 minutes after meals.
- Exercise without strain daily. Leave 30 minutes after exercise before eating and do not exercise energetically for 1-2 hours after a main meal.

THE THEORY OF SIGNATURE

- states that by careful observation one can learn the uses of a plant from some aspect of its colour, form or place of growing
- Lungwort, due to the spots on its leaves was related to Pulmonary complaints. Plants with yellow flowers or roots, such as Goldenrod were believed to cure conditions of Jaundice by the signature of colour.

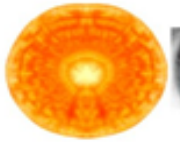
- Plants with a red signature were used for blood disorders.
- The petals of the Iris were commonly used as a poultice for bruising because of the signature of colour, the petals resembling in hue the bruise they were to alleviate.

THE THEORY OF SIGNATURE (continued)

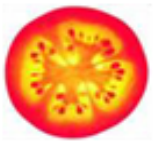
Apart from the signature of colour was that of form. If a portion of a plant resembled an organ or other part of the Human Anatomy, it was believed to be beneficial to that part

Eg:

A sliced **Carrot** looks like the human eye. According to science, eating carrots greatly enchances blood flow to the eyes. Carrot gets their orange colour from a plant chemical called *beta-carotene*, which reduces the risk of developing cataracts. The chemical also protects against macular degeneration an age-related sight problem that affects one in four individuals over the age of 65. If one tries to pop a pill of beta-carotene it doesn't have the same effect, says scientists at John Hopkins Hospital in Baltimore, USA



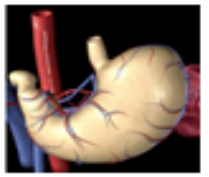
A Tomato has four chambers and is red in colour, so also the heart is red and has four chambers. Research has confirmed that tomatoes are loaded with lycopene and it is indeed pure heart and blood food.



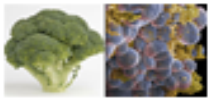
Grapes resembles the alveoli of the lungs. The lungs are made of branches of ever-smaller airways that finish up with tiny branches of tissue called alveoli. These structures allow oxygen to pass from the lungs to the blood stream. A diet high in fresh grapes has shown to reduce the risk of lung cancer and emphysema. Grape seeds also contain a chemical called proanthocyanidin, which is thought to reduce the severity of asthma triggered by allergy. One reason that premature babies struggle to survive is that, these alveoli do not begin to form until 23 to 24 week of pregnancy.

A **Walnut** looks like a little brain, a left and right hemisphere, upper cerebrums and lower cerebellums. Even the wrinkles or folds on the nut are similar to those of the neo-cortex. Scientists claim that walnuts help in developing over three dozen neuron-transmitters within the brain enhancing the signaling and encouraging new messaging link between the brain cells. Walnuts help warding off dementia. They also extract and break down the protein based plaques associated with Alzheimer's diseases, according to a study by Dr. James Joseph of Tuft University in Boston.

Figs are full of seeds and hang in twos when they grow. Studies have shown that Figs increase the mobility of male sperm and increase the sperm count as well as overcoming male sterility.



Ginger looks like the stomach and it also aids in digestion. Indians and Chinese have been using it for over 5000 years to calm stomach and cure nausea, and motion sickness. It also slows down the growth rate of bowel tumors.



Broccoli – the close-up of tiny green tips on a broccoli head looks like 100 of cancer cells. A team of researchers at US National Cancer Institute found if a weekly serving of broccoli was enough to reduce the risk of prostate cancer by 45%.

Kidney Beans actually heal and help maintain kidney function and are shaped exactly like the human kidneys (hence their name).

Celery, Rhubarb, Bok-choy and more look just like bones structure. These foods specifically target bone strength. Bones are made up of 23% sodium and these foods have sodium in them. If you don't have enough sodium in your diet the body pulls it from the bones, making them weak. These foods replenish the skeletal needs of the body.

Brinjals, Avocadoes and Pears are good for the health and functioning of the womb and cervix of the female and look just like these organs. Modern research shows that when a woman eats one avocado a week, it balances the birth hormones, sheds unwanted birth weight and can even prevent cervical cancer. It even takes exactly nine months to grow an avocado from blossom to ripened fruit, just like a human baby! There are said to be over 14,000 photolytic chemical constituents of nutrition in each one of these foods (modern science has only been able to study and name about 141 of them).

Sweet potatoes look like the pancreas and actually balance the glycemic index of diabetics.

Red wine, a source of antioxidants and polyphenols including powerful resveratrol, resembles blood. When you drink it, you're really loading up on the healthy stuff that protects against destructive things in the blood.

Indians – rich traditional knowledge and natural remedies for minor ailments, even carrying seeds of these plants on the long journey to SA; they also adapted by using indigenous plants in KZN for these purposes

Bitter Gourd (karela)

Okra (bindi)

Some of the Indian men after their arrival in South Africa

A few images from the archives....

Indian women processing sugar-cane after cutting

Indian Indigenous Knowledge

- Moves to decolonise education in SA – by including indigenous knowledge and also that of the minority groups – eg. Indians
- Ayurveda and Yoga – 2 examples of Indian Indigenous Knowledge – integration into Life Sciences curriculum to be considered.
- Contributes to improving results in Life Sciences particularly for Indian learners while also informing all learners about the diversity of indigenous knowledge.
- Teachers need adequate PCK to enable effective teaching of Indian Indigenous Knowledge in the Life Sciences classroom.
- Teacher training institutions should "prepare teachers for the implementation of Indigenous Knowledge in the science classroom" (Kibirige & Van Rooyen, p. 237)

APPENDIX M: LIST OF PAPERS WRITTEN BY THE RESEARCHER AS THE MAIN AUTHOR AND PRESENTED AT CONFERENCES

*** Papers with an asterisk were included in DHET accredited proceedings.**

PAPER	CONFERENCE
The integration of Indian indigenous knowledge into the South African Life Sciences curriculum*	ISTE2016
The indigenous knowledge debate in Life Sciences: What about Indian indigenous knowledge?*	ISTE 2017
Indigenous knowledge in the rainbow nation's Life Sciences classrooms: only African indigenous knowledge?	SAARMSTE 2018
Systemic pressures – cutting the wings of Life Sciences teacher development*	ISTE 2018

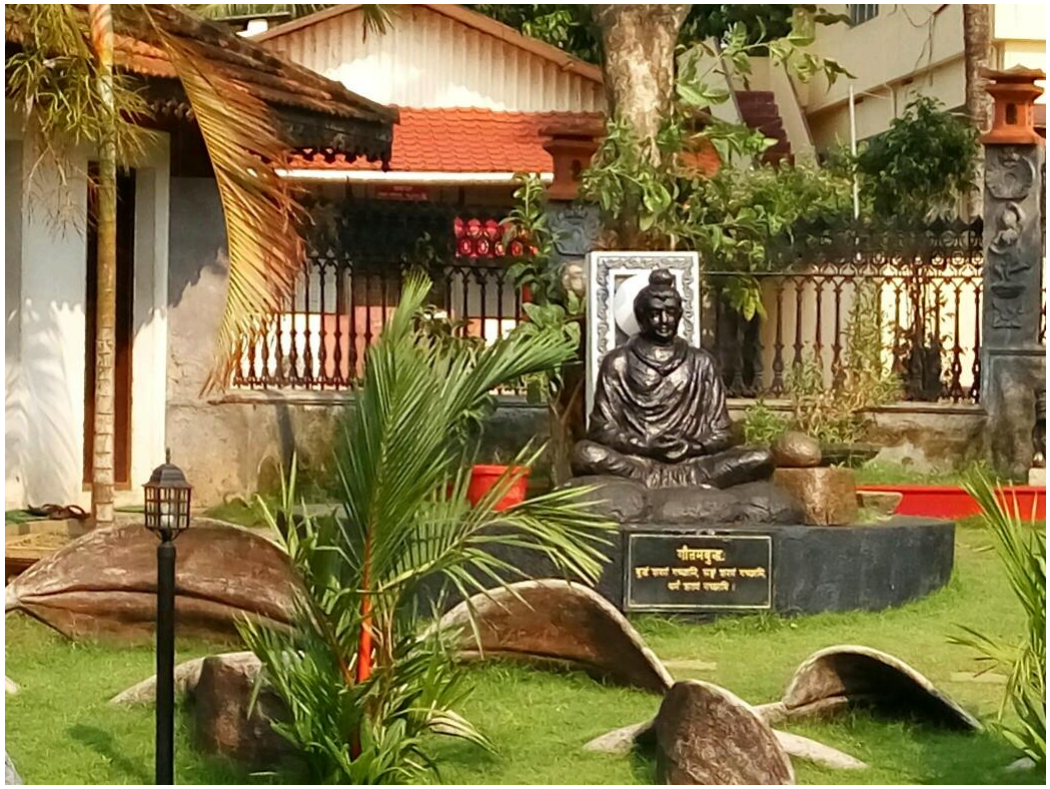
APPENDIX N – LIST OF LINKS TO VIDEOS ON SLPS

1. https://youtu.be/s5gG2olNIBk FOR the use of puppetry in IK
2. https://youtu.be/7d3Zt-ZsGA4 FOR the Calvinia SLP (cycle 3)

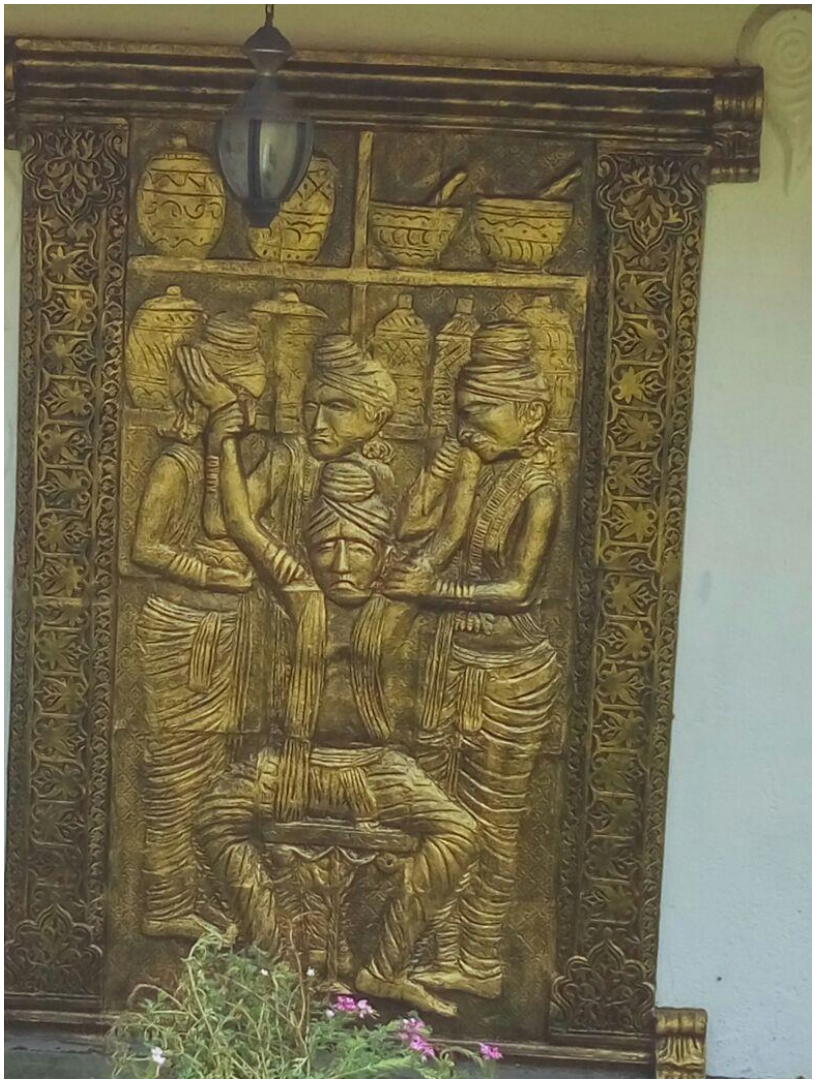
APPENDIX O – THE VAIDYARATNAM EXPERIENCE (Kerala, India, April 2017)

The Vaidyaratnam Foundation in Kerala, India

The founders of the Vaidyaratnam Foundation



Statue of an Ayurveda physician – in the grounds of the Vaidyaratnam Museum



A carving showing people from ancient times treating a patient using Ayurveda remedies

A carving showing the goddess who bestowed the gift of Ayurveda upon the world – carving from the museum in Kerala

Some of the medicinal plants seen at the Ayurveda botanical garden in Kerala

Jackfruit tree bearing several fruit (*Artocarpus heterphylllus*) in the area around the Vaidyaratnam Hospital. These fruit have several benefits nutritionally especially as a meat substitute in vegan diets.