

**Exploring the integration of Indigenous
Knowledge Systems (IKS) into the teaching of Life
Sciences through Information and Communication
Technologies (ICTs)**

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DECLARATION

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

Signature

08/12/2022

Date

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James Clear, the author of *Atomic habits*, wrote “When your screen is loaded with examples of the strongest, wealthiest, and smartest, it’s tempting to overvalue the outcome and undervalue the process.” In the light of the unseen deep side of completing a research project, I would like to thank the team that made remarkable contributions to helped me through my studies.

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ABSTRACT

In the last decade, there has been intensive discussion on the benefits of Indigenous knowledge (IK) in science education. This study investigates incorporating Indigenous Knowledge Systems (IKS) into the teaching of Life Sciences using Information Communication Technologies (ICTs), with the goal of determining whether teachers are applying the skills they learned in the Short Learning Programmes (SLPs) that were conducted for teachers on integrating IK in the teaching of Life Sciences through ICTs. Secondary school Life Sciences teachers who were trained to use smartboards and other technologies to improve teaching and learning made up the study sample. The teachers who took part were from township schools of Tshwane North District of the Gauteng Department of Education, (GDE). The research study is informed by the review of literature on the integration of IK in science education and the use of ICT in teaching and learning of science.

This is a mixed method study with strong emphasis on the qualitative side and quantitative data supports the study, hence it is QUAL-quan study in which teachers were interviewed and lesson observations were conducted. The recorded interviews were transcribed and analysed using a thematic content analysis technique. The Views of the Nature of IK (VNOIK) instrument was used as pre- and post-tests to track any changes that occurred in the teachers' views on IK. Third generation Cultural Historical Activity Theory (CHAT) was used as a lens to interpret the data. CHAT was used as a research lens, to enable to the identification of factors / 'tensions' that limit ICTs supported IK integration in the classroom, as well as how electronic platforms, have either assisted or restricted the implementation of skills that were learnt in the SLPs, on the integration of IKS into the teaching of Life Sciences through ICTs. Although this study is predominantly qualitative, numerical data was collected with the use of the FIT:COM instrument, which uses the Likert scale, therefore there is limited quantitative data (quan) which supports the qualitative data (QUAL).

The main findings that were identified from this study were:

1. Even though teachers acknowledged that the short learning program provided them with some knowledge and skills in employing applicable IK in ICT supported learning, most teachers continue to teach in the traditional method.
2. As indicated by the results on VNOIK before and after intervention tests, in chapter 4 table 4-16, teachers developed more complex understandings of indigenous knowledge during the SLP, the post-intervention statistics, on the other hand, revealed virtually little or no transfer of the acquired knowledge and skills to the classroom.

3. Despite the well-documented benefits of learner-centred incorporation of IK into topic teaching, this study found that teacher-centred, passive teaching practices predominated in the classroom lessons that were observed post the interventions.
4. The CHAT analysis in Chapter 4 demonstrated how systemic pressures undermine the potential affordances of tapping into learners' interests to achieve optimal learning.
5. Teachers appreciate the potential that ICTs may offer to teaching and learning, but in this study, many lack the skills to improve technology, pedagogy, and content (TPACK), and hence are hardly utilizing this opportunity.
6. While the Department of Education supports for the integration of ICTs in teaching and learning, South Africa's digital divide continues to impede internet access.
7. Teachers encounter a range of challenges in ICT-supported learning environments, including a lack of knowledge on how to use the available resources effectively. As a result, it is difficult for them to assist learners to acquire learning skills.
8. There is a lack of internal and external assistance for teachers to build abilities to use available resources effectively.
9. The findings of this study demonstrated that, with a few notable exceptions, most teachers use ICT devices to transmit knowledge rather than to foster self-directed learning, higher order thinking, or 21st century skills

The findings revealed that the short learning programs had an impact on instructors' attitudes and skills, as they recognized the need of making learning interesting and exciting. Post the interventions, teachers were excited to conduct lessons where they have an atmosphere of shared learning goals, which allows interactive participation of learners to promote optimal learning achievements. The reality of the school environment, however, mandates otherwise, as teachers confront systematic pressure to educate for present results, which puts them under pressure to comply with regulation and to produce good results as opposed to producing critical thinkers. The severe scarcity or lack of resources, particularly in poor socioeconomic communities, deprives future generations of important and memorable learning experiences.

KEYWORDS

Integration; Indigenous Knowledge Systems (IKS); Information Communication Technologies (ICTs); Blended learning (BL) and Online learning; Technological, pedagogical content knowledge (TPCK); Life Sciences; Self-directed Learning.

OPSOMMING

Daar is die afgelope dekade 'n lewendige diskoers gevoer oor die voordele van die aanspreek van inheemse kennis (IK) in die wetenskap-klaskamer. In hierdie studie word gepoog om vas te stel in watter mate lewenswetenskappe-onderwysers tydens onderrig IK integreer deur gebruik te maak van informasie- en kommunikasietegnologie (IKT) Lewenswetenskappe-onderwysers in die hoërskool wat opleiding ontvang het in die gebruik van slimvertoonskerms/slimborde en dergelike tegnologiese hulpmiddels om onderrig en leer meer doeltreffend te maak, maak deel uit van die steekproef. Hierdie onderwysers is almal werksaam in township-skole van die Gautengse Departement van Onderwys (GDO) wat binne die grense van die Tshwane-Noord distrikkantoor val. Die literatuurstudie ten opsigte van die integrasie van IK in die wetenskap-klaskamer en die gebruik van tegnologiese hulpmiddels tydens onderrig en leer, het die basis gelê vir hierdie studie.

Dit is 'n gemengde-metode studie wat hoofsaaklik fokus op die kwalitatiewe deel wat ondersteun word deur kwantitatiewe data. Dit kom neer op 'n KWAL-kwan-studie waarin onderhoude met onderwysers gevoer en waarnemings tydens lesaanbieding gedoen is. Die onderhoude is opgeneem, getranskribeer en geanaliseer deur die aanwending van 'n tematiese analise-tegniek. Die *Views on the Nature of IK (VNOIK)*-instrument is gebruik as pre- en post-toetse om vas te stel of daar enige veranderinge voorgekom het ten opsigte van onderwysers se sienings van IK. Die derde-generasie Kultuur-Historiese Aktiwiteitsteorie (*Third Generation Cultural Historical Activity-teorie, ofCHAT*) is gebruik as 'n lens om data te interpreteer en om faktore te identifiseer wat beperkings plaas op die integrasie van IK in die klaskamer deur middel van IKT, asook om te bepaal of elektroniese platforms onderwysers se implementering van vaardighede wat tydens die Kort Leerprogramme aan hulle voorgehou is, aangehelp of beperk het. Alhoewel hierdie hoofsaaklik 'n kwalitatiewe studie is, is numeriese data ingesamel deur gebruik te maak van die FIT:COM-instrument en die Likert-skaal vir data-beoordeling.

Die volgende bevindings spruit voort uit die studie:

1. Alhoewel onderwysers toegee dat kort leerprogramme hul toegerus het met kennis en vaardighede om IK in die IKT-omgewing aan te wend, het die meeste onderwysers voortgegaan om op tradisionele wyse te onderrig.

2. Die resultate van pre- en post-toetse (*VNOIK*-instrument Hoofstuk 4 tabel 4-16) dui daarop dat onderwysers wel 'n meer gevorderde begrip van IK ontwikkel het tydens kort leerprogramme, maar post-intervensie statistiek dui egter op baie min of geen oordrag van hierdie kennis en vaardighede na die onderrigsituasie.
3. Ongeag goed gedokumenteerde voordele van leerdergesentreerde insluiting van IK tydens onderrig oor sekere onderwerpe, bly passiewe onderwysergesentreerde onderrigptaktyke steeds die onderrigmetode van voorkeur wat na intervensie waargeneem is.
4. Die CHAT-analise (Hoofstuk 4) wys daarop dat sistemiese druk 'n ondermynende effek het op die potensiële voordele wat kan spruit uit die gebruikmaking van leerders se belangstellings ten einde optimale leer te verseker.
5. Onderwysers besef die potensiaal van IKT in die onderrig-leersituasie, maar uit hierdie studie blyk dit dat baie onderwysers nie IKT gebruik nie omdat hulle nie oor die vaardighede beskik om hulself te verbeter ten opsigte van tegnologie, pedagogiek en inhoudskennis nie.
6. Alhoewel die onderwysdepartement die integrasie van IKT in die onderrig-leersituasie ondersteun, bly die gebrek aan internettoegang 'n beperkende faktor.
7. Onderwysers ervaar baie uitdagings in die IKT-geondersteunde leeromgewing, insluitende 'n gebrek aan kennis oor hoe om beskikbare bronne effektief te gebruik. Gevolglik vind onderwysers dit moeilik om leerders te help om leervaardighede te verwerf.
8. Daar is 'n gebrek aan interne en eksterne hulp aan onderwysers om hulle vaardighede om beskikbare bronne effektief te gebruik, uit te brei.
9. Die studie bevind dat, ten spyte van enkele uitsonderings, die meeste onderwysers IKT gebruik om kennis oor te dra, eerder as om dit aan te wend om leerders te help om hoër orde denkvaardighede, vaardighede vir die 21ste eeu en selfgerigte leervaardighede te ontwikkel.

Die bevindings dui daarop dat kort leerprogramme 'n uitwerking gehad het op instruktors se houdings en vaardighede wat geblyk het uit hulle besef dat dit noodsaaklik is om leer beide interessant en opwindend te maak. Nadat intervensie gedoen is, was onderwysers opgewonde om lesse aan te bied waarby leerders aktief betrokke is ten einde optimale leer te verseker. Die realiteit van die onderrigomgewing, byvoorbeeld 'n gebrek aan bronne, sowel as sistemiese druk om goeie resultate te behaal eerder as om kritiese denkers te ontwikkel, het egter hierdie planne belemmer.

SLEUTEWoord

Integrasie; Inheemse kennisstelsels; Tegnologiese; pedagogiese inhoudskennis; Lewenswetenskappe; Selfgerigte leer; Inligting en Kommunikasie Tegnologie; Gemengde leer; Aanlyn leer.

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LIST OF ACRONYMS AND ABBREVIATIONS

CAPS	Curriculum and Assessment Policy Statement
CHAT	Cultural-Historical Activity Theory
CoV	Coefficient of variance
CoP	Community of practice
DoE	Department of Education
ESDC	Embodied, situated, and distributed cognition
EKI	Ethnobotanical Knowledge Index
GDE	Gauteng Department of Education
GET	General Education and Training
IK	Indigenous knowledge
IKS	Indigenous knowledge systems
ICTs	Information and communication technologies
NOS	Nature of science
PBL	Problem-based learning
PCK	Pedagogical content knowledge
TPCK	Technological pedagogical content knowledge
SANBI	South African National Biodiversity Institute
SDL	Self-Directed Learning
SLP	Short learning programmes
STEM	Science
VNOIK	Views of the nature of indigenous knowledge
ZPTD	Zone of proximal teacher development

APPENDICES

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CHAPTER 1 OVERVIEW OF THE STUDY

1.1 Introduction

This study addresses two pertinent issues in the current South African educational discourse. The decolonisation of the curriculum debate has dominated educational discourse the past decade, and in this dissertation, the value of indigenous knowledge is explored as a vehicle of decolonisation. Firstly, indigenous knowledge, when placed at the centre of the educational process, has the potential to transform education and enhance sustainable development (Ndlovu, 2016; Masenya, 2022). Secondly, there is a rapid growth in the use of ICTs to facilitate teaching and learning (Matli, 2020; Keikelame, & Swartz, 2019; Ford, 2020). Contrary to the strong argument raised by Olivier, Van der Westhuizen, Laubscher and Bailey (2019), on the affordances of technology for teaching indigenous knowledge, South African education still lacks in exploiting the great potential of its rich indigenous knowledge for teaching, (Sebotsa, 2020; Matli 2020). In this study, the focus is on exploring the integration of indigenous knowledge into the teaching of Life Sciences through ICTs.

Indigenous knowledge systems (IKS) have been specified as a basic principle in the South African school curriculum, National Curriculum Statements Grade R-12 (2012:10) as “this could be a vehicle to contextualise the science curriculum for culturally diverse South African learners.” It is important to explore, what South African teachers’ experiences of integrating indigenous knowledge in the teaching of Life Sciences through using ICTs are, and what the challenges are that teachers face in this regard. Teachers who readily integrate ICTs in their classroom, according to Judson (2006), are more likely to have a constructivist teaching approach, which involves learners actively producing knowledge rather than passively receiving information. As a result, it has piqued my curiosity to explore the integration of indigenous knowledge in the teaching of Life Sciences through ICTs.

South Africa has a diverse and rich archive of indigenous knowledge (Masenya, 2022). Indigenous knowledge, according to Ngulube (2002), is primarily tacit and derives from local experiments, ideas, inventiveness, and experiences imprinted in the thoughts and behaviours of communities with long histories of close interaction. “Indigenous knowledge encompasses cultural, traditional and community knowledge created and owned by local people in their respective communities and passed down from one generation to the next via practice and oral transmission” (Govender et al., 2013: 157). Masenya (2022:1-3) strongly argues that “this knowledge must thus be always preserved and decolonized for the benefit of indigenous communities.” According to Jackson, (2019), including indigenous knowledge into the curriculum may better prepare Natural Sciences and Life Sciences teachers in South Africa for integrating indigenous knowledge with scientific material to ignite learners’ interest in learning science. It is on this background, that the DoE encourages valuing indigenous knowledge systems by acknowledging the rich history and heritage of this country,

furthermore, according to DoE (2011:5), "in Life Sciences, indigenous knowledge 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."

"The implementation of the Curriculum and Assessment Policy Statement (CAPS) curriculum (hereafter referred to as the CAPS curriculum) falls in an era where the South African Department of Education (DoE) encourages the use of Information Computer Technology (ICT) in schools", DoE (2004:7-11; DoE, 2018:9-10). "ICTs will play a critical role in both pre-service teacher training and ongoing professional development for working teachers", according to the Department of Education (2004:22); (DoE, 2018:9-10). According to Olivier, et al.(2019), "since the inception of the CAPS curriculum, the value of IK is clear; nevertheless, IK implementation in the curriculum has been inadequate." "In the Gauteng Province of South Africa, big strides have been made in distributing electronic gadgets such as smartboards and tablets as well as the training of teachers and subject specialists in ICT" (GDE, 2011:16; DoE, 2018:9-10). This provides an opportunity to explore the possibility to assist teachers, who have attended Short Learning Programmes (SLPs), to include indigenous knowledge systems (IKS) in the teaching of Life Sciences, through using ICTs and other technologies such as interactive smartboards, laptops, mobile devices, and other wireless or cable-connected technologies that might aid with information access and perhaps improve teaching and learning effectiveness.

In this study, Life Sciences teachers were involved in short learning programmes on integration of IK and the use of ICTs. The SLPs focused on the pedagogical strategies Life Sciences teachers use in integrating IK with the support of ICTs. Stemming from the SLPs, schools were visited to observe how teachers incorporate new knowledge and skills on integration of IK with the use of ICTs in their classrooms. Interviews were conducted with teachers to understand their experiences in integrating IKS as well as how they experience making use of ICTs in the teaching and learning of Life Sciences.

1.2 Research problem

Life Sciences curriculum developers in South Africa have realised the importance of IK in the teaching and learning of Life Sciences (Dubinsky et al, 2013; Cronje, 2015; De Beer, 2019 and Sebotsa, 2020). Despite the evident importance of IK in education, its incorporation in the curriculum has been limited (Bailey, 2019). The desire for 'Africanisation' or 'decolonisation' of the curriculum, has been a dormant debate since Ngũgĩ wa Thiong'o's (1986) seminal text, *Decolonisation of the Mind*. However, this has gained traction since the #RhodesMustFall violent student protests in South Africa (Le Grange, 2019). Rather than taking a political stance on equal education and epistemic access to the (western) curriculum, I will discuss the benefits of indigenous knowledge in the teaching of Life Sciences using ICTs. Shizha (2016) highlights the need for more contextualised

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science education in Africa. This realisation has led to a change in science education research paradigms where the focus now is increasingly on culturally inclusive science education as a means of making science relevant to learners of all ethnic backgrounds (Aikenhead & Jegede, 1999; Mosimege, 2004; Ogunniyi, 2007, 2008, Cronje, 2015, and De Beer, 2019). This could be argued from a perspective of embodied, situated and distributed cognition (Hardy-Vallée & Payette, 2008).

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As observed by Cronje (2015), several research studies support the importance of integrating IK into teaching natural sciences. Nascent research in neuroscience shows how indigenous knowledge holds affordance in integrating IK into the teaching of science to enhance cognition and the importance of both relevance and multi-modality in learning (Dubinsky et al, 2013). Such research predominantly argues for the infusion of IK from an embodied, situated, and distributed cognition (ESDC), a construct that was coined by Hardy-Valley and Payette, (2008), put into Life Sciences education perspective (De Beer, 2016). South African curriculum developers have recognised the importance of including IKS and created an opportunity for the integration of IKS into the CAPS for the science, technology, engineering and mathematics (STEM) subjects.

While IK has been projected as an authentic body of knowledge that has a place in the science classroom (Ogunniyi, 2008), less effort has been directed to the technicalities of blending IK and school science in the classroom. Teachers struggle to develop pedagogical strategies that will integrate the two knowledge forms that have been projected to be epistemologically diverse yet share several common tenets (e.g., both are empirical and subject to change) (Cronje, 2015). This study – which is part of a larger National Research Foundation-funded (NRF) project – seeks to focus on pedagogical strategies utilising ICTs for the integration of IK into Life Sciences. While the studies done by Jacobs (2018), De Villiers (2018), Reddy (2019), and Sebotsa (2020) investigated the epistemological border-crossing between science and indigenous knowledge, this study looks at how ICTs and blended learning may be utilized to integrate IK into the teaching of Life Sciences.

This research seeks to explore how teachers include IK in the teaching of Life Sciences using ICTs. Learners come to the Life Sciences classroom having a naïve understanding of scientific concepts based on the specific environments in which they live and from their experiences and cultural backgrounds (Cronje, 2015; Jacobs, 2018; De Beer 2019 and Sebotsa, 2020). The role of the teacher is to bridge the gap between preconceived understanding and scientific interpretation or between learners' naïve understandings and scientific concepts (Cronje, 2015).

For ICT integration, teachers need the necessary pedagogical content knowledge (PCK), a concept that was introduced by Shulman (1987), to mediate and promote learning through the Vygotskian (1978) zone of proximal development (ZPD) from a learner's actual development to his/her potential

development to achieve a learner's best conceptual understanding. PCK will be discussed in greater depth in chapter two. This PCK, however, relates to both knowledge and skills in terms of teaching indigenous knowledge, as well as the utilisation of ICTs and blended learning. According to Mishra & Koehler, (2006), the TPCK framework (Technological Pedagogical Content Knowledge) identifies the categories of knowledge that teachers must have to properly integrate technology into their teaching. This study looks at how teachers' TPCK is necessary for effective ICTs-assisted IK integration in the Life Sciences.

A particular focus of this study is to look at the role of ICTs in achieving teacher development in IK. In line with the Gauteng Department of Education's (GDE) strategic plan 2015–2020 (Gauteng Department of Education, 2014), in 2014 the GDE embarked on training teachers to use smartboards – a pilot project that rolled out in Grade 12 township (In South Africa, the term township generally refers to the mostly economically underdeveloped racially segregated urban areas that were historically reserved for non-whites, during the apartheid era.) classrooms from the beginning of 2015. This 'paperless classroom' project made use of ICT and tablets as tools in teaching and learning to keep abreast of international standards on the use of digital information. Such ICTs hold affordances for IK integration in the Life Sciences classroom.

1.3 Keywords and clarification

1.3.1 Integration

Integration is the act of bringing together and incorporating different entities. In this study integration refers to the epistemological border-crossing between IK and Western science, highlighting common principles / tenets, such as both constructs being empirical, tentative and creative (Cronje, 2015; Cronje *et al.*, 2015). The assumption is that both IK and Western science share common tenets and that such epistemological border-crossing in the Life Sciences classroom could provide a richer and more contextualised learning experience for learners (De Beer, 2016). Later in this study, I will shed light on the complexity of such border-crossing, as indigenous knowledge systems also have characteristics that are not well aligned with the tenets of science, i.e., IKS are holistic, and also include metaphysical aspects. This leads to criticism that the inclusion of IK in the science curriculum could lead to pseudo-science (De Beer & Mothwa, 2014; De Beer and Van Wyk, 2012).

1.3.2 Indigenous knowledge systems

Indigenous refers to roots, something natural, innate to culture and an integral part of culture (Jones & Hunter, 2003). IKS refers to the combination of knowledge systems encompassing technology, legal and governance systems (Odora-Hoppers & Makhale-Mahlangu, 1998). Odora-Hoppers highlights that IKS are distinguished by their intense integration of the cultural experiences, values, and historical context of communities. The intricacy with which IKS is deeply immersed into specific communities' traditions, customs, and ancestral experiences, shapes the collective identity and significance of indigenous societies. In South Africa, IKS offers valuable insights into local traditions and societal dynamics, and heritage by embodying the accumulated wisdom and practical understanding shaped by African communities over generations (Department of Education, 2012).

In teaching Life Sciences, IKS would encompass the different cultural and historical knowledge and practices of the South African population. Several opportunities should be given to learners to allow them to learn about the history of science and how science is relevant outside school, as well as provide a baseline for understanding the development of scientific knowledge. "Understanding the applications of Life Sciences in daily life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and science", is addressed in the Life Sciences CAPS curriculum (Department of Education 2012:17). Learners must be introduced to the evolution of science and indigenous information structures from other periods and societies through the CAPS curriculum. Science should provide learners with an understanding of themselves, where they come from and their relationship with the natural environment. Learning should include how people use natural resources and their cultural development to improve human lives. This study particularly focuses on ethnobotany and the rich IK of using medicinal plants, especially in rural parts of the country.

1.3.3 Information Communication Technologies (ICTs)

Mofosi (2021), defines Information and Communication Technologies as the application of educational technologies to enhance and improve the approaches of teaching and learning. ICTs are not stand-alone entities but rather tools that are utilized within an educational context to improve the quality and effectiveness of teaching and learning experiences. ICTs include all technologies used to create, manage, and disseminate information, as well as the internet, wireless networks, computer networks, and other forms of communication, according to Dlamini et al (2019). In keeping with the idea of Jain, (2014), information and communication technologies (ICTs) are currently used to all over the world to manage both intangible and tangible knowledge. "Microelectronics, computer hardware and software telecommunications and optoelectronics such as microprocessor, semiconductors and fibre optics, all enable the processing and storage of large amounts of data, as well as their rapid dissemination through computer networks" (Dlamini et. al 2018: 137). Teachers can utilize various technology tools and platforms to facilitate more engaging, interactive, and efficient teaching approaches, resulting in achievement of teaching and learning goals.

The South African DoE has turned to use ICTs to better teaching and learning while also addressing historical disparities in education. Karsenti, Collin, and Harper-Merrett (2011), on the other hand, argue that this intervention has had minimal impact. According to the 'Action Plan to 2019' report, "there is still a major gap in the system when it comes to the application of ICT to improve the teaching and learning process" (DoE, 2015:14). In a study done on the integration of ICTs in the teaching of mathematics Graham et al. (2020) argues that "integrating ICT into teaching and learning is a time-consuming process that necessitates planning to make learning more relevant and fruitful, furthermore there should be ways to inspire teachers to use ICTs not only to promote teacher productivity but also to foster pedagogical improvements and improve conceptual understanding in teaching and learning."

Lwoga (2009) proposes that utilising ICTs to manage IK can enhances knowledge holders' confidence, facilitates the cross-cultural understanding within communities, and strengthens cultural bonds, particularly in South Africa's culturally diverse context. Ndlovu (2016) finds that teacher beliefs, experience, subject needs, and learner needs all play a part in deciding the value ICTs offer to the teaching and learning experience. The importance of these features indicates and emphasizes the teacher's role as a mediator in bringing instructional value to ICTs in the classroom. "The goal of incorporating ICTs into the classroom is to improve the efficacy of a teacher's instruction and a learner's learning experience, resulting in more productive attainment of curricular learning goals, and better addressing learners' academic needs" (DoE 2004:19).

The white paper on e-education promotes for the use of ICTs as tools to improve teachers' and students' participation in the information society. As a result, ICTs can be used to integrate IK into the Life Sciences classroom. According to the study done by Ojo & Adu (2018), "the management of indigenous knowledge is enhanced with the use of ICTs. Mobile phones and other sophisticated voice and image recording equipment have become more accessible in African communities. This has made them the most appropriate technology for enabling IK access and dissemination" (Dlamini 2018)

1.3.4 Blended learning and online learning

Bosch (2017) states that although Blended Learning (BL) is gaining international acceptance, there is still no universally agreed-upon definition that is widely accepted. Staker (2012) defines blended learning (BL) as the combination of face-to-face teaching and online learning, in which learners have a choice of where and when they study, and the teacher decides the extent of the choice as well as the content which is to be done online and which is to be done in class. However, as Bosch (2017) points out, BL goes beyond simply incorporating technology into the classroom or to determining the appropriate combination of technologies for learning. BL requires the teacher to create a transformative learning environment where critical and intricate learning skills could be developed. Furthermore, BL should be optimally integrated so that the strengths of each component are blended into a unique learning experience that is aligned with the specific context and the intended educational learning outcomes. The University of the Free State (UFS, 2013:5) considers BL "a learning approach that appropriately combines online instructional resources and face-to-face facilitated activities." As stated by Graham (2009), the three most common reasons for mixing learning are (a) to improve learning efficacy, (b) to enhance access to learning materials, and (c) to reduce costs.

In this study, BL refers to the combination of face-to-face short learning courses on IKS and the continued online support that teachers receive and to how teachers make use of face-to-face approaches as well as online interactions with their learners. According to Luna Scott (2015), BL gained popularity in the nineties. Early forms of BL included the distribution of content courses on CD-ROM media or by using cable connection to transmit course content as a video feed.

Currently, the increased access to technology allows BL to be used for learners as well as for teachers' professional development programmes in which teachers get continued support on IKS and technological pedagogical content knowledge (TPCK), Mishra & Koehler (2006). In this study, the short learning programme instructors, have an important role in planning how to integrate science and IK to achieve teacher professional development goals.

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Bakia *et al.* (2009:9) define online learning as “learning that takes place partially or entirely over the internet.” Furthermore, the internet provides access to content and opportunities for online instructor-and-learner interaction. Therefore, learning can be conducted online as a substitution of face-to-face instruction and can happen synchronously or asynchronously.

According to Queiros & de Villiers (2016), online learning needs three key connections: a strong social presence, technical platforms and proficiency, and the tools / resources. The social presence is achieved by providing timely feedback to learners. Furthermore, the interaction between learners and the teacher also improves the element of social presence. Peer-to-peer contact allows learners to exchange information, in the short learning programme, the online conferences will offer teachers an opportunity to research and share information on IK. When teachers transfer these practices to their teaching, learners will participate in online discussion groups and collaborate on projects, as evidenced by their strong social presence.

Websites, video clips, interactive forums, and online chats on social media apps are all examples of online learning resources. Quiero's view on online learning, is consistent with Venter, (2019), who states that online learning affords participating learners (in my short learning programme the subject is the Life Sciences teacher) the opportunity for online interaction regardless of location, background or time.

1.3.5 Self-directed learning

Knowles (1975:19), who is considered the father of self-directed learning (SDL), defines it as follows: “In its broadest meaning self-directed learning describes the process by which individuals take initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies and evaluating outcomes.” Gibbons (2003:2) defines SDL as “any increase in knowledge, skills, accomplishment, or personal development that an individual selects and brings about by his or her own efforts, using any method in any circumstances at any time.”

SDL is an approach to learning which requires self-motivation to make use of available resources to acquire knowledge and skills. With the emphasis on principles supporting SDL, the teacher guides learners to achieve set targets and assists learners to create their own meaning and understanding of knowledge. The learner takes the initiative in the learning task; therefore, learning is the conscious decision of the individual. This study focuses on how Life Sciences teachers acquire and utilise knowledge and skills that are relevant to teaching and learning in a more self-directed way.

1.3.6 Technological, pedagogical, content knowledge

Technological pedagogical content knowledge (TPCK) builds on Shulman's (1986) construct of pedagogical content knowledge (PCK) to include technology knowledge, for effective teaching with technology. According to Koehler and Mishra (2009), teachers' knowledge is divided into three categories: content (CK), pedagogy (PK), and technology (TK). Interactions between and among these three bodies of knowledge, denoted as PCK (pedagogical content knowledge), TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPCK (technological pedagogical content knowledge), are equally crucial. According to Mishra and Koehler (2013) "teacher's contextual knowledge includes anything from a teacher's understanding of accessible resources to the teacher's knowledge of everything that influences teaching and learning, awareness of the context is essential for teachers as teaching and learning takes place in different conditions. The TPCK (Technological Pedagogical Content Knowledge) framework defines the types of knowledge that teachers must have to successfully integrate technology into their classrooms." This study explores how teachers' TPCK is important for effective integration of IK that is supported by ICTs to promote learning in Life Sciences.

1.3.7 Life Sciences

The National Curriculum Statement in the form of CAPS defines "Life Sciences as the scientific study of living things from the molecular level to their interactions with one another and their environment" (Department of Basic Education, 2011a: 13). It also indicates that scientific knowledge develops as people change their knowledge and understanding of the world around them.

Life Sciences is a subject that is learnt from Grade 10 to 12. It builds on the knowledge and skills learnt from the Life Sciences knowledge area of Natural Sciences in the General Education and Training (GET) Grade 4 to Grade 9 phase. This subject offers learners an opportunity to understand the history of scientific discoveries and the relationship between IK and modern science. Learners must acquire a better understanding of how knowledge develops as humans interact with their environment.

1.4 Purpose of the study

The Life Sciences CAPS requires learners to understand the different contexts in which IKS were developed and it requires that the examples that are used in teaching and learning should reflect diverse cultural groups and should be directly linked to the subject content.

The Life Sciences CAPS curriculum offers an opportunity for the teaching and learning of IKS through Specific Aim (SA) 3: "*Appreciating and Understanding the History, Importance and Applications of Life Sciences in Society*" (Department of Basic Education, 2012: 13). The CAPS

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curriculum further outlines that Life Sciences should enable learners to understand that school science is relevant to their lives outside of school and that it enriches their lives. Teachers must adhere to this; however, this is not always the situation.

For instance, the heavily loaded Life Sciences work schedule (an official document issued by the Department of Basic Education) makes it a challenge for teachers to include IKS as required. Most South African classrooms consist of learners from different cultural backgrounds; hence, it is very challenging for a Life Sciences teacher to incorporate IK in the classroom. The dilemma concerns *whose* IK to teach. We should also be wary of IK approaches that do not reflect the nature of science and/or indigenous knowledge (Cronje, 2015; De Beer, 2019). Learners should engage with techniques, such as the Kirby-Bauer technique for testing the antibacterial properties of medicinal plants historically utilized, as proposed by De Beer (2019). This puts a lot of pressure on teachers' PCK. The assumption, therefore, is that a teacher should be a lifelong and self-directed learner who will research the IK of the cultural groups represented in the classroom and learn techniques such as the Kirby-Bauer technique (Mitchell & Cater, 2000). This ideally means that teachers should favour inquiry learning in their classrooms and use modern technologies to foster 21st-century skills.

The South African DoE, in trying to keep abreast of international trends, is expanding the teaching and learning horizon by availing internet and interconnectivity through programmes such as e-learning and ICTs with interactive smartboards. These resources can be utilised to explore the use of BL in which the traditional instruction approach can be combined with digital, online media and independent learning to enable the inclusion of IKS of learners from different cultural backgrounds (Ankiewicz *et al.*, 2015).

The researcher is a Life Sciences subject adviser and works directly with teachers to monitor and support curriculum implementation in the Tshwane North District in Gauteng. This study offers an opportunity for the researcher to contribute to the literary knowledge on the integration of IKS into Life Sciences, the development of SLPs for teacher development and to explore how selected Life Sciences teachers maximise the use of the ICTs they have access to in their classrooms to integrate IKS to enhance teaching and learning.

1.5 Research questions that guide this research

The research question specifies what intrigues one and focuses on what will be studied. It becomes the radar that guides one through the study period as one strives to answer the construct named 'the research question' (Jansen, cited by Maree, 2014:3). According to Jansen (cited by Maree, 2014), the research question is essential since it is an indication of what the study is all about and guides the literature to which the researcher should refer. It helps to maintain the focus of the

research. Cronje (2015) argues that the research question should direct the study and decide on what approaches should be used in the research; this should be outlined in the research objectives.

Given that there is a lack of literature on the topic of the integration of IKS into Natural Sciences (and Life Sciences) using ICTs, this study is guided by the following primary research question:

- How do teachers integrate IKS into the teaching of Life Sciences using ICTs?

The following secondary research questions guide this research:

- How are teachers incorporating the relevant IK of different cultural groups into their teaching of the Life Sciences through the utilization of ICTs?
- What teaching approaches are Life Sciences teachers utilizing to improve the teaching of IK through ICTs?
- To what extent are teachers' classroom practices consistent with what was practiced in the SLPs in terms of integrating IK through ICT-supported teaching?
- What are Life Sciences teachers' lived experiences with integrating IK when using ICTs to teach and what challenges do they face in this regard?

1.6 Aim of the study

The study aims to explore how teachers integrate IK into the teaching and learning of Life Sciences through using ICTs.

1.7 Objectives of the study

The following are the objectives of the study:

- To explore how teachers are integrating the relevant IK of different cultural groups into their teaching of the Life Sciences content using ICTs.
- To explore how the approaches that Life Sciences teachers are using to improve the teaching of IK through ICTs.
- To see how far teachers' classroom practices for teaching IK with ICTs have transformed because of the SLPs.
- To find out what are the Life Sciences teachers' lived experiences with using ICTs to teach IK and the challenges they face in this regard.

1.8 Gaps that this study addresses

The literature reviewed confirms the statement of Cronje (2015) that there is not much work done on the integration of IK into the natural (and life) sciences in South Africa. While there are various studies on approaches in teaching IK (Jacobs, 2018, De Villiers, 2018, Reddy 2019), there is limited work on the use of ICTs in teaching IK. A study on the affordances of technology for teaching IK, undertaken by Olivier, et al.(2019), focuses on the use of technology include IK in various subjects,

Commented [A9]: Caps? Consistent with the use of caps in Life Sciences as this is also a learning area.

guided by the principles of blended, e-learning, and self-directed learning . Cronje (2015) argues that both indigenous and Western knowledge have their own ontology, epistemology, methodology and volition. This results in difficulty for teachers to integrate indigenous and Western knowledge into the science classroom due to underdeveloped PCK, which is required for such epistemological border-crossing.

This lack of PCK often results in cognitive conflict in learners since teachers do not have a nuanced understanding of the nature of science and IK. For example, some teachers have objections to teaching IK (Mothwa, 2011) and this might hinder the conceptual development of learners. Pintrich *et al.* (1993) state that conceptual change is often looked at through a 'cold' and purely cognitive lens. With 'warm' conceptual change (De Beer & Henning, 2010), it is acknowledged that human emotions, worldviews, and belief systems shape conceptual change.

As is the case in other studies in this larger NRF project (Jacobs, 2018; De Villiers, 2018; Reddy, 2019 & Sebotsa, 2020), my study also entailed short learning programmes (SLPs) for teachers. The short learning programmes offered to teachers concentrate on their content and pedagogical development but also focus on their own affective development (e.g., their beliefs about IK). However, to foster both cognitive and affective development, a more longitudinal intervention is needed (e.g., by establishing an online platform to further assist teachers in their PCK development) (Cronje, 2015).

The development of the technological domain of teachers is not given the necessary attention so that they can choose, use and manage technological tools, as a result there is limited integrated TPCK (Voogt & McKenney, 2017). Short learning programmes to focus on teachers' TPCK are needed. Although the CAPS curriculum offers an opportunity in Life Sciences for the integration of IKS, there is not sufficient research that explores what is happening in classrooms to get an understanding of how teachers include IK in lesson delivery.

1.9 Theoretical and conceptual frameworks

This research is based on Vygotsky's (1978) social constructivism and is guided by this theoretical framework. As a research lens, Engeström (1987)'s third-generation Cultural-Historical Activity Theory (CHAT) was used to do a secondary analysis of the data, on the influence of the short learning programmes on reformed teaching practices. The principle of social constructivism underpins CHAT. I used the four stages of Warford's (2011) zone of proximal teacher development to structure the teachers' intervention programme. The stages include self-assistance, expert other stage, internalisation (automatization) and recursion (de-automatisation). These stages in Warford's ZPTD effectively fits well with Knowles's concept of self-directed learning, through which individuals

(in this case, the teachers) take responsibility for their own learning. They do this, “by identifying learning needs, setting learning goals, identifying relevant resources, choosing appropriate learning strategies, and evaluating the outcomes,” (Knowles 1975:19). Through these interventions I intended to develop Life Sciences teachers as self-directed learners. TPCK, IK, integrated use of ICTs, and communities of practice are all part of the conceptual framework in this study.

Whereas I see a theoretical framework as a broader and higher-order construct, the conceptual framework is best explained by Engeström’s (1987) reference to “intermediate theories”. In this study, aspects such as indigenous knowledge, self-directed learning, teachers’ TPCK and blended learning constitutes constructs under the conceptual framework.

1.9.1 Social constructivism as theoretical framework

Vygotsky’s (1978) principles of social constructivism, which are based on the idea that people construct meaning through an interactive process, form the basis of this research. Unique understanding of phenomena comes from a social setting; what is already known is used to figure out new meaning. In the same way, learners have background knowledge, experiences and practices that are informed by IK, and this can be useful in creating meaning when learning Life Sciences (De Beer, 2016).

Life Sciences can be used to broaden learners’ existing knowledge. Teachers need to use interactive methods to guide learners to build on what is already known or perceived to build scientific meaning. This study is therefore guided by social constructivism theory that promotes the active construction of personal meaning and understanding of knowledge as influenced by their own experiences .

Some constructivists, especially Vygotsky (1978), emphasise the shared social construction of knowledge, believing that the particular social and cultural context and the interactions of novice learners with experienced learners enable and scaffold learning. Through experiencing and reflecting on those experiences, a new meaning of phenomena is constructed.

Constructivism as a paradigm or worldview considers that learning is an active and constructive process (Cronje, 2015; De Beer, 2016). Learners are information constructors, who actively create their own representation of reality, where new information and prior knowledge are linked. “The South African curriculum aims to ensure that learners acquire and apply knowledge and skills in ways that are meaningful and relevant to their lives and the curriculum promotes knowledge in local contexts while being sensitive to global imperatives” (Department of Education, 2012:4).

Short courses which teachers attend do not necessarily develop them to their full potential. In this intervention, care was taken to scaffold teachers’ learning across Vygotsky’s (1978) well-known zone

of proximal development (ZPD) or, in Warford's (2011) parlance, the zone of proximal teacher development.

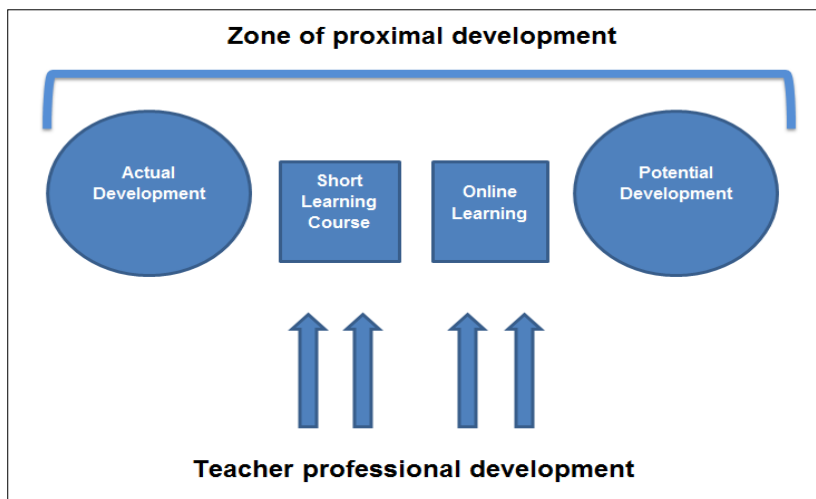


Figure 1-1 An illustration of Vygotsky's Zone of Proximal Development. Based on Armstrong (2015: 133-144)

Vygotsky (1978) sees learning as occurring on two levels, namely firstly on a social level, and secondly on a personal level. During the SLPs, teachers engage together with the new knowledge and skills, and socially construct new knowledge. Afterwards, when they reflect on this learning, they internalise this knowledge, and build it into their existing schemata or world views. In chapters 2 and 3, the four stages of Warford's ZPTD are applied to the SLPs as a guiding principle.

1.9.2 Cultural Historical Activity Theory, stemming from Vygotsky's work, as research lens in this study

The third generation Cultural Historical Activity Theory (CHAT), which is further illustrated in figure 3.7 in chapter 3, as conceptualised by Engeström (2000), was developed as a post-Vygotskian legacy, and will be used as a lens to make meaning of the data. CHAT will be used to understand teachers' behaviour in considering the integration of IKS into teaching Life Sciences and utilising online and BL approaches.

The CHAT lens offers a unique viewpoint into an activity system – identifying an acting subject (in this case, the Life Sciences teacher), an object of the activity (e.g. teacher development) tools and signs used in mediating the activity (e.g., ICTs and indigenous knowledge practices), rules that apply in the system (e.g., the tenets of respectively Life Sciences and indigenous knowledge), the

community (all the stakeholders involved in the learning activity), and the division of labour in the system (the different roles that the Life Sciences teacher demonstrate, e.g., a facilitator of learning, or a reflective practitioner) (De Beer & Mentz, 2016). By using CHAT as a research lens, factors / 'tensions' that prevent the implementation of IK in the classroom, or the effective use of online learning can be identified. In chapter two, I will discuss CHAT in more detail.

1.9.3. Conceptual framework: pedagogical content knowledge (PCK), Technological pedagogical content knowledge (TPCK), indigenous knowledge and blended and online learning

The teaching and learning of Life Sciences are based on three broad subject-specific aims which are informed by Bloom's taxonomy (Bloom, 1964) for the cognitive, affective and psychomotor domains. The affective domain, as developed by Krathwohl (1964) is important in the teaching of Life Sciences, as it is concerned with thoughts or emotions, as well as social/emotional learning and skills. According to CAPS, "learners are expected to apply Life Sciences in everyday life as well as understand the history of scientific discoveries and the relationships between IK and science. CAPS requires learners to know the subject content and they should be involved in practical work and investigations. Learners should understand the different cultural contexts in which IK systems were developed," (Department of Education 2012:17). In chapter two indigenous knowledge will be discussed in more depth.

1.9.3.1. Indigenous knowledge

Teachers are expected to make use of examples of IK that reflect the different South African cultural groups. Practical inquiry learning expects teachers to have a sound understanding of the tenets of both IK and science. The short courses focus on providing teachers with a good understanding of the tenets of relevant science and IK.

1.9.3.2. PCK and TPCK

The teaching of science often necessitates attention to the context and experience in adapting delivery methods and the relevance of the content. Teachers need more than the content knowledge mastery to effectively teach science. Shulman (1996:8) refers to this skill as "pedagogical content knowledge (PCK). PCK refers to a teacher's subject knowledge, and skills to teach those concepts to a particular group of learners so that they maximally understand the content."

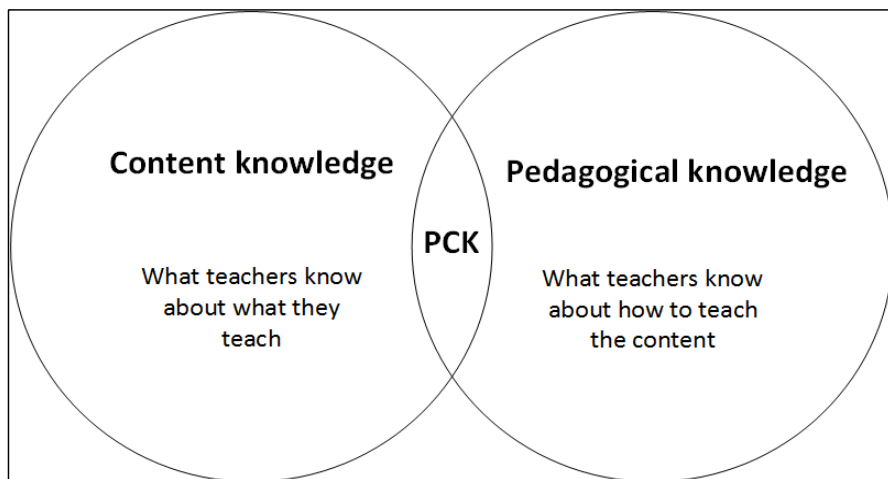


Figure 1-2 A representation of PCK. Adapted from: Sebotsa (2020:14)

PCK is topic-specific, and I used the nature of science (NOS) and the nature of indigenous knowledge (NOIK), and a particular focus was on teachers' PCK related to indigenous knowledge.

According to Schulman, an effective teacher will be mindful of the different misconceptions and challenges that learners have and know how to make use of these to present new content so that learners can have a correct understanding of the phenomenon. With the digitalisation of teaching and learning, are Life Sciences teachers sufficiently skilled to make use of different approaches, such as BL, to integrate IKS into the teaching of Life Sciences?

Mishra et. al., (2011) added the aspect of technology to the PCK of teachers. In this study, technological knowledge (TK) refers to the knowledge of teachers in using the technologies that are relevant and used in a Life Sciences classroom and includes the different tools and technological devices as well accessing online information and using online learning. Content knowledge (CK) refers to the Life Sciences content knowledge in line with the curriculum requirements of CAPS. Pedagogical knowledge refers to the knowledge of how to use different methods of teaching Life Sciences. These aspects are not dealt with as separate entities; they overlap as illustrated in the TPK model of Mishra and Koehler, (2011) in Figure 1-4 below.

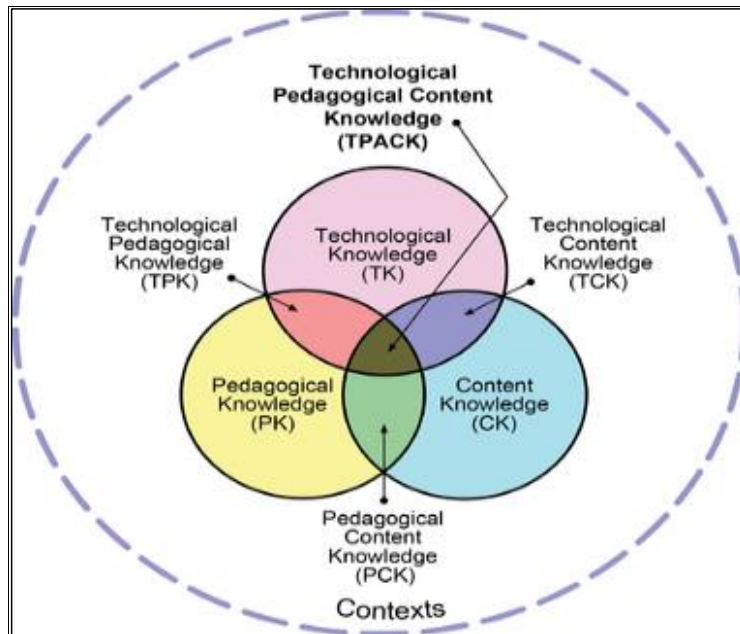


Figure 1-3 A visual representation of Technological pedagogical content knowledge. Based on Koehler et. al., (2014:103)

Life Sciences teachers who are using smartboards and other technological devices are expected to bring together knowledge of the subject matter with what is good for learning, ICTs, and pedagogical knowledge. The combination is described as TPCK. As highlighted by Grandgenett, (2008:151), “short courses may not provide teachers with all the potential TPCK that will be relevant for teaching a subject.” In this study, teachers will be assisted to develop an open mind for using a variety of approaches and strategies in integrating IK into Life Sciences.

1.10 Philosophical orientation

The methodologies of this research are based on the following educational philosophical orientation:

- Humanism:** This is founded on the ideas of Erasmus who opposed the religious teachings of his time. He pointed out the various moral iniquities, mental laziness, harmful habits and ignorance of the church faculty (Wrońska, 2019). Erasmus appreciated the value of teaching in small groups, he believed that learning should take place in a conducive environment where learning is not forced or rushed since it happens in stages. (Wrońska, 2019) Rousseau and Pestalozzi developed humanism as an educational philosophy. This links very well with the concept of SDL since humanists believe that the learner, being self-motivated to achieve, is responsible for her/his own achievement.

- **Progressivism:** An education philosophy that was developed from the ideas of Dewey, (1998) that focuses on the idea that an individual learner should be developed holistically, focusing on the needs, experiences and abilities of the learner other than those of the content or the teacher. Dewey advocated an interactive learning environment where learners can solve problems and be critical thinkers from active, experiential learning. Learners should be able to learn through relating to their daily experiences and linking this to the content in the classroom. Progressivism advocates that learning is achieved from what people consider relevant to their lives and education should prepare learners to live in society. In this study, progressivism is considered since the Life Sciences curriculum is in line with the same principles of learner-centred learning through investigative approaches.

1.11 Research design

A research design is defined by Terre Blanche *et al.* (2006:33) as “a strategic framework for action that links the research question and the execution of the study.” Merriam (2009:72) refers to research design as “identifying the means of completing the intended research process to answer the research question(s).” A research design provides the guiding principles that the researcher intends to follow and is thus the Geographical Positioning system “GPS” of the study (Reddy, 2012).

In qualitative research, the focus is on understanding people’s interpretations of their experiences, according to Merriam (2009:14). “A research design includes the underlying philosophical assumptions needed to specify the selection of respondents and the data gathering techniques and analysis methods to be used” (Nieuwenhuis, cited by Maree, 2014:70).

The integration of ICTs in teaching and learning has various learning affordances. Kay & Greenhill, 2011, strongly suggest that modern-day challenges require a variety of critical thinking, innovation and creativity skills that focus on communication, problem solving, and collaboration to prepare learners for the future (Kay & Greenhill, 2011:52-60). This study intends to acquire an understanding of how Life Sciences teachers include IKS in their lessons and how they interpret their experiences with the integration of IKS and their experiences of BL, i.e., both the face-to-face and online learning environments. The study strives to get the participants’ perspective on their experiences of professional development on using ICTs to support the integration of IK by practically involving teachers learning activities during the SLPs. The study is based on pragmatic principles and is tailored to best answer the research question.

“Mixed methods research employs both quantitative and qualitative approaches, to provide more insight into the research problem in different ways, but they can both be used as to solve the same research problem”, according to Ivankova et al (2014). In this study, I used a mixed method

approach, which combined quantitative and qualitative methods to investigate the same research question. Views-of-the-nature-of-indigenous-knowledge (VNOIK) (Cronje et al, 2015) instruments, was used in a pre and post SLP context, to understand the teachers views on the nature of sciences, before the interventions and after the interventions. I gathered numerical data via scores from FIT:COM (Judson, 2006) during the post-intervention classroom observations, to determine if there is transfer of knowledge and skills from the intervention into the classroom. Teachers were interviewed post classroom observation to understand their reflection on the impact of the SLP on their teaching.

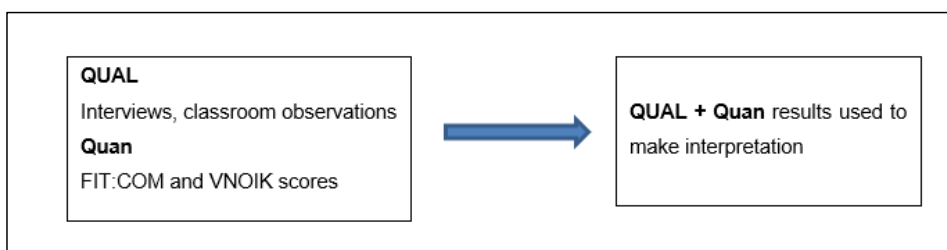


Figure 1-4 A visual representation of mixed methods design procedure. Based on Ivankova et al (2014:281)

This is a mixed method study with strong emphasis on the qualitative side, (QUAL) and the qualitative data has elements of phenomenology. Although it is predominantly qualitative, I collected numerical data with the use of the FIT:COM instrument, which uses the Likert scale, therefore I have limited quantitative data (Quan). The study used the mixed method in which the qualitative and quantitative data complement each other to respond to the research question. The fact that pre-designed conceptual and theoretical frameworks were used disqualifies this study from being a true phenomenological study.

According to Sharma, et. al., (2018) pragmatism, as a realistic and utilitarian school of thought, has had a significant impact on education. This study is anchored in pragmatism, as I have adopted methodologies that would best answer the research questions. The integration of IK into the Life Sciences curriculum necessitates the use of creative teaching and learning techniques. Teachers' approaches used problem-based learning, self-directed learning, and experimentation to respond to the teachers' professional development needs.

1.12 Research data

According to Ivankova, et al. (2014:268), "one research methodology may not adequately explain the complexity of the research topic; rather, a mixed methods approach can help to acquire a more complex understanding of the research problem." "To explore and describe the phenomena under

investigation, valuable data are to be collected in context and fieldwork should cause little disruption to the environment that is under investigation" (Silverman, 2011:299). "To achieve this, participants can be approached with the required care and engaging with them through open communication and in an empathetic manner", (Merriam, 2009:107; Terre Blanche *et al.*, 2006:287).

1.12.1 Data collection

The collection of data was carried out in six schools (sampling is discussed in the next paragraph). This study used the mixed method, in which teachers' pre- and post- intervention questionnaires, interviews, classroom observations and teachers' artefacts i.e., lesson plans were used to collect both quantitative and qualitative data.

The teachers in the chosen schools participated in the short courses to empower them to integrate IKS concepts into lesson preparation and lesson delivery. The Views of the Nature of IK (VNOIK) instrument was utilised as pre- and post-tests to map any changes that occurred in the teachers' views on IK (Cronje *et al.*, 2015).

As a follow-up to the [short learning programme](#), individual interviews to get an understanding of the teachers' experiences, practices, and attitudes towards the inclusion of IKS in Life Sciences lessons were conducted. These interviews were transcribed and coded and the emergent themes will inform future short course offerings as they will be distilled as design principles.

A personal interview schedule with questions that captured teachers' views on IKS in Life Sciences was developed. Open and non-directive questions were formulated. Broad questions to get teachers' perspectives were posed first and then enquiries about their efforts to include IK when teaching Life Sciences were made.

The second phase of the research examined what level of transfer of skills took place in classrooms. The literature refers to the so-called "wash-out effect" related to teacher professional development, where "newly acquired knowledge and skills obtained during education programmes was washed out at the coalface of teaching in that classroom" (Zeichner & Tabachnick, 1981:7; Mentz & De Beer, 2019:68). Six schools were visited, and lesson observations were conducted. These observations focused on the integration of technology. The observations were guided by using the Focus on Integration of Technology Classroom Observation Measurement (FIT:COM) instrument developed by Judson (2006). This was done to determine the extent to which the classroom interactions had been reformed.

Commented [A11]: At times a *short course* is mentioned and at other times a *short learning programme* as per sub-research questions.

Commented [A12R11]: Addressed as SLP

Third generation CHAT (Engeström, 2000) was used as a lens to make meaning of the data. By using CHAT as a research lens, factors / 'tensions' that prevent the implementation of IK in the classroom can be identified.

1.12.2 Methods of data analysis

The aim of data analysis is to create information from the collected data (Krysik & Finn, 2010:265). In the process of analysis, unexpected data may emerge; hence, the data is first gathered and then interpreted as the new themes and information become evident (De Vos *et al.*, 2005:65). "The practical purpose of answering the research question(s) develops during a process where discoveries or groupings emerge", (Merriam, 2009:176).

The individual interviews were transcribed and coded. The coding method described by Saldaña (2009) was used; descriptor codes were assigned to all responses. These codes were then grouped into categories, and these were again fed into emerging themes. The lesson plans were examined to learn how they were developed and how they contributed to how the delivery of the observed lessons.

The VNOIK instrument of Cronje *et al.* (2015) was analysed according to the procedure described by these authors. Cronje, De Beer and Ankiewicz (2015) suggested that a rubric is used to quantify the responses of teachers to each of the items in the instrument. An uninformed view was scored as zero (0), a partial view was scored one (1), and an informed view was scored two (2). The average score of all the items, provide an indication on whether teachers hold nuanced views of indigenous knowledge. Although it seems to point towards quantitative data, Cronje *et al.* explains why this should still be seen as qualitative data.

Third generation CHAT (Engeström, 2000) was used as a lens to make meaning of the data. By using CHAT as a research lens, the researcher was able to identify factors / 'tensions' that prevent the implementation of ICTs supported, IK integration in the classroom and how electronic platforms, have either facilitated or restricted teachers' professional development.

1.13 Sampling strategies

Maree and Pietersen (2014:172-180) define "sampling as the selection of the part of the population through which the researcher decides to undertake the study." Purposive sampling was used in this research. Purposive sampling involves the selection of participants based on specific criteria that qualify them to be suitable to provide the data that are required for the study. Data that will answer the research question(s) should be collected and purposive sampling can achieve this.

Furthermore, Maree and Pietersen (2014) recommend that, sampling should be flexible and can continue until new themes emerge or until data saturation is attained, after which further data collection will not add value to the research.

Research is restricted by time and cost; hence it was convenient to sample teachers in the Gauteng province (the researcher's place of residence) to study how they integrate IKS in their classes. The maintenance of ethically acceptable relationships with the teachers in the research was ensured; ethics is discussed later in this study.

In this study, the researcher combined stratified purposive sampling with criterion purposive sampling. Stratified sampling is used because only Life Sciences teachers who are part of the GDE smartboard pilot project were selected. It is also a criterion of purposive sampling since not all teachers in the sampled area have gone through smartboard training. (The project started with Grade 12 teachers in 2015; Grade 11 teachers were trained in 2017 and Grade 10 teachers in 2018).

In Gauteng teachers work in professional learning groups. Hence the database was broadened by using snowball or chain referral sampling with the possibility of finding other participants who were relevant, able, and willing to contribute to this study.

For the classroom observations and individual interviews, the researcher used purposive sampling to identify fifteen Life Sciences teachers from six public schools in the Tshwane North District of Gauteng. The fifteen teachers who participated in this investigation were part of the professional learning groups within the district. The teachers were in working schools that were part of a pilot project on the use of interactive smartboards and they had been trained on smartboard use.

1.14 Data credibility and trustworthiness

"Validity and reliability are important aspects to consider in conducting a study. Internal validity refers to the accurate presentation of the research results and the honesty value thereof; in other words, the results are presented in the same context that the researcher investigated" (Nieuwenhuis, 2007:80).

Pietersen & Maree (2014:214-222) argues that "to have reliable research results, they should remain consistent, even when the data are obtained on different occasions or in different forms." He further argues that "the data should be valid, ensuring that the study measures what it is intended to measure. He proposes crystallisation as a way of validating the results by using multiple methods. To ensure credibility and trustworthiness, different methods of data collection were utilised. This

included transcriptions of individual interviews, classroom observation reports and the analysis of artefacts, namely lesson plans and learner activities.”

Crystallisation was used for data analysis to enhance the trustworthiness of the patterns that came from the participants' diverse experiences. The interview techniques were reviewed by a panel of specialists to verify validity.

In Chapter 3, I will measure this study against the four standards proposed for validity by Eisenhart and Jurow (2011).

1.15 Ethical considerations

According to Creswell (2013), ethical issues should not only be considered in the data collection stage instead it should be considered throughout the study. The protection of the participants' identities, along with the confidentiality of the results and the findings of the study are critical ethical aspects that contribute to the validity of the study (Maree & van der Westhuizen, 2014:41). “Ethics serves as a set of moral principles that are agreed on by individuals in a group or society at large and generate increasing arguments in modern science's design of research projects” (UNISA, 2015:182). The researcher considered ethical issues throughout the study.

Ethical clearance for the larger NRF-funded project was obtained from the North-West University (NWU-00271-16-A2) (Appendix A). However, individual ethical clearance from the NWU-EMELTEN-REC (NWU-0066-19-S2) (Appendix B) was also acquired as customised interview protocols were being used. The Gauteng Department of Education (GDE, 2012) has outlined processes and procedures to be followed to guide researchers intending to study within its schools. It is a prerequisite that the researcher applies and obtains written permission from the District Director before starting with the research. Upon commencement of the research, the District Director's letter was presented to school principals as an indication that the researcher had been granted permission to research in the district, (Appendix D). The six school principals signed permission letters for the researcher to enter their schools.

An independent person obtained ethical consent from all participants. Interviews were only conducted after school hours so that the normal school programme was not interrupted, and teachers contact time was always protected. The researcher outlined a programme that indicated to the school principals and the District Director how contact time was to be protected.

This study was not commissioned by the GDE; hence lesson observations were scheduled as per guidelines that are stipulated in GDE regulations. The schools that participated did not incur any costs since the researcher utilised her own research resources such as transport, telephone, faxes, photocopies, and stationery.

Confidentiality was ensured by using pseudonyms and not mentioning the names of the schools, principals and teachers who participated in this study. Participants were informed of the purpose of the study and their involvement was clearly stated. Participants were made aware that participation was not compulsory but was voluntarily and that participants could withdraw from the research at any time without any consequences for them. Participants were required to give informed consent by signing individual letters of consent stating their willingness to participate.

To promote the confidentiality of the findings and protect the identity of the participants, all the information and results were kept private. This was also explained to participants. The supervisors of the researcher also committed themselves to the ethical issues by signing a declaration of accountability for the protection of sensitivity towards participants and the authenticity of the research.

The researcher will make a short presentation to the District Management Team and the participating schools to share the purpose, findings and recommendations of the research. A copy of the research will be made available to the District Director.

1.16 Contribution of the study

This research exploits the value of ICTs in building the capacity of Life Sciences teachers, which has an impact on the integration of IKS into the subject's teaching and learning. Short courses for teacher professional development that focus on developing teachers' TPCK to capacitate Life Sciences teachers with technological skills relevant for BL will be presented.

The findings of this research will contribute to the literature and scientific knowledge base of current classroom dynamics with regards to the integration of IKS in the teaching of Life Sciences through ICTs. The study can assist in determining the views of Life Sciences teachers on the nature of IK and assist with the development of programmes that can be used for teacher development.

1.17 Study overview

The study is divided into five chapters, the first chapter provides a background for this study by giving a layout of the integration of IK through ICTs in South African education. The research questions

and the purpose statement are also presented in this chapter. This chapter ends with a synopsis of the thesis chapters.

The second chapter, which is the literature review, establishes the foundation for concepts that are utilised in this study to construct an argument that helps engage in the context of this study.

In chapter three the study methodology is presented and justifies the research methodologies appropriate in this study. The engagements of teachers in SLPs are discussed in this chapter by focussing on how the study methodology used is appropriate for a thorough examination of integration of indigenous knowledge into the teaching of Life Science through the Information technologies.

In the fourth chapter the data from the participating teachers is presented. The interpretations are then used to make judgements about whether the expectations and the executed practices are consistent.

The fifth chapter outlines the findings, the recommendations, contributions and limitations of the study, and the conclusion according to the study. The flow of the study is summarised in figure 1.6 below.

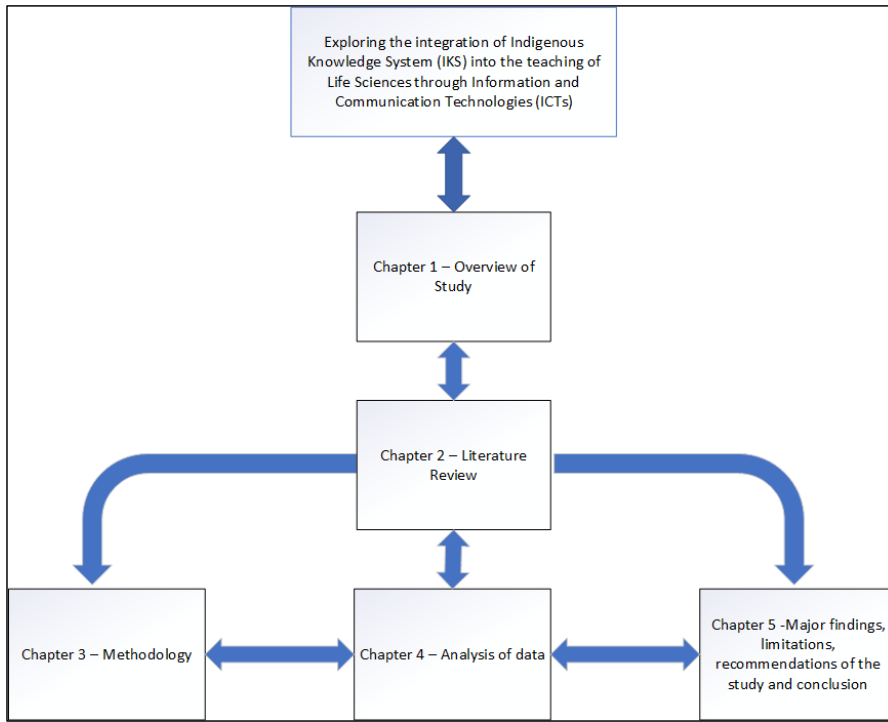


Figure 1-5 A visual representation of the research.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Research shows that, as the integration of technology is increasingly becoming evident at different schooling levels, the challenges of availability, accessibility and effective use of these technology tools are becoming a cause for concern (Amuko et al., 2015; Chikasha et al., 2014; Ramorola, 2013). It is critical that education systems create and deploy ICT supported learning environments by establishing professional development strategies to ensure that teachers are competent and “use ICTs to enhance teaching and learning,” as well as leaders and support staff who can help teachers to acquire digital learning competencies (Department of Education, 2018:9). To keep up with international developments, the South African Department of Education is widening the teaching and learning horizon by providing internet and interconnectivity through programs like e-learning and ICTs with interactive smartboards. The GDE has supplied these resources to previously disadvantaged schools. According to the department of education (2018:10), at all levels of education, there ought to be a well-defined plan to support teachers’ digital learning skills. The plan should be able to target specific needs of individual teachers, thereby enhancing learners’

achievement of curriculum objectives, through effective teaching methods, digital resources, and appropriate digital tools. Teachers who are new to the profession should have a basic understanding of how to use technology in the classroom. This study explores the teaching of indigenous knowledge in Life Sciences through ICTs, as well as the teachers' lived experiences and the challenges they face in this regard.

In a study done by Mothwa, (2011), it is shown how indigenous knowledge and cultural practices provide learners with a solid foundation for the scientific world. Teachers, according to Mothwa, should recognize the value of imparting new information based on learners' prior knowledge. This will help to develop learners' entrepreneurial skills and provide new career opportunities while displaying relevance of science in our daily lives (De Beer, 2019). One of the reasons why such epistemological border-crossing (between the western science curriculum, and indigenous knowledge) does not happen in the classroom, is the metaphysical and holistic nature of indigenous knowledge systems, which seems to be in contrast with the tenets of the natural sciences. This is in line with a study done by De Beer (2019), where it is stated that the inclusion of the metaphysical component of indigenous knowledge in science education is a contested issue. Learners may gain more complex understanding of the essence of science and differentiate between science and pseudoscience by dealing with certain metaphysical aspects related to indigenous knowledge.

This chapter contains an overview of the literature that was studied to get a view of the available knowledge and experiences with regards to integration of IK in the teaching of Life Sciences through ICTs. A study into the lived experiences of Life Sciences teachers in the integration of IK through ICTs is important in the era of the decolonisation of the curriculum debate (De Beer, 2019), as well as the growing interest in ICT's that was catapult by the Covid-19 pandemic. The philosophical and pedagogical principles that guide this study are explained in this chapter. Research shows that the cultural background of learners plays an important role in applying learner-centred approaches to teaching and learning; however, not much has been done so far to get an overview of the lived experiences of teachers in the integration of IK into the teaching of Life Sciences using ICTs.

2.2 Gaps that this study addresses

The current changes in education demand that teachers make use of technologies. De Villiers *et al.* (2016) highlighted the lack of sound pedagogical content knowledge (PCK) in teachers of Life Sciences as one of the major contributing factors to why it is challenging for Life Sciences teachers to appropriately implement problem-based learning and SDL in their classrooms. In a similar study, De Beer (2016) observed that many Life Sciences teachers do not have the PCK to effectively facilitate inquiry learning opportunities that explore IK.

Teachers who struggle to incorporate more technology into their lessons face new obstacles because of the nature of newer digital technologies, which are unpredictable, unstable, and opaque.

As Koehler et. al. (2013:14) noted, teaching with technologies is complicated; teachers who struggle to integrate more technology into their teaching face new challenges because of the nature of newer digital technologies, which are unstable, unpredictable, and opaque. In South Africa, most teachers are 'born before technology (BBT)'. This is a result of their receiving their professional training at a time when technology was at a different level of development in comparison to today. According to Ndlovu's (2016) research, teachers are not necessarily sufficiently prepared to use technology in the classroom, let alone to acknowledge the value technology can add to the integration of IK. The Department of Education (2018:10), highlights the need of a teacher professional development framework that must examine how ICTs may assist teaching and increase learning in all subjects and in the different socioeconomic circumstances that teachers meet in South Africa as well as the need for teachers who are able to employ a variety of pedagogical strategies to maximize the potential of limited digital tools and resources for supporting and enhancing learning. Consistent with Tredoux, (2012), it is critical to remember that the heart of integrating ICTs is aligned to the access of relevant and valuable knowledge and skills.

In the aftermath of the Covid-19 outbreak, the South African government is supporting the incorporation of ICTs and the use of BL (Dube, 2020). Many learners from socioeconomically deprived communities (such as rural areas and townships) are excluded from online learning because they lack or have very limited opportunities. According to the department of education (2018:11) teacher professional development for digital learning is important for teachers to grow from a pedagogical foundation while integrating ICTs in teaching and learning and to realize the value ICTs can add to the process of learning. It's also feasible that fewer resources are more valuable than many resources because the extent of technology used isn't the most important aspect in determining its success, teachers should be able to contextualise the use of ICTs in their environment. The 2020 COVID-19 pandemic has drawn attention to the digital divide in the country, perhaps this shows why such research on ICTs is of relevance in South Africa.

The gap that this study intends to address is to status of using IK and ICTs as supporting tools for teaching Life Sciences concepts. Cronje (2015) and De Villiers *et al.* (2016) point to the fact that many Life Sciences teachers have limited knowledge about IK and the way to incorporate IK into Life Sciences lessons. While the Department of Education (2018:9), emphasizes the need for an education support system that has a clear strategy for professional development at all levels of support in terms of digital learning, and teachers who have a clear plan for their own needs for professional development, it remains critical to find out the following: Firstly, what is the situation with

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the teaching of IK in Life Sciences using available ICTs? Secondly, do teachers make good use of the available ICTs to ensure achievement of learning goals in the unique teaching circumstances or context?

While the notion of Blended Learning has grown in popularity in education, authors like Hockly (2018) and Cronje (2020) concur that it is difficult to describe. Blended Learning is defined by Graham as “learning systems that integrate face-to-face instruction with computer-mediated training,” and this is without a doubt one of the most generally used definitions (Graham, 2006:41). In a BL environment, the core idea is that face-to-face and online learning should be combined as effectively as possible to provide a singular learning experience that is consistent with the setting and the intended educational goals (Garrison & Vaughan, 2008). “Blended learning has evolved into an umbrella word that refers to any combination of the traditional face-to-face instruction and technology-assisted learning”, (Ossiannilson, 2018:18). Furthermore, Ossiannilson, (2018:16) emphasizes that using “blended learning expands opportunities due to emerging technological breakthroughs in fields such as the Internet of Things, robotics, artificial intelligence, autonomous vehicles, biotechnology, nanotechnology, 3D printing, materials science, quantum computing and energy storage.” Koehler, et.al (2013) highlights that integration should be creatively designed or structured for subject matter ideas in a specific classroom context. What are Life Sciences teachers lived experiences in multicultural classrooms? In line with the DoE, Digital Learning Framework, (2018:22-30) Life Sciences “teachers should examine the following contextual factors: (a) the pedagogical context, (b) awareness of available ICTs and resources. These factors influence the establishment of a transformative learning environment in which educational methods and ICT resources are employed to facilitate the achievement of learning goals.”

2.3 Pedagogical context

Even if ICTs are not exploited to their full potential, teachers should leverage pedagogical reform to support more effective learning. “Higher degrees of pedagogical practice, learner-centeredness, higher-order thinking skills, and a variety of interactions between learners, content, and teachers are all features of transformative pedagogies” DoE, (2018:7). Learners that are involved in pedagogies have greater possibilities to use ICTs and resources to assist achieving learning objectives, DoE, (2018:47).

2.4 Awareness and use of available ICTs and resources

Teachers should be aware of the advantages that available ICTs can provide in terms of facilitating teaching and learning and use ICTs to increase learner engagement thereby add value to the learning process, DoE, (2018).

The following points made by the Department of Education (2018) plays an important role in this study: "ICT integration in education is crucial for learners and teachers to develop and support their educational needs at all learning levels if our education system is to be relevant and transformed in line with current global trends." Contemporary instructors play a vital role in shaping the intellectual depth of their online communities by helping learners to become self-directed learners.

De Beer (2016) argues that "the inclusion of IK in the school science curriculum provides affordances for authentic learning and the enhancement of science education in South Africa." This study examines Life Sciences teachers' experiences with the integration of IK in teaching of through ICTs and the challenges they face in this regard.

The theoretical and philosophical underpinnings of this work are explained in the following section. The outline of the theoretical and conceptual frameworks in this study is depicted in Figure 2.1 below.

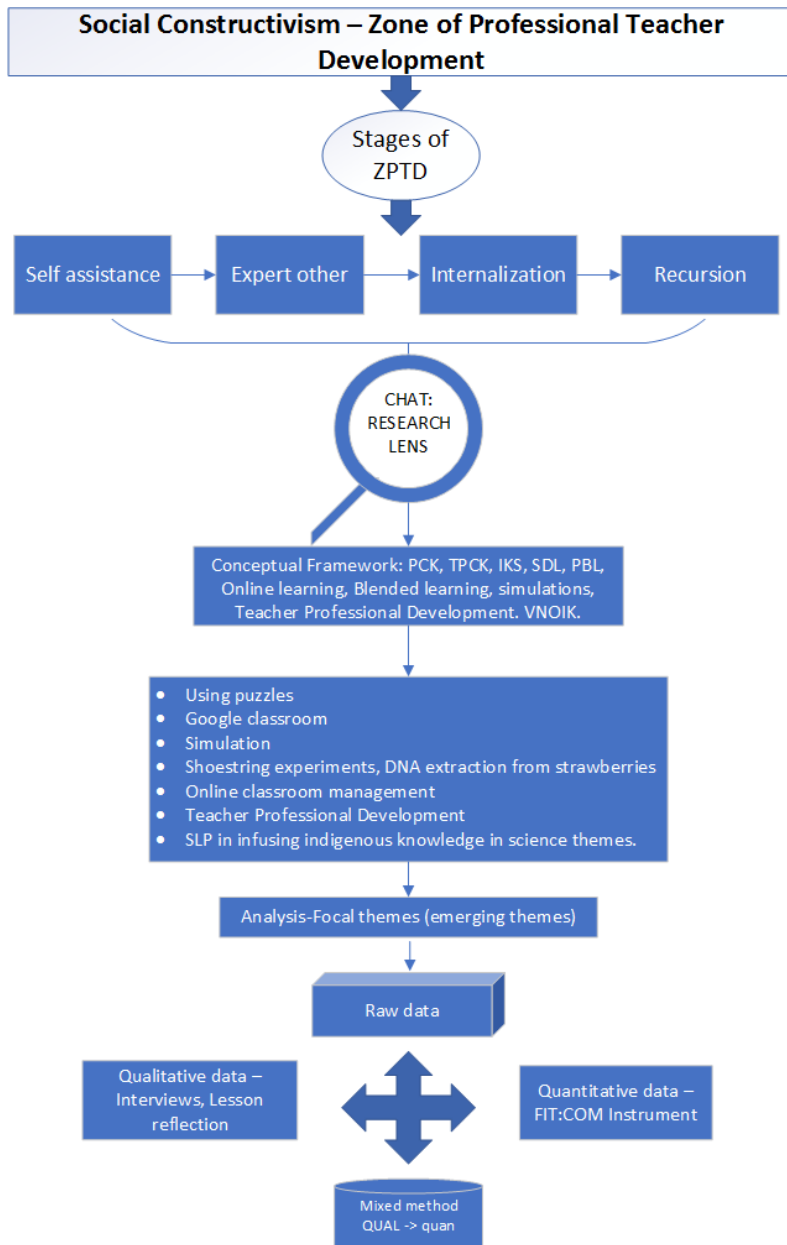


Figure 2-1 A representation of the study’s theoretical and conceptual frameworks of the study: Adapted from: Sebotsa, (2020:109)

2.5 The theoretical framework underpinning this study: social constructivism

Constructivism originates from the ideas of psychologists and philosophers such as Socrates, Piaget, (1967) Bruner (1966) and Perkins (1992) who strongly believed that the construction and understanding of new knowledge are enabled through the interaction between the teacher and the learner; the learner brings along some undeveloped concepts and learning is a process of constructing meaning by making sense of the personal experiences of learners (Amineh & Asl, 2015).

This study builds on Vygotsky's (1978) social constructivism theory, that states that new knowledge is constructed collaboratively, as individuals learn from one another. Warford (2011) provides context of how Vygotsky's (1978) construct of the Zone of Proximal Development could be applied in the context of teacher professional development, through his construct of the Zone of Proximal *Teacher* Development (ZPTD). Warford (2011) states four stages through which teachers can be scaffolded in their professional learning, and this formed the basis for the SLPs that underpinned this research. According to Warford (2011), the four stages are (a) self-assistance; (b) expert other assistance; (c) internalization (automatization) and (d) recursion.

In this study, I looked at how Life Sciences teachers developed professionally through this "zone of proximal teacher development." Table 2.1 shows how I applied these four stages to my short learning courses.

Table 2-1 Warford's (2011, p. 254) Zone of Proximal Teacher Development, which underpins this research study based on Sebotsa 2020:112

ZPTD (Warford, 2011)	Samples of Interventions	Activities in this SLP / workshops:
I. Self-assistance	Prior knowledge & experiences that teachers bring to the short learning courses.	Discussion on what teachers know about using ICTs use in Life Sciences and indigenous knowledge before the training. We wanted to know what IK we must build on what teachers already know.
II. Expert other assistance [(Stage I in ZPD) (Galimore & Tharp, 1990)]	Development of google classrooms. Activities for online learning Ethnobotanical survey	Teachers worked in groups and co-constructed knowledge on creating and using online platforms, during the SLP.
III. Internalization (automatization)	Reflection on teaching practices Lesson plans The FIT:COM instrument	The teachers engaged in tasks independently to internalize the acquired skills without expert assistance.
IV. Recursion (De-automisation)	Teachers' online group chats Streaming / broadcasting content Recording of lessons	Online conferencing Collaboration Sharing of information

2.5.1 Using the four stages of Warford to scaffold teachers' learning

Stage I: Self-assistance:

In the interventions, we had a discussion to find out what knowledge the teachers already had about IK and the use of ICTs. We wanted to build on what teachers already knew as social constructivists. This is referred to by Warford as "self-assistance."

Figure 2.2 below depicts teachers engaging in discussions on the knowledge they bring to the SLP on the use of ICTs as vehicles for teaching IK in Life Sciences.



Figure 2-2 Teachers engaging during the SLP, in the 'self-assistance' stage (consent for all photography to be included in this study was granted by all participants.)

It was important for me to determine what previous knowledge teachers had at this level of self-help. This was accomplished by teachers working in groups (I observed the discussions closely). The participants filled out a questionnaire that provided the researcher with information about the teacher's pre-intervention profile. I also gave the teachers a pre-test to determine their PCK with regards to using Google Classrooms.

In addition, teachers were assisted with registration and with GDE login credential. We focused on the GDE multimedia content platforms that are indicated in figure 2.3 below:



Figure 2-3 Multimedia platforms used by teachers during the SLP

As guided by the ICT policy, there are various reasons why teachers use technology in their classrooms, and these include among others:

- Improving educational outcomes
- Availability of resources and the education department's expectations
- Increasing learner performance
- Improving learner engagement in learning activities
- Changing the classroom experience
- Introducing new skills for curriculum delivery
- Unlocking administrative efficiency, especially for recording and reporting
- Preparing learners for the Fourth Industrial Revolution.

During the self-assistance stage, teachers were required to include information about their other professional development requirements, which were not limited to content knowledge. This allowed me to recognise additional needs that I might not have addressed in my initial findings, which influenced the intervention. The teachers' observations assisted me in personalising the intervention so that it was authentic and in line with Vygotsky's social constructivism vocabulary. It was also clear that teachers were engaged in activities but were unable to complete them effectively without the assistance of modelling, coaching, and other resources like technology. The difficulties that teachers faced in stage I, influenced the type of expert and other assistance that they needed in stage II.

Stage II. Expert other assistance



Figure 2-4 Teachers engaging during the second stage, 'expert other assistance' (Warford, 2011)

Teachers collaborated in small groups to build Google classrooms under the direction of the ICT facilitator. Quizzes and escape rooms were among the classroom activities that teachers created using Google Forms. These competitive methods can be used by teachers to make their Life

Sciences lessons more engaging, inspire students to read up on the subject beforehand, and make sure that students take ownership of comprehending subjects.

Stage III. Internalization (automatization)



Figure 2-5 Teachers internalizing how they would make use of Google classrooms in teaching for teaching and learning

Teachers had to reflect on their experiences and to provide feedback, based on the IK research activities for online learning on applications of indigenous knowledge systems and biotechnology. The jigsaw technique, as described by Bosch, (2017), Halim, & Syahrin, (2020), was used in the SLP, in which each teacher was assigned a specific topic on harvesting medicinal plants in a sustainable manner. Teachers used the internet to accessed information on conservation and sustainable use of medicinal plants. They wrote how they would use this information in a Life Sciences lesson. Presentations were made on different approaches they would use. These included creating video recording, creating animations and developing various assessment tasks on Google classrooms.

Stage IV. Recursion (De-automisation)

The planned classroom observations were intended to observe how the teachers transfer the knowledge acquired during the interventions into their classrooms. In this way I would have taken the teachers through the Warford's four stages of proximal zone of teacher development.

2.6 Conceptual framework

2.6.1 Indigenous knowledge as a vehicle to decolonise the science curriculum

Colonial education has no doubt deprived the colonised of their indigenous learning structure. In South Africa, the debate on decolonising the curriculum was ignited by numerous student protests

at tertiary institutions from 2015 to 2018. Nonetheless, decolonising the South African curriculum is not limited to higher education; it is evident at all educational levels.

In basic education, the curriculum continues to go through various changes to address the challenges that resulted from colonisation and apartheid. A deeper understanding of the concept of decolonisation resonates with the work of authors such as Kenyan Ngugi wa Thiongo, (1986) who is well-known for his deep desire for a school curriculum that decolonises the mind as colonial education creates a desire for the colonised to disassociate themselves from their heritage and instils a sense of inferiority.

Reddy (2019) argues that marginalising the impact of Western science on IK indicates that the incorporation of IK will be a crucial factor in the decolonisation of the curriculum. The importance of IK in the teaching and learning of Life Sciences has been recognized by South African curriculum developers. The proposal for the curriculum to be “Africanized” or “decolonized” highlights the need for more contextualized science education in South Africa.

Several research studies, as noted by Cronje (2015), support the value of incorporating IK into natural science teaching. Such research primarily argues for the infusion of IK from the perspective of embodied, situated, and distributed cognition (De Beer, 2016). De Beer (2016) demonstrates the benefits of indigenous knowledge for self-directed learning in science education in a study on re-imagining science education in South Africa. “Classroom teaching can be enriched by using the following three examples; Traditional leather tanning as a great way to introduce endothermic reactions, Ndebele artwork as a way of teaching geometric concepts, and lastly, the Indigenous knowledge holders in the Giyani district of Limpopo’s environmentally friendly solution to problem insects, namely the plant *Lippia javanica*, which they have used for decades as an insect repellent” (De Beer, 2019:13).

De Beer (2019) proposes that South African education can provide interesting insights into how IK could foster localised education in a world marked by evolving demographics and increased learner diversity in the classroom. Furthermore, South Africa needs to be competitive globally and De Beer (2019) argues that the concept of ‘Western science’ will always be at the core of curriculum content.

As part of rebuilding the nation in the post-apartheid era, the inclusion of IK in the South African curriculum has on the other hand exposed how teachers are teachers struggle to blend IK and school science in the classroom, (Cronje, 2015).

2.6.2 What is indigenous knowledge?

IKS is a term that refers to a set of information systems that includes technology, legal, and governance systems (Odora-Hoppers & Makhale-Mahlangu, 1998). IKS are described by their embeddedness in the cultural network and people's history, according to Odora-Hoppers.

According to De Beer and Motwa (2013), Indigenous Knowledge (IK) refers to the knowledge and wisdom acquired by local cultures through generations, enabling them to thrive in their environments. It represents the knowledge specific to indigenous communities within a country. Masoga and Shokane (2019) and Senanayake (2006) share the common notion that IK is transferred from generation to the next, through oral traditions and cultural practices. IK has been the foundation of various activities that support communities and their environments for many centuries.

Taylor, & Cameron, (2016) recognize that the different definitions of IK, agree that diverse communities, cultures, and societies possess IK systems that undergo evolution and transformation as they progress and interact with other knowledge systems. IK is shaped by specific communities, cultures, and societies. Different communities and cultures possess their unique knowledge systems that are not isolated but are influenced by interactions with external sources of knowledge. This highlights the dynamic nature of indigenous knowledge as IK is enriched and transformed through the exchange with other knowledge systems. This dynamic nature of IK is also supported by Reddy, de Beer, & Petersen, (2017).

Havenga (2019:224) explains that "the implementation of IK requires knowledge, skills, and behaviours and these should be preserved for the future." Furthermore, Havenga (2019:224) outlines the following four mechanisms as applicable in the context of IK: (a) Encapsulation, which refers to the safeguarding of IK within certain communities; (b) Reuse, that is the application of IK in well-known circumstances as passed down from generation to generation; (c) Extension, which refers to the development of IK to solve local challenges; (d) Polymorphism, which relates to the various forms and new circumstances of applying IK to address local challenges.

IK is therefore the knowledge, skills, and practices that a particular community protects and uses over ages to address local problems; new problems emerge that necessitate communities to build on their existing IK to address these problems and sustain lives. IK is dynamic and develops over time.

2.6.3 Integration of relevant indigenous knowledge of different cultural groups into the teaching and learning of Life Sciences

Numerous studies to explore the importance of integrating IK into teaching and learning have been undertaken. A study conducted in Kenya by Owuor (2007) suggests that the solution to most problems on the African continent lies in the utilisation of indigenous African knowledge to promote

sustainable development. Abah *et al.* (2015) propose that, in the teaching of science, IK provides learners with a deeper understanding of knowledge as it provides the foundation of learning.

Kaya and Seleti (2014) suggest that the effective integration of IK needs to include the meaningful collaboration of curriculum developers and IK holders and can be achieved by accessing centres of African Heritage, where African indigenous healing plants are grown. Life Sciences teachers can collaborate with IK holders to assist learners to acquire a meaningful understanding of the content.

Chakale, Asong, Struwig, Mwanza, & Aremu, (2022), Magodiello, (2018), De Beer and Petersen, (2012) highlight the fact that one of the areas of high interest in Ethnobotany is the conservation of medicinal plants. In South Africa most of the plant material used in traditional medicine is harvested in the wild by gatherers, who usually collect without regard to how the plants will survive for the future. Traditional medicine makes use of the various parts of the plant, namely the roots, leaves, fruits, flowers, bulb, rhizomes or the bark. It is increasingly difficult to naturally have enough medicinal plants collected from the wild, and some species are becoming extinct. I believe that incorporating IK into the teaching of Life Sciences will help raise awareness of the importance of conserving our natural resources. This opinion is also supported by Richter, & De Sousa, (2019) in their discussion on the implementation of environmental education to promote sustainability. As a result, it is critical that teachers be equipped and assisted in integrating indigenous knowledge. During the SLP that was conducted at the Pretoria Botanical Gardens, Life Sciences teachers participated in the identification of various indigenous plants. Teachers learnt different methods of sustainable harvesting. These methods include timing of harvesting, identification of material to be harvested (leaves, stem, bulk, flowers, fruits or roots), harvesting techniques, e.g., the aloe leaf tapping to produce aloe juice on a sustainable basis, collection of lateral roots and protecting the tap roots, harvesting equipment and safe storage of the medicinal plant. This is possible IK information Life Sciences teachers can use when teaching human impact on the environment.

2.6.4 Views on the inclusion of IK in the science curriculum

Teachers need to know that there are three different perspectives through which IK can be incorporated the teaching of science, (Zinyeka et al, 2016; Taylor & Cameron, 2016). The three different perspectives on the infusion of IK are: (a) the inclusive perspective, (b) the exclusive perspective and (c) considering IK and science as intersecting domains.

The inclusive perspective sees it as part of science, while the exclusive perspective views IKS and science as distinct domains. The exclusive perspective is based on the viewpoint that science is restricted to observing the physical world and does not include the metaphysical which is part of indigenous knowledge systems. The intersective perspective, view IKS and science as intersecting

domains, of overlapping strands; as a result, the focus should be on the shared tenets of western science and indigenous knowledge.

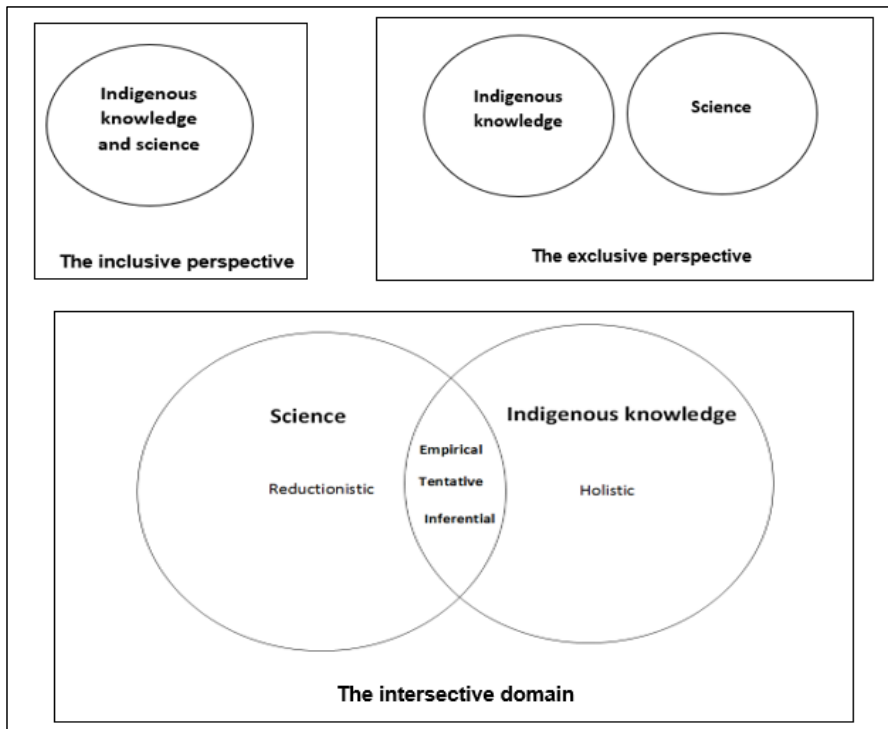


Figure 2-6 The epistemological border crossing between IK and science. A visual representation of the viewpoints. Adapted from Sebotsa, (2020:70).

The integrating indigenous knowledge (IK) into science, is one way of maximizing the sociocultural significance for improved learner performance. “The epistemological gaps between the nature of science (NOS) and the nature of indigenous knowledge (NOIK), on the other hand, pose a significant challenge for integrating IK into science curricula”, according to Zinyeka, et. al. (2016).

In this study, I argue for the crossing of epistemological borders between IK and science, and my arguments are anchored on the third viewpoint, in which IK and science intersect. In integration of science and indigenous knowledge the focus should be on the similarities / shared tenets rather than the differences between the two knowledges (refer to Table 2.2).

Science, like indigenous knowledge, is based on empirical evidence, however IK also has a metaphysical component. Both IK and sciences are tentative as they both evolve over time. IK and science are both inferential, conclusions are drawn from observations and procedures. Furthermore, both are creative, as perception and imagination have a contributing factor. IK and science share the tenet of being socially and culturally dependent, as information is shared.

When “the nature of science and the nature of indigenous knowledge are contrasted”, Cronje (2015:42) shows that “there are several shared tenets (despite some differences).” Table 2-2 below shows the shared tenets between western science and IK as well as the differences.

Table 2-2 Table showing the tenets of NOS and NOIK (adapted from Cronje, 2015:42)

Commented [A14]: Table numbering?

Tenet	Nature of Indigenous knowledge (NOIK)	Nature of Science (NOS)
1	<i>Empirical and metaphysical.</i> NOIK’s nature is real, at least in part, and has been thoroughly checked and studied. Experimentation depending on needs. The universe is a metaphysical, orderly, and partially predictable place.	<i>Empirical knowledge</i> NOS is derived from observations and studies in the natural world.
2	<i>Tentative yet resilient</i> Indigenous knowledge is flexible and transformative, IK is constantly evolving. It is important to remember that the elder’s repository of ways of knowing is true and should not be questioned.	<i>Tentative</i> Science is not absolute or definite, and it is subject to change. Critique and technical advancements will change scientific evidence over time.
3	<i>Inferential</i> Investigational techniques and findings are used to draw conclusions and make interpretations.	<i>Inferential</i> Experiments and observations are used to make deductions.
4	<i>Creative</i> Observation and experimentation aren’t the only ways to gain knowledge. Human imagination, innovation, and myths all play a part.	<i>Creative</i> NOS is creative because deductions are the product of perception, creativity, and imagination.
5	<i>Subjective</i> Indigenous ways of understanding are cosmologically centered and intertwined	<i>Subjective (theoretical)</i> Scientists tend to be objective and culture-free, but they are subjective,

	with tradition and spirituality. Prior ways of knowing and values will influence the elders.	conditioned by theoretical and disciplinary responsibilities, prior experience, and values as human beings.
6	<i>NOIK is socially and culturally based</i> Indigenous knowledge is created by the citizens of a particular location. The background is cultural. It is the product of activities related to a group of people's daily lives in their natural environment. Generalizations are relative within a given context, and they may be shared across cultures and beyond.	<i>NOS is socially and culturally Influenced</i> Scientists strive for objectivity, but science is a human endeavor that is influenced by social and cultural factors. Scientists do work alone on occasion. The generalized scientific laws and theories have global applications.
7	<i>Approached in a holistic manner</i> IK is approached holistically and has a strong metaphysical component.	<i>Approached in a reductionist manner</i> NOS is approached in a reductionistic manner.

2.6.5 The nature of indigenous knowledge and 'western' science

It is of the utmost importance to focus on the epistemological, ontological and evolutionary similarities and differences between IKS and western science in teacher professional development. In Table 2.2, the tenets of the two domains of knowledge are compared (Cronje, 2015).

2.6.6 Advocating for the inclusion of IK from a learning psychology perspective: Embodied, situated, and distributed cognition, (ESDC)

Embodied, situated and distributed cognition states that "cognition is psychologically embodied, socio-culturally situated, and ostensibly distributed among individuals" (Chahine, 2013:434). Chahine (2013:435) states that "cognitive processes are multimodal, and that bodily movement, use of manipulatives, acts of drawing pictorial displays, verbal language, and use of symbols play a role in understanding concepts. Indigenous knowledge could therefore enhance cognition, e.g., learners could engage (embodied cognition) with cultural artefacts or processes." "The ESDC paradigm is based on the idea that cognitive processes are physiologically embedded in action, located in the sociocultural environment, and dispersed among agents, artefacts, and external structures" (Chahine 2013:434; Hardy-Vallée & Payette 2008).

Teachers interacted with IK holders during the intervention, and I view their physical involvement in activities like, indigenous plant identification and classification of plants, in a sociocultural space as collectively constructing information in a way that promotes learning and cognition.

2.7 Approaches in the teaching and learning of Life Sciences

Previous studies (Le Grange, 2019; Lotz, 2021) have shown that to effectively translate learners' experiences for them to gain conceptual understanding at higher cognitive levels, teaching requires several foci that include a curriculum designed for higher cognitive learning, effective teaching techniques and learner-centred approaches that translate to critical thinking and problem-solving. Approaches in teaching and learning of Life Sciences that could enhance self-directed learning, are problem-based learning and cooperative learning (Petersen, Golightly & Dudu, 2019; De Beer, 2022).

2.7.1 Problem-based learning (PBL)

Problem-based learning entails finding solutions to problems that have been identified, and it necessitates problem-solving, critical thinking, and collaborative skills. Swart (2018) argues that PBL promotes a learner-centred approach and promotes self-directed learning by increasing motivation to learning and solving problems. According to Heystek (2021), PBL is a teaching and learning technique that ensures that real-life opportunities are used in the teaching and learning. Furthermore, learners are expected to take an active role in problem-solving, with the teacher guiding them to find solutions in real-life situations.

Learners start the PBL process by analysing the situation to discover and construct learning issues or learning objectives. Learners then engage in self-directed learning to obtain information about the learning objectives that have been established. This new knowledge is applied to the context of the problem in the follow-up session, and they evaluate if they have met all of the specified learning challenges or objectives. As they progress, new learning problems may emerge, and the cycle repeats again. The CAPS curriculum "aspires to develop learners who can identify and solve problems as well as make decisions using critical and creative thinking." DoE (2012:8) emphasizes that in teaching Life Sciences "teachers should use methods that include formulating hypotheses and carrying out investigations and experiments as objectively as possible to test these hypotheses."

According to Belecina and Ocampo (2018), critical thinking and problem solving are vital in the development of successful pupils in mathematics education. Additionally, the usage of problem situations motivates students to learn. McCormick, and Raines, (2015), argue that learners use critical thinking skills in problem solving by analysing problems and synthesizing and applying

previously learned concepts. The Life Sciences CAPS curriculum requires learners to solve problems to gain a better understanding of the world DoE, (2012:5). It is against this background that this study investigates the development of concepts and how teachers make use of the available technologies to teach the required content.

2.7.2 Cooperative learning (CL)

According to Bosch (2019:59), cooperative learning (CL) is based on learners' active engagement rather than passive involvement, and it demands students to complete a task in small groups. Teachers encourage learning, create shared learning experiences, and welcome student diversity. Cooperative learning encourages students to take charge of their own learning, fostering interdependence and accountability, and has the potential to enhance self-directed learning (Petersen, Golightly, and Dudu, 2019; De Beer, 2022).

Positive interdependence, individual accountability, beneficial face-to-face engagement, interpersonal small-group abilities, and group processing are all significant aspects of CL (Johnson, and Johnson, 1994). Positive interdependence is the most significant aspect of CL because it allows members of a group who share common goals to work together to attain those goals. Life Sciences "education necessitates the employment of specific strategies for widening existing knowledge and discovering new things. These procedures must be repeatable, and a methodical approach to scientific inquiry is required" (DoE, 2012:8). Positive interdependence allows for learner-centred learning, in which learners carry out more of the learning activities as they construct knowledge, and it promotes shared learning accountability. Learners participate in activities in which they are given individual tasks and conduct discussions on connected topics. CL enables the successful implementation of social constructivism since new information is produced as a result of learners' collaboration as they all actively participate in groups to conduct conversations and solve problems. The exchanges that occur during discussion will help all group members since they will take use of each group member's skills while also filling in the gaps. Silalahi and Hutauruk (2020) claim that teacher's innovation is required to ensure that learners use time wisely and direct their energy toward constructing new knowledge.

2.7.3 The Person Process Context (PPC) Model of self-directed learning: A 21st Century Vision for SDL

According to Morris and Rohs, (2021) learners are primarily responsible for planning, carrying out, and reviewing components of their learning process in the SDL process. Du Toit-Brits and van Zyl (2017), articulate the concept of 'self-directed learning' as referring to the requirement for learners to

govern their own learning processes. Furthermore, self-directed learners plan by identifying their learning goals, as they are aware of what they intend to achieve. They plan how to gain access to learning resources. They are also curious, autonomous, and take the initiative to study in a self-controlled manner. Self-motivation is crucial in developing self-directed learning skills.

In the study of Hiemstra and Brockett, (2012), they highlight the dynamic interrelationship between the three basic elements of SDL which are: (a) the person or learner, (b) the process: teaching-learning transaction, that is influenced by (c) the social context – in which all the three elements of SDL are equally important as shown in the Person Process Context (PPC) model that is illustrated in Figure 2.7 below.

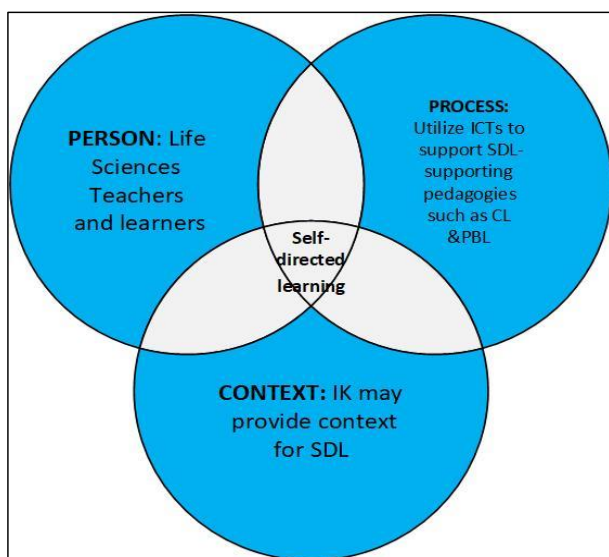


Figure 2-7 An illustration of The Person Process Context (PPC) Model. Based on Hiemstra and Brockett (2012:158)

The PPC model states that the ideal situation for self-directed learning occurs when the person, process, and context are all in balance. The person dimension of the PPC model encompasses personal traits that influence learning, and these include, creativity, originality, critical thought, zeal, life experience, life satisfaction, drive, prior education, resiliency, and self-concept (Hiemstra and Brockett, 2012). The engagements in this study will assist me to identify some strategies and approaches to enhance SDL qualities in both teachers and learners. Self-directed learning abilities are a crucial part of both present learners' and future workers' success. The research therefore has elements of action research, thus enhancing its significance. Despite what appear to be inherent

barriers to change within the educational system, teachers have a duty to their learners and communities to give learners the chance to acquire these abilities (Zsiga and Webster, 2007). Likewise, Morris and Rohs, (2021), strongly argue that learners frequently need assistance, particularly with the planning and reviewing components of self-directed learning, as well as direction on how to use digital devices successfully for educational reasons. Through the SLP, teachers were provided with some knowledge and skills in employing applicable IK in ICT supported learning for them to be able to access information and use the acquired skills to create innovative learning environment that impacts on the learners' SDL in our increasingly complex and unpredictable world that requires the ability to learn independently.

The process includes facilitation, learning skills, learning styles, planning, organizing, and evaluating skills, teaching styles, and technical know-how in the teaching-learning transaction (Hiemstra and Brockett, 2012). In this study my goal was to use ICTs to support pedagogies / strategies such as co-operative learning and problem-based learning to support self-directed learning in the teaching of Life Sciences. As claimed by Zsiga and Webster, 2007, teachers are urged to achieve and maintain high levels of learner involvement and interest to facilitate SDL. Thus, learner-centred teaching strategies are essential for encouraging self-directed learning, and students should be helped to build problem-solving skills by actively participating in the learning process.

As outlined by Hiemstra and Brockett, 2012, the context for SDL, includes factors like culture, authority, the environment in which people learn, finances, gender, the learning climate, organizational policies, the political environment, race, and sexual orientation. In this study indigenous knowledge could serve as a context to support self-directed learning. According to the PPC model, when the person, process, and context are balanced, self-directed learning is most effective. Even though, there will be instances in which one component, has a more significant role, all the three factors are very important for optimal SDL. Furthermore, when the learner is very self-directed, the teaching-learning process is designed to support learners' ownership of their own learning, and the socio-economic environment and learning environment foster a climate that supports self-directed learning. By including the learners' own lived experienced from the indigenous knowledge Life Sciences teachers can create a learning environment that supports self-directed learning.

2.8 Cognitive, affective and psychomotor outcomes in Life Sciences

Learning Life Sciences is a process which can be categorized into three domains: the cognitive (knowledge), the affective (attitudes) and psychomotor (skills). According to Hoque, (2016) each domain has different levels of complexity, that ranges from the basic level of information to more

complex level higher-order learning levels. As indicated below, there are three major subject-specific aims in Life Sciences that connect to the purposes of learning science.

2.8.1 Cognitive outcomes in Life Sciences

Specific Aim 1 of the CAPS curriculum guides the knowledge that learners must acquire. Learners should acquire information that aids in understanding and making sense of sciences because of learning Life Sciences, allowing them to make numerous links between ideas and concepts. Learners can use their knowledge in new and unexpected circumstances when they develop such connections. Furthermore, in the process of acquiring knowledge, Life Sciences learners should be able to access information from different sources. To make sense of Life Sciences, “learners must first understand and connect ideas and concepts. Learners are required to apply the Life Sciences knowledge in new and unfamiliar situations”, DoE, (2012:13-14). This is consistent with PBL and CL approaches that require learner-centred approach.

2.8.2 Affective outcomes in Life Sciences

The affective domain has been one of the learning spheres that has received inadequate attention in the teaching of sciences, according to Buma, (2016) and Jackson (2019). Jackson contends that the affective domain is crucial in teacher development and that the focus should not be solely on cognitive outcomes. In the CAPS curriculum Life Sciences addresses the affective domain through the specific aim 3 that requires learners to appreciate and understand the history, importance and applications of Life Sciences in society. Furthermore, learners should be able to understand and link school science to their lives outside of the classroom, emphasizing the need of embracing indigenous knowledge and Life Sciences. DoE, (2012).

2.8.3 Psychomotor outcomes in Life Sciences

Physical movement, coordination, and the use of motor-skills are all components of the psychomotor domain. “Life Sciences is a practical subject, which requires learners to carry out investigations as well as solve problems that require some practical ability”, DoE, (2012:15-17). Learning activities should give learners opportunities to handle and use equipment in carrying out investigations, acquiring laboratory skills such as the Kirby-Bauer technique to teach IK. In the CAPS curriculum the psychomotor outcomes are guided by the “second specific aim that requires learners to carry out investigations through are range of investigative skills”, DoE, (2012:14-17).

2.8.4 Revised Bloom’s taxonomy

The revised Bloom’s taxonomy was developed by Anderson and Krathwohl in 2000 and is built on Bloom’s taxonomy created in 1956 (Anderson & Krathwohl, 2000). The taxonomy is built on the cognitive domain from lower-order thinking to higher-order thinking. The taxonomy is used by Life

Sciences teachers especially in assessment to develop learners' cognitive capacity from simple to more complex forms thereby promoting higher-order thinking.

In the revised Bloom's taxonomy, Anderson and Krathwohl (2000) used verbs instead of nouns thereby highlighting the fact that learning is an active process. In this study, the revised Bloom's taxonomy is a 'framework of active learning' which emphasises learners' engagement in learning.

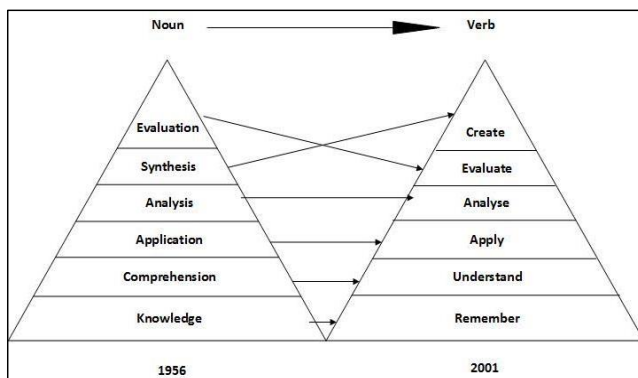


Figure 0-8 The revised Bloom's taxonomy. Anderson and Krathwohl (2000). Adapted from: Dlamini, et. al. (2019:7)

Bloom's Taxonomy is divided into three domains: cognitive, affective, and psychomotor. Feelings, perceptions, and thoughts are all part of the affective domain as defined by Krathwohl. Considering that the CAPS curriculum deals with real-life situations, the teaching of Life Sciences includes the emotional reactions of teachers and learners to external and internal phenomena such as attitudes, enthusiasm, and motivation. According to Buma, (2016), the affective domain is described as the "missing link" in Life Sciences education. This is why we advocate for the inclusion of IK, as it could better contextualise the western curriculum, and appeal to affective outcomes (such as an interest in the content). When teachers use learners' knowledge of how plants like the *Sclerocarya birrea*, widely known as Marula, are highly nutritious and high in vitamin C, learners may readily relate and tap into their own life experiences to link indigenous knowledge and acquire new skills, thereby making learning relatable and relevant. Krathwohl's et al. (1964) taxonomy for the affective domain is shown in Table 2.3, as well as my comments on how this could be addressed in the teaching and learning of Life Sciences.

Table 2-3 How the taxonomy of the affective domain (Krathwohl et al, 1964) is applicable to the teaching and learning of indigenous knowledge in the Life Sciences classroom

Level in hierarchy	Implications for the Life Sciences classroom
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Receiving	Making learners aware of indigenous knowledge systems; in my SLP, I had to sensitize teachers to the affordances of including indigenous knowledge in curriculum themes.
Responding	Teachers, through their engagement with IK, develop a better understanding and appreciation for IK and its tenets; teachers explore the alignment between the tenets of science and IK.
Valuing	Through their engagement with IK, teachers start to appreciate the role of indigenous knowledge more and come to value IK as a knowledge system.
Organisation	Teachers build IK perspectives into their cognitive structures or worldviews; they develop a reformed teaching- and learning philosophy, based on the integration of IK and western science perspectives.
Characterisation	This new teaching and learning philosophy dictate the pedagogical decisions that the teacher makes.

2.9 Technology-integrated learning environments

The Department of Education (2004:14) defines e-Education “to accelerate the achievement of national goals. This is done through connecting learners and teachers to each other and professional support services and providing platforms for learning.” In the South African context, technology-integrated environments will therefore support pedagogical, curricular and assessment reforms to improve education and the use of educational resources such as ICTs. Technology-integrated learning environments will therefore support the access to information, collaborative learning and the development of teaching and learning material through the use of the internet, software, other media and telecommunications. South African education embraces the international vision of World Education Transformation Countries and recognizes that, in the fourth industrial revolution (4IR), ICTs are no longer a luxury or a choice, but rather a necessity for every child to learn, DoE (2016). It is therefore crucial that curriculum delivery is strengthened through the utilization of ICTs, through BL environments.

2.10 Principles for using ICTs to support teaching IK in Life Sciences.

According to Lembani et al., 2020, when considering the use of ICT in current education systems, it is important to analyse the indicators of emerging learning paradigms, and this should focus on what teachers and learners do with ICT in relation to teaching and learning. It is therefore crucial in this study to zoom into the principles for using ICTs to support teaching IK in Life Sciences. Moreover,

ICT infrastructure, access to technology and information within the curriculum, and teacher training and support for ICT deployment will all have an impact on usage patterns, which can be associated with the integration of ICTs into teaching and learning. The main principles for using ICTs to support teaching and learning are (a) contextual learning, (b) learning as an active process, (c) learning as a social process and (d) reflective practice in learning (Ndlovu, 2016; Cilliers 2017; Buma, 2018; Lembani et al., 2020). These four principles are discussed below.

Contextual learning: According to Ndlovu, (2016:53), “effective learning occurs when learners integrate new information or knowledge in a meaningful way that makes sense within their own frames of reference, their inner world of memories, experiences, and responses.” Furthermore, ICTs are effective teaching and learning tools that enable bringing instructional concepts to life by modelling real-life scenarios or connecting the classroom context to the outside world, such as the community, business, or scientific and technology practitioners (Lembani, et al, 2020). Teachers should use IK and ICTs as enablers for effective teaching of Life Sciences concepts.

Learning as an active process: People learn more effectively from their own experiences than from passive acceptance of knowledge offered by others or from technology means. As a result, teachers should consider computer technologies to be tools for knowledge discovery and development, rather than tools for knowledge transfer or passive acceptance (Cilliers, 2017). Physical experience is important for learning, especially for when learners are involved in hands-on and minds-on activities. Heystek (2021) proposes encouraging active learning in ICT-enabled environments by structuring learning around activities that require a significant amount of creativity, decision-making, and problem solving. Problem-based learning, and collaborative learning are examples of learning approaches in which learners are expected to take an active role in problem-solving, with the teacher assisting them to construct knowledge that leads to finding solutions in real-life circumstances.

Learning as a social process: Learning is inextricably linked to the process of communication between the learner and others - teachers, casual acquaintances, family members, and peers. Buma, 2018, highlights that individual learners are not the only ones who can benefit from computer technologies. Rather, ICTs are used as tools that facilitate shared thinking and knowledge development through personal connections with others.

Reflective practice in learning: According to Cilliers (2017), for learners to gain from experience, it is critical to encourage them to reflect on their own experiences as individuals and groups. To promote reflection in learning, it is necessary to identify the educational objectives for reflection, to give a chance for learners to clarify their understanding of the reflection process, and to provide time for reflection when utilizing ICTs to facilitate learning (Ndlovu, 2016).

2.10.1 Characteristics of appropriate technologies for indigenous knowledge

There are many different perspectives on the qualities of appropriate technologies for IK; nevertheless, one element that appears to be prominent is that appropriate technology includes the comprehensive engagement of the local community throughout the development process (Tharakan 2015, Olivier et al, 2019:292). "The idea of appropriate technologies requires that they be rooted in the community and that their implementation and development can involve the community, resulting in capacity-building and empowerment" (Olivier et al, 2019:292). As a result, appropriate technologies for IK should be understandable, controllable, and maintainable within the community they are implemented. The local community must stay up with technological issues for more advanced technology to be successfully operated and maintained (Tharakan 2015:54, Olivier et al, 2019:292). "Local communities should be involved in all stages of technological implementation or intervention, including conceptualization; the development process, from innovation to development to implementation; and the monitoring and assessment of the intervention" (Tharakan 2015:54, Olivier et al, 2019:292).

Consideration should be given to technologies that are cost-effective and need low capital expenditure, they should use local materials as much as possible, are labour-intensive, small-scale, and inexpensive (Tharakan 2015, Olivier et al, 2019). The issue of nature conservation should play a central role in reducing or, if possible, eliminating negative environmental impacts that may emanate from the process of developing and using technologies, limiting environmental impacts, and promoting sustainability. Appropriate technologies for IK should remain adaptable and versatile, furthermore, they should be capital-intensive and be focused on community empowerment and development. (Tharakan 2015, Olivier et al, 2019).

2.10.2 The digital divide

According to Lembani et al., 2020, the concept of digital divide includes the ability to use digital technology meaningfully. In this case, the resources theory is used to characterize three distinct resources that are critical in understanding the concept of digital divide: (1) material resources, (2) cognitive resources, and (3) social resources. Different multidimensional theoretical models have been established based on these resources, with the most recent models explaining differences in ICT access and use because of digital skills, motivation, use patterns, and possession (Liebenberg et al., 2012, Lembani et al., 2020).

"First and foremost, access to ICT is limited by material resources. This covers a person's financial ability to own a computer and access to the internet at home, as well as use public ICT facilities like libraries, schools, information kiosks, and internet cafés. Second, cognitive resources, or students'

ability to read and process, handle, and comprehend information made available by ICT, is an important resource type in this digital age” (Lembani et al., 2020:4).

The third factor described in the resource theory is social resources. “Possession of a computer and access to the internet is influenced by social connections that an individual may have with people in similar social contexts who own or have regular access to digital technology” (Lembani et al., 2020:4). Positive responses to ICTs can alleviate the doubts that typically accompany the views about the possession and use of digital technologies, especially if the facility fits within a household's or community's existing norms and values.

Lembani et al., (2020:5), highlight that the difficulty with previous discussions on the digital divide is that they mainly focused on the binary distinction between information "haves" and "have-nots," with little or no emphasis on grading the information "haves" based on the degree of access to ICT. “If we are to respect the cognitive, social resources, and material, of various groups, such as those living in cities and those living in peri-urban and rural areas, we must reconsider the digital divide. Investigating the location of ICT access and the extent to which it differs across diverse persons from various geographical locations and socio-economic backgrounds would contribute to a better understanding of how meaningful ICT access might promote or impede inclusive and equitable access to technology-enhanced learning.” (Lembani et al., 2020:5). This is a painful reality that is widening the inequality gap in South Africa.

Technology diffusion from developed to developing countries has been mapped and implemented at both the national and global levels (Lembani et al., 2020), as well as bridging the rural-urban digital divide through the facilitation of public ICT access through libraries, schools, and internet cafés (Pick & Nishida, 2015; Mykhnenko, 2016; Lembani et al., 2020). Previous research easily fit the notion of ICT access into a binary model of ICT "haves" and "have-nots," with only a few studies indicating that levels of access vary within each construct (Liebenberg et al., 2012). South Africa is a very diverse country with various cultural, racial, or ethnic groups and socio-economic backgrounds, as a result the access to ICTs goes beyond a binary model of “haves” and “have-nots”.

2.10.3 Blended learning environments

A blended learning environment, according to Horn and Staker (2012), should give learners some control over time, place, path, and/or pace. Furthermore, Permana and Santosa (2018) claim that using Blended Learning creates a very active classroom in which students are engaged in learning activities and are learning to strengthen their problem-solving skills. There are different models that can be used in BL environments. First, the rotation model, in which the individual rotation involves learners alternating between learning modalities on an individually designed, fixed schedule, at least

Commented [A15]: Spaces between paragraphs not consistent.

one of which is online learning (Staker & Horn, 2012; Bosch, 2017). Second, through activities such as small-group instruction, group projects, and individual tutoring, the subject teacher or other adults provide face-to-face help on a flexible and adaptive as-needed basis. Staker & Horn (2012); Ozdamli and Asiksoy, (2016) state that the amount of face-to-face support depends on the learners' needs. Third, is the self-blend model, through which, learners choose to take one or more courses entirely online to supplement their traditional teaching and the subject teacher offers instructions online. Learners have the option of taking classes on-site or off-site (Staker & Horn (2012), Bosch (2017)). Fourth is the enriched-virtual, which requires learners to split their time between attending classes on campus and learning remotely using information and instruction delivered via the internet. Many Enriched-Virtual programs start as full-time online schools, then evolved into blended programs to give learners face-to-face learning opportunities, Staker & Horn (2012); Bosch (2017).

2.11 Technological pedagogical content knowledge

The TPCK framework was developed by Mishra and Koehler (2006) and built on PCK, the well-known Shulman's (1987) construct. TPCK acknowledges that, with developing technologies, teaching has become a complex activity that embraces various kinds of knowledge.

For Hardman (2015), the use of computers in teaching opens collaborative interaction between learners and impacts the division of labour in the classroom. Authors such as Tarling, and Ng'ambi, (2016), Hockly, (2018) and Charbonneau-Gowdy, (2018) argue that the constructivist nature of technology-integrated learning provides learners with multiple opportunities to collaborate rather than just with face-to-face teaching.

Rosenberg and Koehler (2015) highlight the importance of context in TPCK. The TPCK model emphasises the complex interrelatedness of three forms of knowledge. The process of teaching is affected by factors beyond the classroom. This study takes place in schools that are in economically previously disadvantaged communities where learners and teachers do not necessarily have computers to work on at home. The school communities play an important role in the safety and security of the technological devices that are supplied by the DoE.

TPCK is a way of integrating technology into Life Sciences lessons. Considering that technologies are a wide source of information, teachers must guide learners on how to use ICT tools for educational purposes. Teachers should also guide learners on how to get credible information. To integrate the three TPCK components, this includes (a) the content knowledge, which includes subject matter, (b) pedagogical content knowledge, the ability to select and use teaching methods best fit the content and (c) use of the appropriate tools to facilitate teaching and learning. Teachers should start from the subject content that is informed by the Life Sciences CAPS document and then

select the appropriate enablers/tools for the lesson. The tools will then inform the selection of the relevant pedagogy.

2.12 Teachers experiences of technology integrated teaching

In studying the experiences of language teachers with online learning, Comas-Quinn (2011) argues that teachers' readiness and willingness to engage with new technologies play an important role in how well teachers make the transition from traditional face-to-face teaching to more complex BL. Judson (2006) strongly expresses that a bad attitude towards technology or the fear of using technology is unlikely to lead to lessons that are different from the traditional ones.

The studied literature indicates that the success of any changes in education, such as the introduction of online teaching and online technologies, greatly depends on how well teachers are prepared to implement the new ideas. Eaton *et al.* (2015) highlight the fact that teacher training that is built on developing teachers' technology skills will better prepare teachers to integrate technology. This preparation involves the teacher development programmes for upskilling on CK as well as the technological skills that make teachers competent, comfortable and confident to integrate technologies.

It should be noted that South African teachers are at different levels of professional development, ranging from well-seasoned experts to novice and unskilled teachers. It is therefore important to consider teachers' needs when designing professional development programmes. Since teachers involved in the research were taken through a once-off technology integration training session, the question is about what attitudes teachers have towards the integration of technology in teaching.

2.13 Challenges experienced by teachers in technology supported learning

Graham *et al.* (2020) claim that several issues contribute to teachers' failure to effectively employ existing technologies to improve teaching and learning. Bingimlas (2009:243) affirms that "teachers are eager to integrate ICTs into their lessons but are limited by barriers such as a lack of competence, confidence, and access to resources." Ndlovu (2016:8), suggests that the insufficient integration of ICTs in education can be a result of inadequate teacher training in the use of ICTs for teaching and learning purposes. Furthermore, challenges such as overcrowded classrooms, limited resources, the complexity of facilitating complex discussions on sensitive topics, and time constraints due to exam preparation are all challenges that hinder the integration of ICTs. Buma (2018:111) cites the same issues as factors contributing to the restricted usage of ICTs for teaching and learning.

According to Salehi and Salehi (2012) "ICT integration into teaching is challenging because it requires more specific skills from teachers." Teachers have a challenge since there are no explicit guidelines on how ICT affordances should be used to enhance the teaching and learning experience (Ndlovu, 2016). "Teachers are more likely to use constructivist teaching approaches when they effectively integrate technology into their lessons" (Judson, 2006).

The Life Sciences teachers who participated in this study, received basic training on the use of smartboards. It remains important that the teachers' attitudes towards the use of ICTs and willingness to use new technologies play an important role in the success of using technologies to support effective teaching and learning. Spangenberg, Erica, & De Freitas (2019), cite that South African Mathematics teachers face challenges in attempting to integrate ICTs to enhance learners' mathematical comprehension. These challenges may arise from the teachers' support programs that fail to adequately address the specific needs of mathematics teachers and the obstacles they encounter when integrating ICTs in their teaching. Furthermore, the lack of reliable internet connectivity for teachers and learners makes it difficult for teachers to sufficiently support learners through online learning. Ndlovu (2016), strongly argues that teachers need to be cognisant of the design principles that can assist them to create learning environments which capture learners' attention towards achieving the learning goals. Additionally, according to Wichadee, (2018), the success of teaching and learning in a BL environment is also affected by the way teachers embrace their role in the traditional face-to-face classroom.

2.14 Conclusion

The problem of poor learner performance is a global challenge, according to Mudulia (2012), and this problem is made worse by the existing digital divide, poverty and other problems unique to the third world. In South Africa, several socio-economic challenges affect teaching and learning. In addition to the provision of resources to enhance learning, there is a need to ensure that teachers are well prepared and supported to make use of available resources.

The Department of Education (2004) acknowledges that "the use of ICTs in schools is gradually increasing, and many schools are exploiting the benefits of ICTs to enhance the quality of teaching and learning." Furthermore, the DoE identifies the integration of ICTs into the teaching and learning process as one of their major challenges due to the digital divide.

It is therefore important to continuously assess how the integration of ICTs facilitates the development of the PCK of teachers and also look into the challenges teachers face in this regard –

an area that this study tries to address. A critical issue for instance is that many teaching resources and textbooks are not related to and not integrated with ICT applications and education software (Levin & Wadmany, 2008). Traditionally South African Life Sciences teachers use a variety of textbooks as a source of teaching and learning information.

In the South African context, research has yet to sufficiently establish the effectiveness of integrating information technologies. This study aims to address this gap by exploring the integration of IKS into the teaching of Life Sciences using ICTs.

CHAPTER 3 METHODOLOGY

3.1 Introduction

Mixed methods research uses elements of both qualitative and quantitative data-gathering methods such as open-ended questionnaires, studying artefacts, focus group interviews, individual interviews, and classroom observations (Creswell, 2013; Creswell & Plano-Clark, 2018). This method is still widely regarded for its ability to achieve a more complex understanding of the research problems

(Creswell & Plano-Clark, 2018). In this study, I thought a mixed-method approach with an emphasis on a qualitative component was appropriate, as my sample is relatively small. According to Ivankova, et.al, (2014:269), “the mixed method technique allows the quantitative and qualitative to complement one another, allowing for a more comprehensive understanding of the study problem.” I therefore found it suitable to combine qualitative and quantitative data to have a better understanding of the teachers’ experiences with IK and ICT supported learning. For classroom observation, I used the FIT:COM tool, which was developed by Judson, (2006), which uses a Likert scale to capture quantitative data. The qualitative component is more predominant than the quantitative aspect since my focus was to understand the experiences of Life Sciences teachers on the integration of IK knowledge through ICTs.

In a mixed method the qualitative and the quantitative methods complement each other. A qualitative research design, according to Nieuwenhuis (2014:70), “is a strategy that moves from the underlying philosophical premise to specifying the selection of respondents, data gathering procedures, and data analysis to be done.” The philosophical principle that underpins this study is social constructivism which states that knowledge is co-constructed hence I found it fit to use the mixed method.

3.1.1 Aim of the study

The study aims to explore how teachers integrate IK into the teaching and learning of Life Sciences through using ICTs.

3.1.2 Objectives of the study

The following objectives have been identified for the study:

- To explore how teachers are integrating the relevant IK of different cultural groups into their teaching of the Life Sciences content using ICTs.
- To explore how the approaches that Life Sciences teachers are using to improve the teaching of IK through ICTs.
- To see how far teachers’ classroom practices for teaching IK with ICTs have transformed because of the SLPs.
 - To find out what are the Life Sciences teachers’ lived experiences with using ICTs to teach IK and the challenges they face in this regard

3.1.3 The research questions that guided this research

This study was guided by the following main research question:

- How do teachers integrate IKS in teaching Life Sciences through using ICTs?

The following secondary research questions guide this research:

- How are teachers incorporating the relevant IK of different cultural groups into their teaching of the Life Sciences through the utilization of ICTs?
- What teaching approaches are Life Sciences teachers utilizing to improve the teaching of IK through ICTs?
- To what extent are teachers' classroom practices consistent with what is practiced in the SLPs?
- What are Life Sciences teachers' lived experiences with using ICTs to teach IK and what challenges do they face in this regard?

3.2 Research approach

This research uses mixed methods with a focus on the qualitative nature of the method. According to Nieuwenhuis (2014:50), "a qualitative research approach aims to collect rich descriptive data about a specific context with the intent of understanding the behaviour patterns and experiences of the participants in the study." Qualitative studies focus on acquiring data from participants within their natural environment (naturalistic context) as the emphasis is placed on 'seeing through the eyes of the participants' (Nieuwenhuis 2014:51). Therefore, the emphasis is on qualitative research, as the study attempts to reflect on the experiences of Life Sciences teachers in integrating IK through ICTs. However, the use of a Likert scale and the statistical analyses done disqualifies this research approach as exclusively qualitative, but rather as a mixed method approach.

Furthermore, it is important to get an understanding of the meaning that teachers attach to these experiences. These teachers' experiences have an impact on how their teaching is transformed to enhance SDL. Therefore, the transformative nature of the experiences in terms of the changed view of IK integration in the teaching of Life Sciences is studied.

In this study, the affordances of online learning environments such as electronic media (internet and social media) and interactive smartboards in the professional development of Life Sciences teachers will be unearthed. Although the study may yield data representing beliefs, attitudes and ideas about IK, it must be noted that these are not the focus of this study.

3.3 Philosophical view

"A research paradigm refers to the philosophical assumptions or beliefs which define the worldview of the researcher" (Kaushik & Walsh, 2019:1). The activities in the SLPs were by pragmatism as the paradigm. "Pragmatism dictates that the researcher should use the methodological approach that works best for the specific research problem that is being investigated" (Kaushik & Walsh, 2019:2).

Merriam and Tisdell (2016:46) state that “pragmatists believe that multiple paradigms can be used to address research problems”.

3.3.1 Affordances of learning scaffolding in teachers’ Short Learning Programs

Life Sciences teachers participated in a short course that dealt integration of IK using ICTs. The study was conducted in the Gauteng Province of the Tshwane North Education District. Teachers’ experiences of the dynamics of integrating IKS into the teaching of Life Sciences after a BL course were investigated. Short learning programmes do not necessarily assist teachers to mature to their full professional development potential (Sebotsa, 2020). Teachers’ learning was scaffolded through Vygotsky’s (1978) well-known ZPD or, in Warford’s (2011) parlance, the zone of proximal teachers’ development in this intervention. The word scaffolding was coined as “a metaphor to describe the type of learning support given by a teacher or peer. In the process of scaffolding, the teacher helps the learner to master a task or concept that the learner is initially unable to grasp independently. The teacher helps with only those skills that are beyond the learner’s capability” (West et al., 2017:185).

In the SLP provided, teachers were assisted with content and pedagogical skills with which they struggle (Figures 3-1 and 3-2). The researcher obtained written consent from all the participants to disclose their identities in accordance with ethical protocol.



Figure 3-1 Teachers’ short learning course on ‘bringing the laboratory into the classroom’.



Figure 3-2 Teachers engaged in the practical work of extracting DNA from strawberries; on the extreme right the researcher is explaining the practical activity.

Teachers were guided through the process of designing meaningful learning and evaluation, with the focus on lesson planning, Bloom's Taxonomy and reflection. Participants were also guided on how to use cooperative learning strategies, such as the jigsaw method and De Bono's thinking hats (Figure 3-3) (De Beer & Whitlock, 2009).



Figure 3-3 Teachers acknowledging the outcome and using a puzzle to explain the DNA molecule.

Furthermore, teachers engaged in an ethnobotanical survey, in which they were guided on how to use the matrix process, the ethnobotanical knowledge index (EKI), and the species popularity index to learn local plant use and the importance of the application of IK (Figure 3-4) (De Beer & Van Wyk, 2012). Such an activity in the classroom holds affordances to engage learners in problem -and project-based activities, which could enhance self-directed learning.



Figure 3-4 Teachers exploring ways of approaching classification.

3.4 Research methodology

3.4.1 Research design: Mixed-Methods research

This is a Mixed-Methods study (Creswell, 2013), with the qualitative component dominant (QUAL), and the quantitative data supportive (QUAL-quan). Research design refers to the strategy used by the researcher to acquire data and that provides guidelines as to how participants are selected as well as how data will be collected and analysed (Nieuwenhuis, 2014:70). Consequently, a research design is selected by the researcher based on the researcher's assumptions, research skills and research practices.

This study has phenomenological elements as it focused on the lived experiences of participants (Nieuwenhuis, 2014:71; Neubauer *et al.*, 2019:91). According to Neubauer *et al.* (2019:91), phenomenology aims to conduct research that looks at interpreting a phenomenon in the same/similar way that the participant has experienced it by outlining how and what was experienced.

Therefore, the rationale for using a pseudo-phenomenological research design was to attempt to capture Life Sciences teachers' lived experiences of BL. However, this study is not a true phenomenological study; the conceptual and theoretical frameworks were pre-designed and thus this disqualifies it as an authentic phenomenological study. According to Merriam and Tisdell (2016:26), the "task of the phenomenologist, then, is to depict the essence or basic structure of experience". In phenomenological studies, the individual interview is the primary method of data collection. However, other data collection methods may be utilised to further enrich the data.

Consequently, in this study, individual interviews with Life Sciences teachers were conducted and integrated with classroom observations; lesson plans developed by teachers were also analysed.

Posthuma (2012:1) argues that “when teachers reflect on their classroom experience, they consider the flaws of their own instruction and consider how those flaws apply to their learners’ comprehension of concepts. They are aware of the implications of their teaching as well as how their own biases and values can affect their teaching.” Teachers’ reflection was used to get an understanding of the teachers’ experiences of their lesson delivery and what they had in mind when carrying out certain activities in the lesson. An in-depth lesson reflection can assist in the professional development of teachers.

3.5 Research process

Data for the study was obtained in two phases. In phase one, semi-structured interviews with the Life Sciences teachers were conducted to get an understanding of each teacher’s experiences, practices and attitudes towards the inclusion of IKS in Life Sciences lessons.

In the second phase, classroom observations that focused on the integration of IKS through ICTs were conducted. In addition to classroom observations, artefacts, such as lesson plans, together with teacher reflections were analysed.

Life Sciences teachers participated in two SLPs on IK and use of ICTs supported learning. Participants were required to answer the pre-intervention VNOIK (views on the nature of indigenous knowledge) questionnaire prior to the short learning sessions, and the post-intervention VNOIK questionnaire following the intervention (Cronje, 2015).

The questionnaire on the nature of indigenous knowledge (VNOIK) was created by (Cronje, 2015). This instrument’s open-ended questions allow teachers to provide feedback based on their own personal experiences. I was able to see if there was any gain on IK, from the intervention by using both the pre and post intervention questionnaires.

Permission for the use of the FIT:COM instrument was obtained from the developer. The FIT:COM instrument includes background and contextual background information, such as the classroom set up as well as the layout and lesson objectives, design of technology integration, class dynamics, meaning and purpose, CK and technology as tools. The instrument uses the Likert scale, with a rating ranging from 0 (never occurred) to 4 (very descriptive). The FIT:COM instrument is included in Appendix H.

3.5.1 Semi-structured interviews

Semi-structured interviews take place between an interviewer and an interviewee; participants engage in a conversation with a researcher (Nieuwenhuis, 2014:87). An interview schedule (Appendix I) with predetermined questions that required appropriate responses from the participants was developed. The questions were designed to capture the participants' views on IKS and the online environment in the teaching of Life Sciences. (See attached transcription in the Appendix)

According to Nieuwenhuis (2014:87), although questions have been predetermined, the researcher can ask a participant follow-up question based on the participant's response. Consequently, the predetermined questions in the interview schedule were open and non-directive questions and allowed for further probing or clarity on certain responses from participants. During the interviews, broad questions to get teachers' general perspectives were posed first and then enquiries about their efforts to include IKS when teaching Life Sciences were made.

Interviews were pre-arranged and were conducted only after school hours so that the normal school programmes were not interrupted; teachers' contact time was always protected. The school's management was informed about the interviews. The interviews were conducted at the schools. This was done so that teachers would not incur any travelling costs. Before the interviews, the teachers were briefed on the purpose of the study and their involvement was clearly outlined. In a Covid-19 context, guidelines, such as social distancing, wearing of mask, and sanitizing, were observed.

The interviews were conducted in English. Questions were simplified and the researcher listened carefully while taking notes and allowed teachers to finish their answers without interrupting. Where clarity was needed, follow-up questions were asked. The interviews were transcribed, and coded and emergent themes will inform future short course offerings as they will be distilled as design principles.

Several guidelines must be followed in arranging and securing an appointment for interviews and classroom observations. Most appointments with teachers required multiple telephone calls or emails before the teacher could commit to a set date. Several set appointments had to be rescheduled due to competing priorities. This was especially difficult within the Covid-19 pandemic, as I could not access schools at times, and I had to always adhere to the Covid-19 protocols. Nonetheless, persistence ensured that the researcher was able to secure an appointment with teacher.

3.5.2 Systematic observations

In the second phase of the research, namely exploring what transfer of knowledge and skills takes place in the classroom, six schools were visited, and lesson observations were conducted with the fifteen teachers. Observations allow the researcher to collect data directly from participants; this is known as primary data. According to Nieuwenhuis (2014:83), observations are a “systematic process of recording the behavioural patterns of participants, objects and occurrences without necessarily questioning or communicating with them”.

Nieuwenhuis (2014:83-84) concurs with Simpson and Tuson (2003) that using observation as a data collection technique allows the researcher to record participants' behavioral patterns, objects, and incidents without directly interrogating or communicating with them because the observer uses a pre-designed observation tool. Thus, the observations in this study focused on the integration of technology and were guided by using the FIT:COM instrument. This was done to determine the extent to which classroom interactions had been reformed, thus, I hope to gain an understanding of what promotes or inhibits the transfer of knowledge and skills on IK and ICT supported learning into the classroom by studying teachers after the intervention program.

3.5.3 Documents and artefacts

Documents were used as a primary source of data required for the study as lesson plans and teacher reflections were obtained directly from the participants (Nieuwenhuis, 2014:82).

According to Halstead (2017), secondary school science teachers must create time to develop and implement reflective practices after teaching a lesson. After the classroom observations, the researcher had a feedback session with the participants, and they could reflect on the observed lessons by responding to a few reflection questions designed by the researcher (Appendix I).

3.6 Sampling and selection of participants

3.6.1 Site selection

Site selection was based on the premise that, as this was a mixed method study, data had to be collected in a naturalistic context. Furthermore, the environment of the participants had to be an environment in which they were comfortable and with which they were familiar (Nieuwenhuis, 2014:50).

In this study, the naturalistic context would be the schools in which the Life Sciences teachers worked. Consequently, the study was conducted in secondary schools in the Tshwane North

Education District within the Gauteng province. The Tshwane North District was selected because the researcher works in that area, and it was time and cost-effective to conduct the study there.

The study was conducted in six public schools. The schools selected for the study were part of a pilot project on the use of interactive smartboards. The schools that were involved in the study are situated in Soshanguve and Hammanskraal, areas that lie to the north of Pretoria. These two townships are in a semi-rural area which is managed by the City of Tshwane. These communities are generally economically underdeveloped with most of the schools still surrounded by gravel roads. The schools' infrastructure is both brick and mortar and mobile classrooms. All the schools in the sample are classified as no-fee paying schools.

Most learners in these schools are social grant beneficiaries; as a result, they depend on their schools as support systems. They do not have access to computers or connectivity in their homes and depend on the technologies that are available at schools. Very few learners have access to smartphones.

3.6.2 Choosing a sample

Sharma (2017:749) considers sampling as "a technique (procedure or device) employed by a researcher to systematically select a relatively smaller number of representative items or individuals (a subset) from a pre-defined population to serve as subjects (data source) for observation or experimentation as per the objectives of his or her study." The sampling method used in this study was a combination of convenience sampling and purposive sampling.

Convenience sampling refers to a method that selects participants that are easily and conveniently available. In this case, the teachers in schools in the Tshwane North District were selected as these teachers were in schools that were easy and convenient for the researcher to access.

In addition, purposive sampling had to be used as the study was looking for a specific sample as the researcher had a specific purpose in mind (Maree & Pietersen, 2014:178). Hudak *et al.* (2004) explain how a purposive rather than random sample maximises the potential for eliciting detailed information about satisfaction relative to those features considered most relevant.

For the classroom observations and individual interviews, the researcher used purposive sampling to identify 15 Life Sciences teachers from six public schools in the Tshwane North District of Gauteng. The 15 teachers who participated in this investigation are part of professional learning groups within the district. The teachers are in working schools that were part of a pilot project on the use of interactive smartboards and they had been trained on smartboard use.

As illustrated in Figure 3.5, the participants were selected on their ability to represent the population of Life Sciences teachers who taught Grades 10, 11 or 12. Also, the teachers had to be teaching in public secondary schools in the Tshwane North District, have basic computer skills, have access to ICTs and be part of the GDE smartboard pilot project. The teachers needed to be accessible and willing to be observed while teaching Life Sciences. Some practical considerations such as time, cost and accessibility of the schools had to be considered. Lastly, teachers with general knowledge of the IKS that is required in teaching Life Sciences were selected for the study.

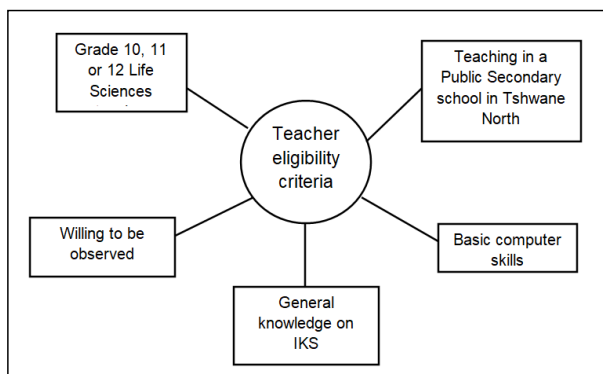


Figure 3-5 Teacher eligibility criteria.

3.6.3 Sample size

To select a sample that gives a sufficient representation of the population, the researcher organised a meeting with two Life Sciences Lead Teachers (LTs). In the Gauteng province, subject LTs coordinate Professional Learning Communities for teachers and provide support to teachers within their learning communities. From the meeting, a list of 25 teachers was compiled; 16 of the 25 teachers agreed to participate in the research study. One teacher got a promotion post in another district, hence the participant had to withdraw from the study. Fifteen teachers were left to complete the study.

3.6.4 Recruitment of participants

The researcher obtained permission from the GDE before the initiation of the study. Thirty-six potential participants were informed about the study through a provincial subject meeting. The information was communicated by an independent presenter. This was done so that teachers would not feel pressurised to participate in the study.

3.7 Data analysis

3.7.1 Analysis of interviews

The interviews were transcribed, then coded and the code-to-theory model developed by Saldaña's (2015) was an acceptable tool to utilise because it demonstrated important relationships from the collected data. The data was organised into themes using an in-vivo coding technique (codes derived from the precise words said by the participants) as represented in Figure 3-6 below.

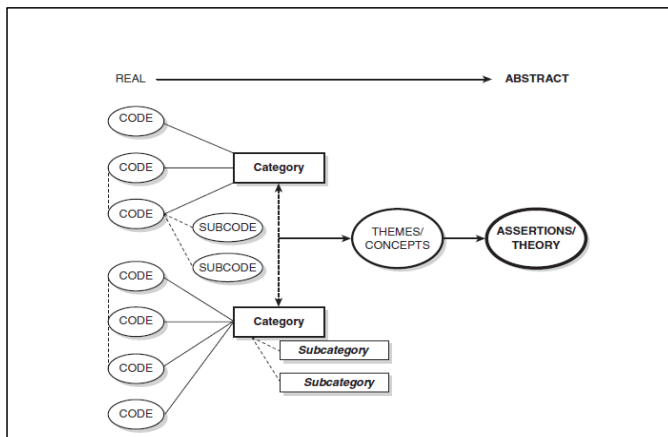


Figure 3-6 Saldaña's code-to-theory model. Source: Saldaña (2015).

From the data, themes were distilled. These themes will be discussed in Chapter 4.

3.7.2 Analysis of observations (FIT:COM)

The classroom observation data, which was recorded on FIT:COM instruments, was analysed with the use of IBM SPSS Statistics Version 26 to reveal the patterns in the data.

3.7.3 Analysis of artefacts (lesson plans)

Artefacts such as lesson plans and learner activities to establish how teachers incorporate IKS into the Life Sciences curriculum were also used. The important aspects that were analysed in the lesson plans included the following:

- Template used
- Intention of the lesson plan
- What guided the lesson plan?
- The content covered in the lesson plan.

I had to consider whether ICTs were effectively integrated as a vehicle, and whether IK was successfully utilised to contextualise the lesson.

3.7.4 Analysis of VNOIK

The technique outlined by Lederman et al. (2002) and Cronje (2005) was used to analyse VNOIK (Cronje, 2005) questionnaires (2015). According to Lederman et al. (2002), reactions can be classified as (a) I or (b) knowledgeable. Cronje (2015) divided the VNOIK questionnaire into three categories: (a) a I or uninformed view (U.I.), (b) a partially informed view (P.I.), and (c) an informed and nuanced opinion (I).

3.7.5 Secondary data analysis, using CHAT as a lens

Third generation CHAT (Engeström, 2000), which was developed from the ideas of both Vygotsky and Leontiev (1978) as a post-Vygotskian legacy, is used in this study as a research lens. CHAT provides an approach to studying human activity as a system of interacting activities. By using CHAT as a research lens, factors/ 'tensions' that prevent the implementation of IK in the classroom in an online fashion can be identified.

Figure 3.7: A model of Cultural Historical Activity Theory, (CHAT), as conceptualised by Engeström, (2000).

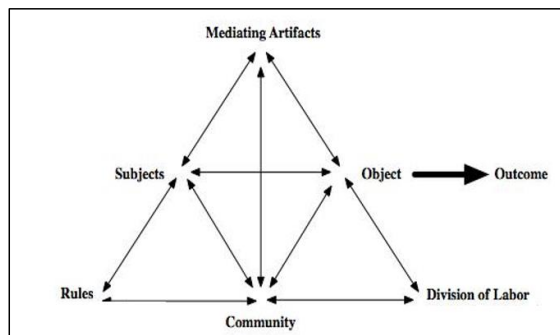


Figure 3-7 A model of Engeström's CHAT. Source: Engeström (2000).

In this study, CHAT is used as a lens to make meaning of the interactions in observed Life Sciences lessons. When this model (Figure 3.6) is translated into a Life Sciences classroom environment, ...

- the subject is the Life Sciences teacher.
- the object is the integration of IK through in an ICT supported learning environment, i.e., achieving Life Sciences learning objectives at a higher cognitive level.
- outcomes are the Life Sciences teacher who integrates IK through ICTs.
- rules are the Life Sciences CAPS documents which outline the curriculum, the National Protocol on Assessment (NPA), the National Policy Pertaining to the Programme and Promotion Requirements as well as the Life Sciences Exam Guidelines; further rules

include the tenets of science and the tenets of IK as well as the principles that should underpin online/BL, as well as self-directed learning.

- community is all the stakeholders that affect the learning of Life Sciences and include the school community (teachers, school management, parents and learners), the DoE and external school support systems.
- division of labour is the continuously negotiated distribution of tasks, power and responsibility; for instance, teachers need to be facilitators of learning, critical-reflective practitioners and lifelong learners; and
- tools/artefacts are the different Life Sciences learning enablers or tools used to teach the content – this could refer to teaching methodologies, indigenous knowledge as well as ICTs.

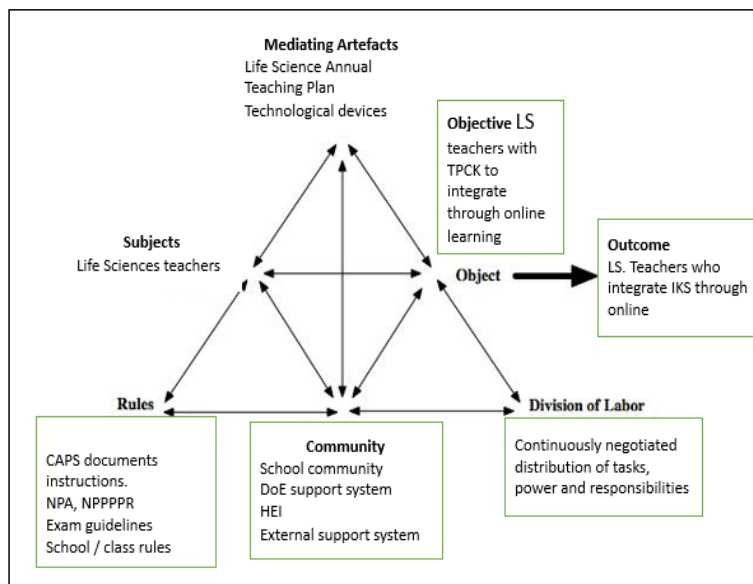


Figure 3-8 CHAT in the Life Sciences classroom.

We did interventions to see how we can assist with professional development of Life Sciences teachers regarding indigenous knowledge and technology. I wanted to see what transfer takes place to the classroom. It is important that this new knowledge and skills developed during the intervention is demonstrated in their classrooms. This is where third generation of CHAT comes in useful. Third-generation CHAT is based on juxtaposing two activity systems, and in my study, system A was the short learning programme offered to teachers, and the post intervention classroom constitute the second activity system.

In these activity systems the subject is the Life Sciences teacher; the object is that the teacher should use indigenous knowledge and technology in their teaching. I want to see how teachers infuse indigenous knowledge and technology in the teaching of CAPS themes, because that was the main purpose of my intervention. I wanted to see what tools the teachers are using, and I was specifically interested in teachers' use of the smartboards. I wanted to see how they use indigenous knowledge tools to contextualize learning and I also want to see how they use online learning to teach indigenous knowledge. Since we want to promote self-directed learning, the intervention process is based on self-directed learning principles. For example, teachers were encouraged to set individual learning goals during the SLP for their own professional learning.

We have several rules, the most important of which is the CAPS, as we need to ensure that the specific outcomes of the CAPS are achieved. There are certain guidelines for instance for the use of ICT's that we need to take note of, so all these are the rules. The community, since teaching and learning happens in the classroom, would include teachers, learners, and parents. However, "external" factors also influence teaching and learning, and therefore the community also include the school principals, the departmental heads, the school governing body, the Department of Education, and the teacher unions. All these community members have expectations on what is happening in the classroom. The division of labor refers to the various roles of the teacher; the teacher is a facilitator of learning, an ICT specialist, and a critical reflective practitioner and I need to see that the teachers really showed evidence that they could critically examine and reflect on their lessons.

In Chapter 4, I will use CHAT as a research lens, when analysing my data and findings. However, other researchers in the bigger NRF-funded project, such as Jacobs (2018), De Villiers (2018), Reddy (2019), De Beer (2019) and Sebotsa (2020) have highlighted tensions such as stakeholder expectations, that could negatively impact on the achievement of the object in the activity system. One of the tensions that these indicate, is that the school principal and the parents have certain expectations of a teacher because many families in poor communities are living in poverty, and parents strongly believe that if learners can get good marks, they will be able to get a degree which will get them out of poverty. Teachers, on the other hand, are evaluated by the Department of Education based on their performance, and there is a lot of pressure on teachers to drill learners and train them for exams to obtain a higher pass rate. The teaching of Life Sciences is subjected to a great deal of systemic pressures, and researchers such as De Beer (2019:18-19) "show that such tensions often lead to what McNeil (2013) refers to as a "contradiction of control", or the non-achievement of the outcome of the activity system". We want to look at how teachers use technology to teach indigenous knowledge, but parents, school principals and the DoE are all focused on learners getting good marks; the professional

development on indigenous knowledge and technology is seen as a waste of time because learners are not assessed on that at any point. I use this activity system to show where the tensions are and there are more tensions, and this is how I have used CHAT as a lens in this study. I used the third generation CHAT to verify the transfer of indigenous expertise and the integration of ICT into the classroom.

The major activity theorist Engeström (2000) argues for at least two activity systems, which means juxtaposing two inter-dependent activity systems. These activity systems must be linked together, and there must be a strong relation between them. As a result, I used the third generation CHAT to juxtapose two activity systems: (a) the intervention itself, which is the SLP; and (b) the transfer to the post-intervention classroom. This helps me to see how transfer occurs. The link between the two activity systems is that I conducted the short learning course for teachers, and then I observed what happened in the classroom with these teachers, so I juxtapose the two activity systems. This is illustrated in figure 3-9 below:

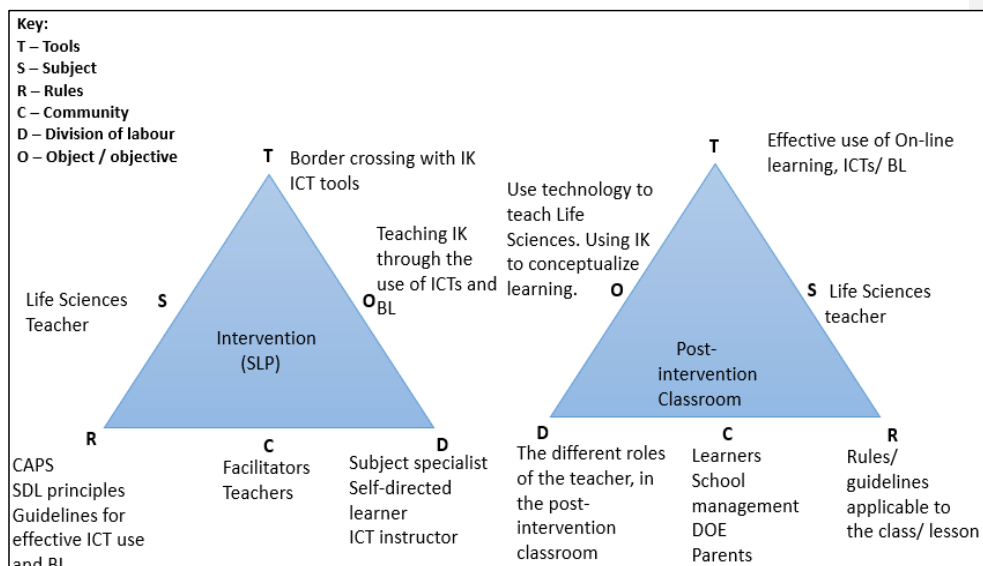


Figure 3-9 Source: de Beer, J. J., & Mentz, E. (2017). A cultural-historical activity theory focus on the holders of indigenous knowledge as self-directed learners: Lessons for education in South African schools. Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie

In Chapter four, I will use the third generation CHAT to analyse the impact of the intervention on the post intervention classroom. I will compare what happened during the intervention, with what happened in the post-intervention classroom. This will show me whether transfer of knowledge took place. It will also indicate the tensions that promote and/or prevent the transfer of IK into the

classroom. According to Mentz & De Beer (2017), the objects should share a common vision for effective learning, but this does not always occur because the emphasis is on gaining good marks rather than substantive learning. There is a degree of complexity to the object known as “contradiction of control” (McNeil, 2013).

3.8 Ethical considerations

Researchers must protect themselves against unethical research practices through their personal individual knowledge under all circumstances (Klink, 2014). The researcher took ethical issues into account throughout the study.

Ethics approval was obtained from the Faculty of Education’s ethics committee, as well as from the ethics directorate. Written informed consent was obtained from all participants.

3.8.1 Permission to conduct the study

Ethical clearance for the larger NRF-funded project was obtained from North-West University (NWU-00271-16-A2) (Appendix A). Additionally, ethical clearance for this study, NWU-EMELTEN-REC (NWU-0066-19-S2) (Appendix B) was also obtained from NWU, as customised interview protocols were being used. The nature and purpose of the study were explained to all participants. Participants were assured of anonymity using codes. They were also told that there were no right or wrong answers or views. All participants signed individual informed consent forms (see Appendix F) that included the following ethical guidelines:

- The purpose of the study and the roles of the participants were clearly outlined.
- Participation in the research was completely voluntary.
- A participant could withdraw at any stage and there would be no consequences for doing so.
- Expectations and implications on the part of participants were clarified, e.g., time frames, that participants should not incur any cost and that there would no financial compensation for taking part in the study.
- Confidentiality was assured through the use of pseudonyms.
- The researcher’s contact details were made available in case participants required clarity.

3.8.2 Beneficence

The researcher undertook to conduct herself in the best interest of the participants and to ensure that procedural guidelines were followed in the best interest of the teachers throughout the study.

3.8.3 Confidentiality in conducting the study

To ensure coherence and the acceptance of responsibility, the commitment was made to keep all the information of participants in the study confidential; in no way would their details be made known.

Confidentiality was ensured by using pseudonyms and not mentioning the names of the schools, principals and teachers who participated in the study.

3.9 Challenges encountered during data collection

This study was conducted during the global Covid-19 pandemic which negatively impacted the research process. Time and again, some appointments had to be rescheduled because of reasons that included:

- The unavailability of participants due to personal circumstances
- Changes in school schedules
- Power outages at schools
- In one case, the school had unfortunately been vandalised the night before.

Since the focus of the study is the integration of IK into the teaching of Life Sciences through ICTs, lack of electricity due to load shedding and/or cable theft and the lack of connectivity was a challenge in some schools. In all cases, the appointments had to be rescheduled and this prolonged the time allocated for data collection.

3.10 Credibility, validity and reliability

Maree and Van der Westhuizen (2014) outline the importance of ensuring that the data obtained in a study are both valid and reliable, ultimately making it credible. The data obtained in a qualitative study need to include honest data, resemble depth and have rich descriptions. The varied strategies used in this study to ensure validity included triangulation, crystallisation and rich thick descriptions.

Triangulation refers to the use of multiple data collection methods which help to improve the validity and reliability of a study (Nieuwenhuis, 2014). Triangulation and member checking were done through personal interviews, classroom observations and the study of artefacts, such as teacher lesson plans and reflections (Figure 3-10).

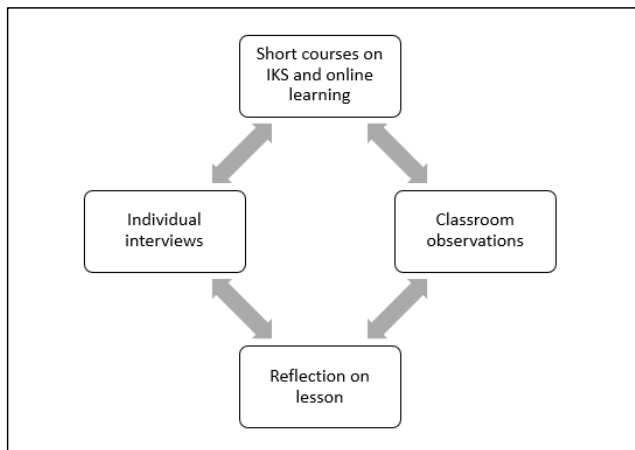


Figure 3-10 Methods of data collection.

Maree and Westhuizen (2014) suggest that the most appropriate term for benchmarking a qualitative study would be crystallisation. Therefore, in this study, multiple data collection methods, such as semi-structured interviews, observations and the use of documents when analysing the lesson plans and teacher reflections, were used. By doing this, multiple realities which led to the emergence of various themes and patterns in the study were able to be presented. According to Nieuwenhuis (2014:81), “crystallisation, therefore, provides us with a complex and deeper understanding of the phenomenon”.

In addition, the use of rich and thick descriptions allows for further validity in a qualitative study (Creswell & Poth, 2016). It was imperative that, in presenting the data, clear and vivid descriptions to contribute to the validity were used. Rich descriptions were used to give a clear picture of the general context in which the data were obtained (the site, the participants etc.) for the reader to be able to visualise the context. Essentially, this makes the study a shared experience between the researcher and the reader. Readers feel as though they were present throughout the study, and nothing is left open for individual interpretation. Doing this makes the study more realistic for the reader and, therefore, makes it valid and credible.

Merriam and Tisdell (2016:238) state that validity and reliability are concerns that could be approached “through careful attention to a study’s conceptualisation and how the data are collected, analysed and interpreted and the way in which the findings are presented”. Three standards suggested by Eisenhart and Jurrow (2011) served as a guide to ensure maximum validity in this study. These standards are the following:

- **Standard 1:** A valid study must demonstrate alignment between the research questions, data gathering methodologies and data analysis approaches.
- **Standard 2:** A research study can be considered valid provided there are credible reasons for a specific choice of subjects, data gathering procedures and analysis techniques. The researcher ensured the studies credibility by, for example, ensuring confidentiality during data collection, particularly when dealing with participants personal information.
- **Standard 3:** The goals of the study must be disclosed and considered to the participants and study leaders, throughout the study. By triangulating and member checking, the researcher's assumptions and prejudices were reduced. This assisted the researcher to ensure trustworthiness as described by Nieuwenhuis, (2014:81).

Summary

Chapter 3 outlines a summary of the research design and the research methodology. This study used a mixed-methods approach, with a focus on the qualitative method and support from the quantitative technique. The method used is not completely qualitative because of the use of a Likert scale and the statistical analyses that were conducted, but rather is a mixed method approach, in which the qualitative and quantitative methods complement each other to give a better understanding of the research question. Teachers were introduced to a range of interactive ICT-based activities during the SLPs; ideally, they will use these in their classrooms. The SLPs that are described in this chapter, involve teachers' learning being scaffolded using Vygotsky's (1978) well-known ZPD, or in Warford's (2011), the zone of proximal development. To ensure validity and reliability of the study, a range of data collection techniques were employed, including the VNOIK questionnaire, in-depth teacher interviews, in-classroom observations, and lesson reflection.

To analyse the impact of the SLPs on classroom teaching, I employed the third generation CHAT. I compared what occurred during the intervention with what transpired in the classroom after the intervention. This made it possible for me to assess if information was applied to actual teaching, thereby highlighting the conflicts that support or hinder the integration of IK into the classroom. The findings of the analysis and interpretation of the data collected will be presented in the next chapter.

CHAPTER 4 ANALYSIS OF DATA

4.1 Introduction

This mixed study includes information gathered through a variety of methods, as outlined in the preceding chapter. The data analysis is presented in this chapter.

Teacher interviews were conducted to capture Life Sciences teachers' perceptions, knowledge, and experiences on the integration of IKS into Life Sciences through ICTs. Additionally, data was captured through teachers' individual lesson reflections. Data was also collected through the VNOIK instrument (Cronje, 2015) and lesson observations by the researcher and using the FIT:COM instrument. The lesson plans of the teachers were examined to determine the lesson objectives as well as the teaching and learning strategies that the teachers intended to employ throughout the lesson.

Third generation CHAT (Engeström, 2000) was used as a lens to give meaning to the data. By using CHAT as a research lens, the researcher was able to identify factors/'tensions' that prevent the implementation of IK in classrooms, as well as establish how electronic platforms have facilitated or restricted teaching and learning and the professional development of teachers.

4.2 Qualitative data analysis

The data in this study were collected by the researcher in six public secondary schools in the Tshwane North Education District in the Gauteng province. The public schools are in townships, and these are the areas that the DoE has prioritised for providing resources and support. Fifteen Life Sciences teachers teaching Grades 10, 11 or 12 were involved in the study.

According to Nieuwenhuis (2014:100), "when analysing qualitative data, the aim is to summarise what the researcher has seen or heard in terms of phrases, common words, patterns, and themes." Furthermore, data analysis aims to interpret and make sense of the data.

Table 4-1 summarises the biographic information of the Life Sciences teachers who participated in this study.

Table 4-1 The biographic information of the participants in the study.

Population	Educators teaching in one of the 15 educational districts in the Gauteng province
Sample	Fifteen (15) teachers
Sampling Method	Purposive
Type of schools	Secondary schools in the townships (Quintile 1-2) i.e., low economically developed areas
Criteria	Teaching Life Sciences to Grades 10 to 12 in schools that are part of a pilot project on the use of interactive smartboards
Gender	Seven females and eight males
Participant's years of experience	Ranges from 5 years to 32 years of teaching experience.
Inclusion criteria	Teaching Life Sciences to Grades 10, 11 or 12 in any of the schools that are part of a pilot project on the use of interactive smartboards

4.2.1 Interviews with teachers

The primary research question that served as the overall guide for the interviews is:

- What are the affordances of ICTs when it comes to integrating IK in the teaching of Life Sciences?

The following secondary research questions further guided the interviews:

- How are teachers incorporating the relevant IK of different cultural groups into their teaching of the Life Sciences through the utilization of ICTs?
- What teaching approaches are Life Sciences teachers utilizing to improve the teaching of IK through ICTs?
- To what extent are teachers' classroom practices consistent with what is practiced in the SLPs?
- What are Life Sciences teachers' lived experiences with using ICTs to teach IK and what challenges do they face in this regard?

The interviews led to the establishment of codes which were derived from the actual words of the participants. The codes were then classified into categories and themes. Seven females and eight males were interviewed. To gain a better understanding of the data obtained, coding was used to identify words or short phrases to generate categories, which were then divided into themes. The codes, categories and themes are represented in table 4-2 below.

Table 4-2 Establishment of codes, categories, and themes

What teachers said	Codes	Categories	Themes
<p>What IKS aspects / events were evident in this lesson?</p> <p><i>Eee, some learners have deep cultural and religious beliefs about the origin of man, and some are reserved about their viewpoints. While others are very passionate about their beliefs.</i></p>	<p><i>cultural and religious beliefs</i></p>	<p>Impact of <i>cultural and religious beliefs</i></p>	<p>Teachers acknowledge that religious and cultural beliefs have an influence on conceptual understanding of science.</p>
<p>How did you feel about the IKS aspects / events in this lesson?</p> <p><i>To tell you the truth, at the beginning I had mixed feelings, umm, eish! You know we have learners coming from different backgrounds especially knowing the community these kids come from. Learners put their beliefs and rights first.</i></p>	<p>Culturally diverse classroom</p>	<p>Dynamics of culturally diverse classroom</p>	
<p>How have the professional development sessions affected your teaching in the classroom?</p> <p><i>The professional sessions are quite helpful, although they come occasionally as a result, we lose touch with most of the developments.</i></p>	<p>Curriculum demands</p>	<p>Professional development to address needs</p>	<p>The effect of the irregular occurrence of the professional development sessions on the teachers teaching skills.</p>

<p>What are your experiences of ICT supported learning environments?</p> <p><i>Our learners are exposed to ICT gadgets at school only. When they don't have the GDE tablets they cannot connect to internet. It is even worse when there is no connectivity at school as most the times, we are offline. Data is expensive surely most of our learners can't afford food let alone data. Those with smart phones really benefit a lot.</i></p>	Information accessibility	Lack of accessibility of information Affordability	Teachers acknowledge the affordances of using ICTs, but view the digital divide as a challenge in their classrooms
<p>What are the challenges that you face with the use of ICTs?</p> <p>Challenge 1</p> <p><i>We are lucky that our SMT has adjusted the school's cell phone policy to allow the use of cell phones in and outside the classroom.</i></p>	School management support	Interpretation of policies	The schools' policies influence the usage of ICTs.
<p>Challenge 2</p> <p><i>The content of Life Sciences is loaded. Smart-board use is time consuming; I will not be able to complete my Annual Teaching Plan as expected furthermore learners also use their tablets to download and listen to music or movies instead of learning. I cannot control them.</i></p>	Curriculum demands Classroom management	Managing the content Technology as tools of learning	Teachers experience several systemic pressures that prevent the effective utilisation of smartboards, such as the full CAPS curriculum and rigid time frames for its implementation.

Based on Table 4-2, the following themes can therefore be distilled:

Theme 1: Despite the fact teachers acknowledged the importance and value of IK, there is limited evidence of transfer of IK in the post-intervention classroom. Passionate learners, who are eager to engage in the classroom activities make it easier for the teacher to use the CL approach. However, the learners who are more reserved because of fear of judgement on their cultural or religious beliefs create a challenge for the teacher to use the CL approach with them.

Theme 2: The irregular occurrence of the professional development sessions influences the teachers' teaching skills. Since the sessions do not occur frequently, the teachers do not have an opportunity to refine the skills taught at the development sessions and resort back to old teaching methods. Literature refers in this regard to the "wash-out effect" (Ziechner & Tabachnick, 1981).

Theme 3: Teachers recognize the benefits of educational technology but see the digital divide as a hindrance to the creation of ICTs supported learning. The schools in this study are Quintile 1 schools. The financial implications of using ICTs are costly for most learners. The digital divide creates a challenge for the teacher to incorporate the use of ICTs in their lessons.

Theme 4: The school's policies have an influence on the usage of ICTs. Teachers are of the opinion that cell phones could be a useful tool in the classroom and feel that SMT's should provide opportunities for its use.

Theme 5: Teachers face several systemic pressures that prohibit them from effectively implementing smartboards, including the complete CAPS curriculum and strict time frames for implementation. The CAPS time constraints impose a challenge for the teachers to incorporate the use of smart boards effectively and efficiently in their lessons. The guidelines also do not contain information on how teachers should make use of the ICTs available.

4.2.2 Classroom observations

The focus of the classroom observations was to explore the degree to which teaching and learning approaches have changed due to the availability of technologies. The criterion-referenced FIT:COM instrument was utilised. The FIT:COM instrument is quite focused as it allows the evaluation of the lesson to be based on the specific lesson without referencing it to another lesson. Figure 4-1 depicts the various resources accessible on the GDE platform for teachers to build ICTs learning, as well as the utilization during the study, which is depicted by the graph.

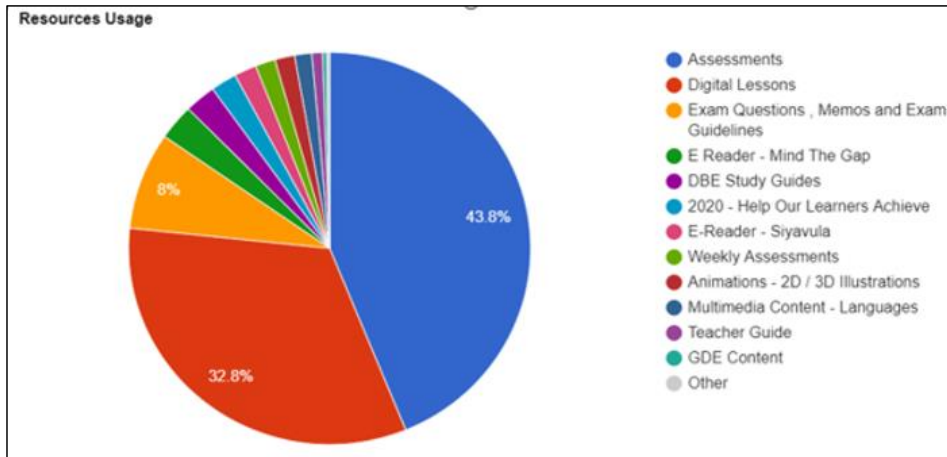


Figure 4-1 Resources and usage on GDE platform

As seen in figure 4-1, most Life Sciences teachers in this study, utilize the content platform mostly for assessment assignments (43.8%), followed by digital lessons (32.8%) and exam questions (8%) and notes. These results imply that most teachers utilize the resources with the intention of test preparation. While this is important, it does create a gap in the opportunity for the use of ICTs of creative and innovative lessons. An example could be a group work class activity in which an escape room created on google forms is to be completed as a competition on their tablets/cell phones. This activity proves to be interactive and engaging for the learners. When this is done as an introduction to a topic, learners may be encouraged to participate in future lessons as they would have had an entertaining way to view the gaps in their knowledge without being discouraged but rather motivated to learn more.

4.2.3 Contextual background and activities of observed lessons

During the classroom observations, the contextual background provided a summary of the lesson, including the environment, objectives, and so on. The researcher also made notes about the learners and the teacher(s), which included among others, learner-teacher ratio, gender, ethnicity, available technology, and physical layout. The contextual background and activities of the observed lessons are presented in Tables 4-3 to 4-8 below.

Table 4-3 School A participants.

SCHOOL A	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS F: Female, M: male	I	II	III
<p>Teacher A1 (F: age group 36-45)</p>	<p>Announced post intervention observation, Life Sciences classroom, Grade 11, lesson 45 minutes long. Topic = Gaseous exchange: IKS treatment of Tuberculosis (TB)</p>	<p>Learners sat in rows, teacher confined to the front, classroom walls blank, Charts of learners' drawn diagrams on the wall.</p>	<p>LED smart board, small white board, learners sat throughout. 48 learners. No Tablets. Teacher used the smart board for presentations. Amount of use = Majority of time Kind of use = presentation Context of use = to the whole class</p>
<p>Teacher A2 (F: age group 46 – 65)</p>	<p>Announced observation, Life Sciences classroom, Grade 11, lesson 45 minutes long. Topic = Gaseous exchange: IKS: treatment of Tuberculosis (TB)</p>	<p>Learners sat in rows, teacher confined to the front, classroom walls blank, only a class timetable on the wall</p>	<p>LED smart board, small white board, learners sat throughout. 46 learners. No Tablets. Teacher used the smart board for presentations. Amount of use = Limited use of the available gadgets. Kind of use = Lecture Context of use = to the whole class</p>

SCHOOL A	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS F: Female, M: male	I	II	III
Teacher A3 (M: age group 36-45)	Announced observation, Life Sciences classroom, Grade 12, lesson 45 minutes long. Topic = Human reproduction: IKS: birth control	Learners sat in rows, teacher moved within the classroom, classroom walls blank.	LED smart board, small white board, learners sat throughout. 42 learners. 36 learners with Tablets. Teacher used the smart board for presentations. Amount of use = Majority of time Kind of use = presentation Context of use = partially to the whole class occasionally to individual learners

Table 4-4 School B participants.

SCHOOL B	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
<p>Teacher B1 (M: age group, below 35)</p>	<p>Announced observation, Life Sciences classroom, Grade 12, lesson 60 minutes long (double period). Topic = Human reproduction: IKS: birth control vs conception</p>	<p>Lesson conducted in the Life Sciences Laboratory, learners sat around the Lab tables, teacher could reach out to individual learners, a few charts on the walls</p>	<p>LED smart board, small white board, learners sat throughout. 48 learners. 43 learners with Tablets. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and exploration Context of use = to the whole class & individual access.</p>

SCHOOL B	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
Teacher B2 (M: age group, 36-45)	Announced observation, Life Sciences classroom, Grade 12, lesson 45 minutes long. Topic = Human reproduction: IKS: birth control vs conception	Learners sat in rows, teacher able to move around, A few diagrams of learners' projects on the classroom walls.	LED smart board, small white board, learners sat throughout. 44 learners & 34 learners with Tablets. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and exploration Context of use = to the whole class & individual access

SCHOOL B	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
Teacher B3 (F: age group, 36-45)	Announced observation, Life Sciences classroom, Grade 10, lesson 45 minutes long. Topic = Cell division: IKS: Brief discussion of beliefs and attitudes concerning cancer	Learners sat in rows, teacher able to move around, A few diagrams of learners' projects on the classroom walls.	LED smart board, small white board, learners sat throughout. 40 learners. No internet connectivity used GDE content. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and class discussion Context of use = to the whole class & individual access

Table 4-5 School C participants.

SCHOOL C	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
Teacher C1 (M: age group, 36-45)	Announced observation, Life Sciences classroom, Grade 12, lesson 45 minutes long. Topic = Human reproduction: IKS: birth control	Learners sat in rows, teacher able to move around, A few diagrams of learners' projects on the classroom walls.	LED smart board, small white board, learners sat throughout. 46 learners. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and Class discussion Context of use = to the whole class & individual access
Teacher C2 (F: age group, 36-45)	Announced observation, Life Sciences classroom, Grade 12, lesson 45 minutes long. Topic = Human reproduction: IKS: birth control	Lesson conducted in the Life Sciences Laboratory, learners sat around the Lab tables, teacher confined to the smart board most of the time.	LED smart board, small white board, learners sat throughout. 47 learners. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and Class discussion Context of use = to the whole class & individual access

SCHOOL C	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
Teacher C3 (M: age group, below 35)	Announced observation, Life Sciences classroom, Grade 11, lesson 45 minutes long. Topic = Gaseous exchange: IKS treatment of Tuberculosis (TB)	Learners sat in groups of 6-8 learners per group. Teacher able to interact and access individual learners.	LED smart board, small white board. 48 learners. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and Class discussion Context of use = to the whole class & individual access. Technology as a tool for learning.

Table 4-6 School D participants.

SCHOOL D	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
Teacher D1 (M: age group, 36-45)	Announced observation, Life Sciences classroom, Grade 12, lesson 45 minutes long. Topic = Human reproduction: IKS: birth control	Learners sat in rows; teacher moved within the classroom.	LED smart board, small white board. 52 learners, 50 with Tablets. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and

SCHOOL D	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
			Class discussion Context of use = to the whole class & individual access. Technology as a tool for learning.
Teacher D2 (M: age group, 36-45)	Announced observation, Life Sciences classroom, Grade 12, lesson 45 minutes long. Topic = Human reproduction: IKS: birth control	Learners sat in rows; teacher confined to the front. Learners sat in rows; teacher confined to the front.	LED smart board, small white board. 46 learners, no Tablets. Teacher used the smart board for presentations. Amount of use = When required Kind of use = presentation and Class discussion Context of use = to the whole class & individual access.
Teacher D1 (F: age group, 36-45)	Announced observation, Life Sciences classroom, Grade 11, lesson 45 minutes long. Topic = Gaseous exchange: IKS treatment of Tuberculosis (TB)	Learners sat in rows, teacher confined to the front, classroom walls blank, Charts of learners' drawn diagrams on the wall.	LED smart board, small white board, learners sat throughout. 42 learners. No Tablets. Teacher used the smart board for presentations.

SCHOOL D	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
			<p>Amount of use = Majority of time</p> <p>Kind of use = presentation</p> <p>Context of use = to the whole class</p>

Table 4-7 School E participants.

SCHOOL E	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
Teacher E1 (F: age group, 46-65)	Announced observation, Life Sciences classroom, Grade 10, lesson 45 minutes long. Topic = Cell division: IKS: Brief discussion of beliefs and attitudes concerning cancer	Learners sat in rows, teacher confined to the front, classroom walls blank, only a class timetable on the wall	LED smart board, small white board, none of the available gadgets were used. 49 learners. No Tablets. Amount of use = No, teacher did not use any of the available gadgets. Kind of use = Lecture Context of use = to the whole class

Table 4-8 School F participants.

SCHOOL F	BACKGROUND INFORMATION	CLASSROOM CONTEXTUAL BACKGROUND AND ACTIVITIES	TECHNOLOGY CONTEXT
PARTICIPANTS	I	II	III
<p>Teacher F1 (M: age group, 36-45)</p>	<p>Announced observation, Life Sciences classroom, Grade 12, lesson 45 minutes long. Topic = Human reproduction: IKS: birth control</p>	<p>Learners sat in rows; teacher moved within the classroom.</p>	<p>LED smart board, small white board, learners sat throughout. 40 learners. 33 learners with Tablets. Teacher used the smart board for presentations. Amount of use = Majority of time Kind of use = presentation and class discussion Context of use = partially to the whole class occasionally individual learners</p>
<p>Teacher F2 (F: age group, 36-45)</p>	<p>Announced observation, Life Sciences classroom, Grade 10, lesson 45 minutes long. Topic = Cell division: IKS: Brief discussion of beliefs and attitudes concerning cancer</p>	<p>Learners sat in rows, teacher confined to the front, classroom walls blank, Charts of learners' drawn diagrams on the wall.</p>	<p>LED smart board, small white board, learners sat throughout. 52 learners. No Tablets. Teacher used the smart board for presentations. Amount of use = Majority of time Kind of use = presentation Context of use = to the whole class</p>

From the above, the following themes can be distilled:

Theme A: Technology is mainly used for the dissemination of facts (knowledge), and not to facilitate higher-order skills development. Since the SLP was a once-off event, not adequately enriched with other professional opportunities, teachers are not confident to explore and be creative when using ICTs. This results in lessons as seen with teacher D1 where the teachers are confined to the front of the classroom delivering lessons on a lecture-based style without the incorporation of CL.

Theme B: Teachers avoid using the available technology because of not being fully confident in the use of ICTs. For example, Teacher E.1 and the learners made no use of any ICTs during the lesson.

Theme C: Teachers with adequate technical skills may or may not have the pedagogical content understanding needed to choose and deploy acceptable ICTs. For example, teacher B1 easily navigated use of the ICTs tools. The planned activity allowed learners to navigate their textbook while the teacher used the smart board, the teacher also missed on an opportunity to create activities that would allow learners to continue learning outside the classroom.

Theme D: Lack of resources affect how teachers teach. For example, teacher F3's lesson was affected by the fact that there was no internet connectivity. This interferes with the intention of using CL during lessons. This also shows limited teacher agency.

In Table 4.10 the frequencies, mean values and standard deviations are shown, based on the scores of the fifteen teachers as recorded on the FIT:COM observation tool that was used in the post intervention classroom observations.

Table 4-9 Frequencies, mean and standard deviations, related to the FIT:COM instrument.

No.	Statement	0 Never Occurred	1	2	3	4 Very Descriptive	Mean	Standard Deviation	CoV
IV1	The design of the technology integration allowed learners to learn in ways not otherwise possible.	3,0	3,0	2,0	7,0	0,0	1,87	1,25	67%
IV2	Technology was a means for supporting curricular objectives, as opposed to being a separate curricular focus.	2,0	5,0	4,0	4,0	0,0	1,67	1,05	63%
IV3	The selection of the technology (hardware and software) was appropriate to meet the learning objectives.	1,0	3,0	8,0	3,0	0,0	1,87	0,83	45%

No.	Statement	0 Never Occurred	1	2	3	4 Very Descriptive	Mean	Standard Deviation	CoV
IV4	This lesson embedded basic learner operation of technology.	3,00	4,0	5,0	3,0	0,0	1,53	1,06	69%
IV5	The integration of technology was designed to promote intellectual challenge (learners pose questions, direct their own work and assess their own work).	2,00	5,0	6,0	2,0	0,0	1,53	0,92	60%
Section Score:							1,69	0,93	

According to the data in the above table it is evident that the design of the technology integration did not necessarily make learning experience that allowed learners to learn in ways not otherwise possible. The lessons were predominately teacher centred and ICTs were mainly used for presentations. There was no evidence of the different models of blended learning and learners were not involved in problem solving activities. The use of technology to support higher order cognitive as observed in the post SLP lessons is further represented graphically in figures 4-2 to figure 4-6 below.

4.2.3.1 Design of technology integration

The technology design reflects the teacher's use of technology to create knowledge in more efficient ways that complement the learning objectives. To ensure optimum technology integration, the chosen technology should be well aligned with the learning purpose. The design technology integration of the observed lessons is depicted in Figure 4-2 below.

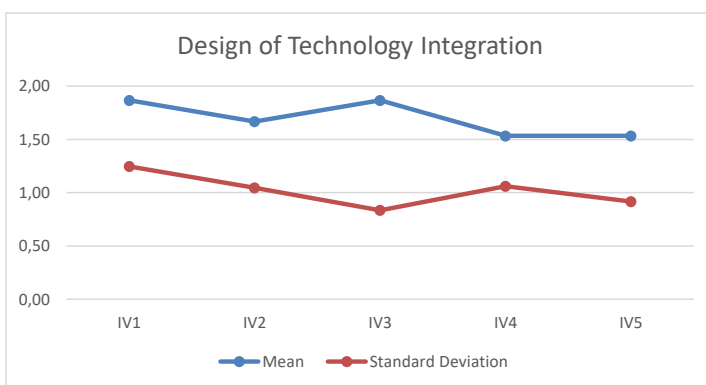


Figure 4-2 Design of technology integration.

The data in Figure 4.2 shows a high frequency – between zero and two – indicating that in this study, the integration of technology did not create new learning opportunities. The observed lessons did not necessarily allow learners to demonstrate a deeper understanding through the utilisation of technology. This relates to the outcomes of the teacher’s interview in which teacher E1 when asked ‘Which ICT devices did you use in integrating IKS in your lesson?’ confirmed that:

Honestly speaking, Life Sciences has a lot of new content that I am still familiarising myself with. As a result, I try to save time by sticking to what I know. Eee, I wouldn’t want to embarrass myself trying to use the computer in front of these learners. I would rather stick to what I am comfortable with.

From the analysis of the interview data, it is also clear that there was very little transformed teaching present. Most lessons were still “transmission-mode” teaching and learning, and technology was mostly used for presentation/ demonstration, and not as a vehicle to promote inquiry learning. This quantitative data supports the themes distilled from the interviews (see par 4.1).

The mean for Section IV: Design of Technology Integration ranged between 1.53 and 1.87 (SD = 0.83 – 1.25) indicating that there was **limited integration of technology in the observed lessons**. The standard deviation graph is below the mean graph, which implies that most of the values are below average. This was confirmed by the Section Score (mean = 1.69, SD = 0.93).

The coefficient of variance (CoV) is determined by the following formula:

$$CV = \frac{\text{Standard Deviation}}{\text{mean}} \times 100\%$$

$$= \frac{1,246}{1,87} \times 100\% = 66.63\%$$

∴ 66.63% of the values are dispersed, meaning that the values are not the same.

Table 4-10 Coefficient of variance.

Coefficient of Variance	Comment
< 10	Very Good
10 – 20	Good
20 – 30	Acceptable
> 30	Not Acceptable

The greater the CoV, the greater the level of dispersion around the mean. If the CoV is 10% or less, it generally indicates good performance. Since the CoV ranges from 45 to 69 this again confirms that

there was **very limited integration of technology in the observed lessons** and this is consistent with the results from the classroom observation, (FIT:COM instrument). A high standard deviation shows that the data is widely spread, confirming the lack/ limited promotion of integration of technology.

4.2.3.2 Class dynamics

The class dynamics focuses on the interactions between the learners, teachers, and technology. Questions that promote higher-order thinking by posing issues that can be responded to in different correct answers or phenomena with multiple legitimate interpretations are essential for encouraging higher-order thinking. The engagement of learners is critical in maintaining and strengthening the flow of the lesson. Figure 4-3 below represents the class dynamics of the observed lessons.

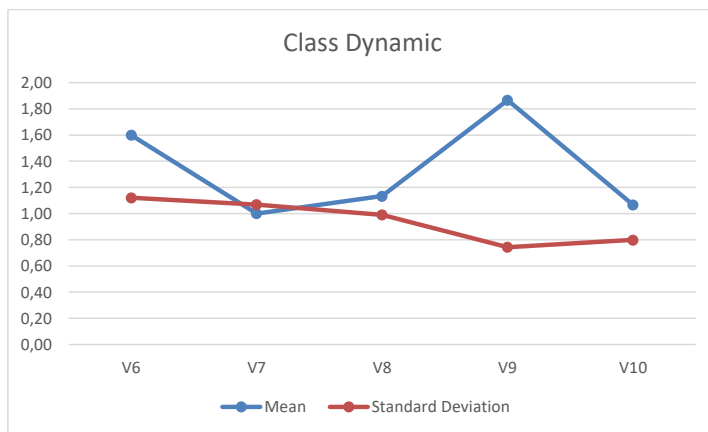


Figure 4-3 Class dynamics.

In Figure 4-3, the standard deviation is generally below the mean. This means that in this study, **teachers play a dominant role in the activity system (teaching and learning), while learners play a passive or responsive role.** Learners are mainly subjected to the teachers' instructions, and this is opposed to the constructivist approach in which learners should be actively involved in constructing meaning in the process of learning. Judson (2006) argues that information obtained does not actually reside with the teacher, nor is it locked inside the technology, according to tenets. Instead, in a learner-centred classroom, learners can use both the teacher and technology as tools to help them make sense of content and learn new things. This is confirmed by teachers B3, E1 and F2, who displayed teacher dominance by using lecture method in the observed lessons. Although there were some elements of classroom discussion in the lessons of teachers D1, E1, C2 and F1, most of the lessons did not meet the elements for effective cooperative learning, as defined by Johnson and Johnson (1994). The element of positive interdependence was not evident in the class

discussions on beliefs and attitudes concerning cancer, which was discussed by teachers B3, E1 and F1. Although learners worked in groups in these classrooms, teachers assessed the learners individually rather than looking at the collective achievements. In these lessons it was only the teachers who asked open-ended questions, but learners were not encouraged to examine arguments, information, ideas, beliefs, and viewpoints. In other words, learners were not encouraged to analyse and compare information to assist them to get deeper understanding that would lead them to new knowledge.

4.2.3.3 Meaning and purpose

The meaning and purpose are concerned with how ICT integration improves learners' understanding and learning of content. Life Sciences should not be taught in isolation of other subjects, therefore, teachers should create learning environments that allow learners holistic development, to develop a coherent whole. It is critical for learners to understand the purpose and meaning of their learning to build a sense of ownership. The approaches that the teacher uses in class can assist the observer to dictate the level of learners' ownership of their learning. The involvement of learners in collaborative learning activities such as discussions, sharing of information and allowing learners to ask questions for clarity and for additional information can be an indication of learners having meaning and purpose for the learning activity. ICTs should be utilized to learn about real-world phenomena and situations that students can relate to, thereby assisting to place learning within the context of actual matter for learners to obtain an understanding that can be transferred to other learning environments. Figure 4-4 presents the data related to meaning and purpose of the lessons that were observed.

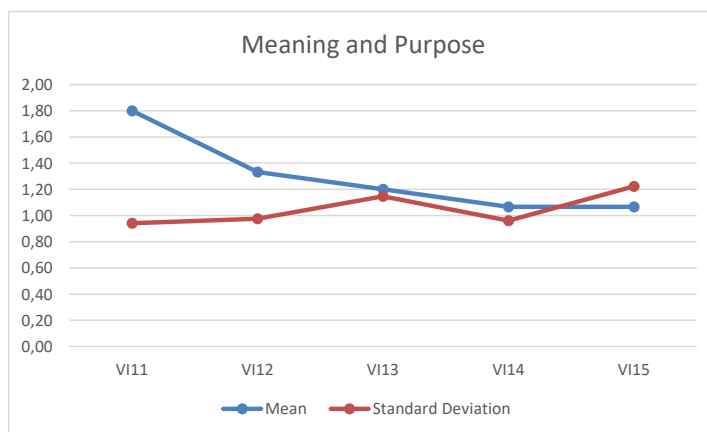


Figure 4-4 Meaning and purpose.

It is interesting to note that in terms of meaning and purpose the integration of technology should allow teachers to tap into learners' IKS to contextualise and connect the learners with real-life challenges. Much as in lessons with teachers B1, B2, C1, C2 and F1, where abortion and birth control methods were discussed, teachers tried to build on learners' knowledge. However, given how learners valued the topic and were eager to engage in the classroom discussions, the allocated time was limited to class discussions only. These lessons had a potential to allow learners to research on a wide spectrum of traditional practices on maintaining and managing pregnancy and allow them to explain the principles of traditional practices in relation to a scientific viewpoint. Teachers could have utilized the different BL models they learnt about in the SLPs and engage learners in CL, to allow learning to continue outside the normal classroom.

Listening triangles, which involve three different participants in group discussions, are one form of activity that teachers utilized in SLPs. The first is the speaker, who explains the task or expresses an opinion on the subject, and the second is the enquirer, who carefully listens and requests additional clarification and details. The scribe, who takes notes, observes the process, and provides feedback to the class, is the third supervisor. Such discussions can be held over WhatsApp groups, Skype, Microsoft Teams, or Zoom. Google Docs may be used to take notes. Alternatively, teachers might have employed talk partners instead of class discussions, to allow more learners to participate in the discussions. Learners are partnered for short discussion activities and can be selected at random and switch partners to exchange information. In this situation, learners could contribute outside of the classroom using the same tools indicated before. The recorded activities can be shared amongst learners via various online platforms; however, it is critical that teachers and learners are aware and comply with issues of safety and online security when using online platforms, and this must be done in accordance with the schools' ICT policy.

4.2.3.4 Content and knowledge

In the section of content and knowledge, I was observing the appropriateness of the content covered in the lessons in compliance with the CAPS requirements, examining whether the integration of IK through ICTs into the lesson promotes coherent conceptual understanding. This section also addresses the teachers' ability to use appropriate IK in the required subject content in an ICT supported lesson. The teacher's eagerness and ability to meaningfully pursue learners' inputs, even if they appear to be far-fetched, reflects the teacher's understanding of the content. When learners can constantly reflect on their thinking, aligning preconceptions with new learning, and evaluate their own work, content is regarded as a dynamic body of knowledge to be constructed in a learning environment.

According to constructivism's ideas, knowledge obtained does not necessarily reside with the teacher, nor is it confined within the technology. In a learner-centred lesson, learners will have access to both the teacher and technology as resources to help them make sense and construct knowledge. Figure 4-5 below indicates the findings for content and knowledge in the lessons that were observed during the study.

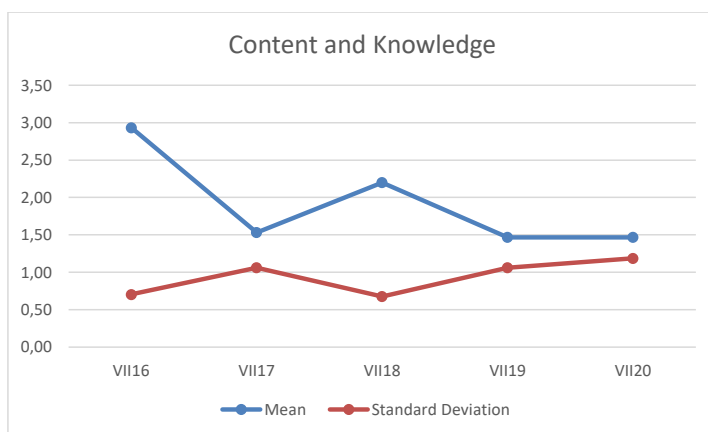


Figure 4-5 Content and knowledge.

As indicated in figure 4-5, the mean of the data for this aspect falls above the standard deviation. This shows that generally, the teachers in this sample do not necessarily demonstrate strength with the integration of IKS using ICTs. In the lesson on 'gaseous exchange: IKS: treatment of Tuberculosis (TB), a topic which teacher A1, A2, A3, C3 and D3 treated during the observed lessons, learners needed to understand the content knowledge on gaseous exchange and to link to the practical aspect were learners had to do hands on investigations. Learners needed to apply the content to real life experiences to facilitate their understanding and the relevance of the topic in everyday life as well as to highlight the importance of scientific discoveries and show the value of the relationship between indigenous knowledge and science. This poses a similar concern to Ndlovu (2016), who strongly supports that teachers must be aware of design concepts that can help them develop learning environments that catch learners' attention and direct it toward attaining learning goals.

In the observed lessons, teachers missed the opportunity to integrate technology to enhance coherent conceptual understanding. The participants also display very basic skills in the use of technology, which they primarily used to access information. As a result, the content delivered in the classroom was mainly guided and limited to what is in the textbook as well as the exam guidelines.

4.2.3.5 Technology as tools

Integrating technological tools into the classroom addresses how teachers and learners use ICTs for learning during the lesson, as well as whether the learning activities are planned in such a way that learners, may use ICTs and continue with meaningful learning outside of the classroom. This item might include the among others, the use of telecommunications, providing presentations, or simply using technology to better clarify a subject content. The data on the use of technology as tools is represented in Figure 4-6 below.

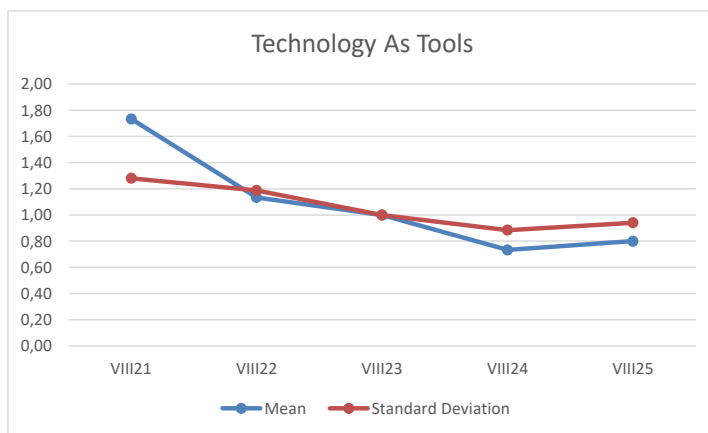


Figure 4-6 Technology as tools.

In this study, there is very limited use of technology, and the technology tools merely replace the traditional tools, for instance teachers A1, A2, A3, C3, and D1 used technology for making presentation on methods of birth control and it was only the teachers who were using technology thus resorting to presenting the information to the learners, as a result the full potential for these ICTs in not explored. While teachers B1, B2, and B3 attempted to engage learners in using available technology, however, the activity questions such as 'what can teenagers do to control the high rate of teenage pregnancy?' were structured in such a way that learners could just look up information from the available resources, much like they would get the information from a textbook. Teachers mainly use it to disseminate information, and the learning strategies are mainly teacher centred, directing learners, step by step.

4.2.4 Teachers' reflections

Halstead (2017) confirms the view that secondary science teachers spend most of their time collaborating, teaching, and planning. However, limited time is spent on reflecting after teaching. This study offered Life Sciences teachers an opportunity to reflect on the integration of IKS through ICTs supported learning. In this study, teachers were offered an opportunity to reflect on their

teaching intentions, what they understand they have achieved through the lesson, what did not go according to plan and their plans to improve teaching and learning.

Analysing the reflections of teachers, quickly resulted in data saturation, and due to the similarities in the reflections, I will only focus on the reflections of two teachers, namely Teacher B1 (Table 4.13), and Teacher E1 (Table 4.15). Teacher B1 showed very little evidence of reformed teaching, and technology was simply used to disseminate information. This was also true for the other nine teachers, (A1, A3, B3, C1, C2, C3, D1, D2 and F2). On the other hand, Teacher E1 used technology better, and used technology to contextualise the curriculum content, and she effectively incorporated indigenous knowledge in the lesson. This was also true for teachers B2 and B1. The other three teachers, (A2, C1 and F1) were not comfortable with the use of technology although during the interviews they acknowledged the importance of using technology in teaching and learning. This shows that there was very limited transfer of knowledge and skills from the SLPs into the classroom.

4.2.4.1 First example of teacher reflection

Tables 4-12 and 4-13 present general information about teacher B1 and his reflections about his lesson in response to the questions posed by the researcher.

Table 4-11 Section A – General information on teacher B1.

Age	39
Gender	Male
Total teaching experience (in years)	8
Experience in teaching Life Sciences/Biology	8
Trained in the use of ICT	Yes, attended the two weeks training

Table 4-12 Section B – Integration of IK into Life Sciences, ICTs supported learning by teacher B1.

Focus question	Teacher's reflection
1. What is your lesson topic?	<i>Topic = Human reproduction. IKS: birth control vs conception.</i>
2. What did you intend to achieve in this lesson?	<i>I wanted my learners to discuss the importance of birth control.</i>
3. What IKS aspects/events were evident in this lesson?	<i>The different cultural/traditional methods of birth control and how some of these methods can be misused especially when people do abortions.</i>
4. How did you feel about the IKS aspects/events in this lesson?	<i>To enlighten the learner during or after the lesson more and more. These learners know a lot especially on this topic but then if one can give them a chance to talk, one cannot finish the teaching plan.</i>
5. How do you think your learners felt about this lesson?	<i>Very much excited. They wished we could have more time.</i>

Focus question	Teacher's reflection
6. Which ICT devices are available in your Life Sciences classroom?	<i>Smartboard, laptop, data projector and clickers for assessment.</i>
7. Which ICT devices did you use in integrating IKS into your lesson?	<i>Smartboard to access the GDE content platform and to do my PowerPoint presentation.</i>
8. What factors are very important in enabling your learners to translate their cultural experiences into gaining conceptual understanding at higher cognitive levels in this lesson?	<ul style="list-style-type: none"> - Listen. - Understanding the topic - Manner of answering a question if it maybe arises - Work or exam guidelines not to be out of the lesson.
9. In this lesson what digital content did you access and how did you present it?	<i>GDE content on human reproduction. I did a presentation.</i>
10. How did/would you customise this lesson to online interactive learning?	<i>The lesson, questions online, then answer questions.</i>
11. What ICT resources did you/would you use for IKS integration in this lesson?	<i>Laptop internet and smartboard. Animations.</i>
12. What ICT resources did you/would you use for homework and assessment for this lesson?	<i>Laptop, cell phone, smartboard. The challenge is that most of my learners only have access to computers here at school and they also do not have smartphones.</i>
13. What are your experiences in learners' knowledge in developing some scientific concepts?	<i>It is difficult for them to understand the difference as they relate the IKS to their cultural practices and beliefs.</i>
14. What is your role in making use of learners' experiences to develop scientific concepts?	<i>Create awareness.</i>

Focus question	Teacher's reflection
15. What are your experiences of ICTs supported learning environments?	<i>I am still developing but at least I have an idea.</i>
16. How is the introduction of ICTs supported learning environments facilitating your professional development of the TPCK?	<i>At least I can get content on the smartboard instead of relying on the textbook.</i>
17. What are the challenges that you face when making use of ICTs learning environments?	<i>Internet offline, no light, no phone. Learners sometimes get distracted and use the computers for their movies, music and other things other than learning the subject so one has to be very vigilant. Our school policy does not allow learners to bring cell phones to school as they become a target of robbery.</i>
18. What are your experiences about both face-to-face and online communities of practice in your professional development?	<i>This has improved our communication with teachers from other schools as we can meet on different platforms such as Google Class, MS Teams etc. But it is always important that we also have face-to-face communication.</i>

The analysis shows that Teacher B1 did not really change his pedagogical orientation or teaching practice after the SLP. It can still be characterised as 'transmission-mode' teaching, where the teacher is dominant, and the learner's passive. Whereas technology holds affordances to enhance inquiry- and self-directed learning, Teacher B1 mainly used technology as a vehicle for transmitting knowledge.

The teacher did not sufficiently tap into the power of cooperative learning due to systemic pressures, such as the 'pace-setters' that accompany the CAPS curriculum. There is also limited data of the effective incorporation of indigenous knowledge in the lesson. In addition, the teacher acknowledged the relevance of online teacher collaboration.

4.2.4.2 Second example of teacher reflection

Tables 4-14 and 4-15 present general information about teacher E1 and her reflections about her lesson in response to the questions posed by the researcher.

Table 4-13 Section A – General information of teacher E1.

Age	50
Gender	Female
Total Teaching experience (in years)	27

Experience in teaching Life Sciences / Biology	26
Trained in the use of ICT	Yes

Table 4-14 Section B – Integration of IK into Life Sciences lessons with online learning by teacher E1.

Focus question	Teacher's reflection
1. What is your lesson topic?	<i>Topic = Cell division. IKS: Brief discussion of beliefs and attitudes concerning cancer.</i>
2. What did you intend to achieve in this lesson?	<i>Awareness of IKS and sustainability and how it can contribute to the economy.</i>
3. What IKS aspects/events were evident in this lesson?	<i>Application of teabags – cooling effect on the eye and relaxation effect of it.</i>
4. How did you feel about the IKS aspects/events in this lesson?	<i>Very informative; more knowledgeable about IKS and its uses.</i>
5. How do you think your learners felt about this lesson?	<i>Impressed. Acquired knowledge to help them view and link theory with practical; more understanding.</i>
6. Which ICT devices are available in your Life Sciences classroom?	<i>Smartboard and laptop.</i>
7. Which ICT devices did you use in integrating IKS in your lesson?	<i>Smartboard and laptop.</i>
8. What factors are very important in enabling your learners to translate their cultural experiences gain conceptual understanding at higher cognitive levels in this lesson?	<i>Learners are now aware of the rich heritage their elders have on IKS and how this knowledge fits into their curriculum. The application of this knowledge creates better understanding.</i>
9. In this lesson what digital content did you access and how did you present it?	<i>Internet and videos; videos played, and explanation and questions asked. View companies that process rooibos.</i>
10. How did/would you customise this lesson to online interactive learning.	<i>Have learner contacts (group) share information via Share-it; answered questions/assessed.</i>
11. What ICT resources did you/would you use for IKS integration in this lesson.	<i>Smartboard and laptops. Being able to use them to access information. Able to answer question/worksheets.</i>

Focus question	Teacher's reflection
12. What ICT resources did you/would you use for homework and assessment for this lesson?	<i>Laptop and smartboard. In some instance learners' phones if possible. Sent home templates.</i>
13. What are your experiences in learners' knowledge in developing some scientific concepts?	<i>Shocked, amazed at how much they know. How they can use this knowledge to apply it to ensure productivity.</i>
14. What is your role in making use of learners' experiences to develop scientific concepts?	<i>I create awareness and discourage ignorance. There should be a correlation between what they learn and real-life experiences.</i>
15. What are your experiences of ICTs learning environments?	<i>It makes learning interesting and fun. It makes learners excited and interested.</i>
16. How is the introduction of ICTs supported learning environments facilitating your professional development of the TPCK?	<i>Assist a lot. Knowledge of technology and its use greatly improved. Usage is often and ever improving. Able to set questions (assessment), download videos to enrich our lessons. Life Sciences are more practical.</i>
17. What are the challenges that you face when making use of ICTs learning environments?	<ul style="list-style-type: none"> - Often internet access is expensive - Often offline - Affordability of resources (learners).
18. What are your experiences about both face-to-face and online communities of practice in your professional development?	<i>Face-to-face you develop confidence in acquiring knowledge. Online can be a challenge for there are too many distractions. Divided attention.</i>

Although the teacher did not effectively indicate in her reflection why Rooibos tea (*Aspalathus linearis*, an important indigenous plant with considerable economic value), was used in this discussion of cell division and cancer prevention, she did succeed in stimulating learners' interest in indigenous knowledge systems. Also, research shows that *Aspalathus linearis* might have anti-cancer properties- something that her learners might explore. Van Wyk et al. (2013:50) show that the plant contains active ingredients such as flavonoids, aspalathin and nothofagin, which have anti-mutagenic properties. The teacher also made better use of technology, and the incorporation of videos and games might enhance the realisation of affective outcomes.

4.2.4.3 How the SLP scaffolded teachers' understanding of indigenous knowledge

In Table 4.16, I show how teachers performed in the VNOIK questionnaire, in a pre- and post-intervention context.

Table 4-15 Teachers' performance in the pre- and post-questionnaire

View of LS teachers on IK	Pre-intervention questionnaire	Post-intervention questionnaire
Uninformed view	1	0
Partially informed view	12	8
Informed view	2	7

Clearly the fifteen teachers benefited from the SLP, in terms of developing more nuanced understandings of the nature of indigenous knowledge. Whereas some teachers indicated in the pre-intervention questionnaire that they consider indigenous knowledge as "pseudoscience", the post-intervention data showed that most teachers came to an understanding that there is also an empirical and inferential basis to indigenous knowledge systems. However, there was limited IK integration in the observed lessons, as most of the lessons showed very limited in-depth interactions.

4.2.4.4 Using the third generation CHAT as a lens to explain the lack of transfer of acquired knowledge into the classroom

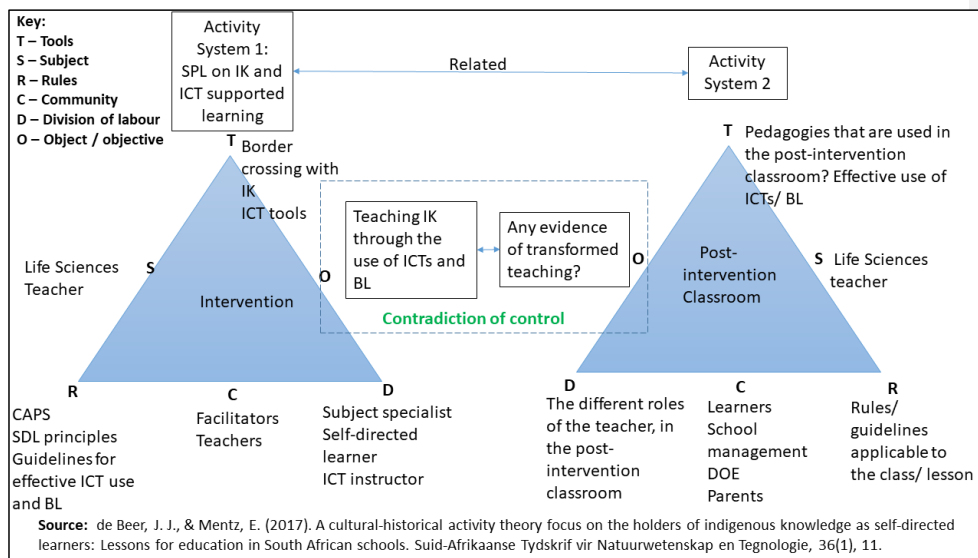


Figure 4-7 Using Cultural-Historical Activity Theory (CHAT) third generation: Identifying the tensions in the Life Sciences classroom (derived from Engeström, 1987; and De Beer & Mentz, 2017)

The fundamental goal of the SLPs was to ensure that IK was fully integrated into the Life Sciences classroom through ICT supported learning. The data shows that there was very limited transfer of what happened in the SLP into the classroom (post-- SLP data). Thus, the ideal (envisaged) outcome shown in Fig 4.7 did not materialise. There is a misalignment between the objects of the two activity systems in Fig 4.7, indicating a contradiction of control (McNeil, 2013). The two objects, that is, the SLPs and the activities in the class post the intervention, show a contradiction of control because I did not achieve what I planned for in the SLPs. I intended to have evidence of transformed teaching and learning post the interventions. Unfortunately that was not the case. By using the third generation CHAT, I can understand the reasons why there was no maximum infusion of IK and ICTs supporting learning in the classroom SLPs.

Firstly, school the community, the parents, the SGB, the DoE, and the school principals, they want teachers to teach for the tests so that the learners can get good marks. According to the data in Figure 4-1, teachers, and learners primarily access assessment activities; as a result, the focus is on drilling learners so that they achieve good marks. All the teachers who were observed adhered

to the GDE's "exemplar" lesson plans, which require them to cover subject in accordance with the annual teaching plans. During the interview, one of the teachers mentioned that the school is classified as underperforming, which is based on matric results, and that several authorities require them to improve their performance. Additionally, the teachers are also expected to teach every topic that is in the annual teaching plan. As a result, they put a lot of pressure that the teachers should teach so that learners should get good marks. They discourage teachers from using time on IK and online learning as it is not assessed in the examinations and can be a waste of valuable teaching time. One of the objectives of the DoE is, the protection of teaching time; and the primary mandate of the school principals from the DoE is to make sure that learners pass, with emphasis on quantity before quality otherwise they are rated as underperforming, hence teachers are under a lot of pressure to teach for the test.

Secondly, most of the township schools have limited resources. Some schools do not have reliable supply of electricity, there is no internet, no data. Furthermore, there are challenges of safety in the under-resourced schools, as a result the additional resources get stolen or destroyed. Most learners are coming from economically challenged families and they can only have access to computers at school, this makes the use of ICTs, especially outside the classroom impossible. This emphasises the tension that exists between the object and the tools in the activity system following the SLPs. In this study, it is evident that while teachers are aware of the benefits of integrating IK using ICTs, they are constrained by the availability of internet and unreliable connectivity, which is exacerbated by loadshedding, particularly in township schools where the schools / communities cannot afford alternative means of obtaining electricity, such as generators or solar panels. As was indicated by one of the participants during the interviews who indicated that most learners can only use technology at school since communities cannot prioritise connectivity while they are struggling to get basic needs such as food.

Thirdly, the rules are a tension because the CAPS document does not give teachers clear guidelines on how to integrate IK and ICTs supported learning in their teaching as a result teachers tend to stick to the textbook and use the chalk and talk approach. Additionally, the pacesetters direct teachers to teach at a specific rate of content coverage, the teachers are under immense pressure to complete the prescribed content, this promotes a culture of compliance and lack of creativity in the teaching of Life Sciences. The pace at which the teachers cover the content is also strictly monitored to ensure that learners cover all the prescribed content. The emphasis on content coverage promotes a culture of compliance, where teachers prioritise completing the required content over enhancing creativity and innovation in their teaching of Life Sciences. The combination of unclear guidelines from the CAPS document and the pressure to adhere to strict content coverage expectations create tension within the teaching environment. This tension hampers the integration of IK and ICTs and may

restrict teachers' ability to explore more creative and effective teaching methods in the context of Life Sciences.

4.3 Conclusion

Teachers recognize that incorporating IK into the teaching of Life Sciences via ICTs provides opportunities to contextualize the curriculum, particularly for culturally diverse learners. However, the tensions that limit or obstruct the integration of IK through ICTs are visible in the activity system following the SPLs. According to the CHAT analysis, the utilization of IK and ICTs as enablers for effective learning is limited or hampered by systemic pressure that profoundly regulates teaching and learning. Furthermore, the digital divide in South Africa continues to impede access to teaching and learning resources such as electricity and the wider internet.

CHAPTER 5: MAJOR FINDINGS, LIMITATIONS, RECOMMENDATIONS, CONTRIBUTION OF THE STUDY, AND CONCLUSION

5.1 Introduction

This chapter focuses on reviewing of the research questions, assessing whether they were answered. The chapter concludes with some recommendations based on the study results, which will help to inform future research in the field of the integration of indigenous knowledge using ICTs

5.2 Reviewing the research questions

This study was guided by the following primary research question: How do teachers integrate IKS into the teaching of Life Sciences using ICTs?

To help in the management of the primary issue, the following secondary questions were included in the analysis:

- How are teachers incorporating the relevant IK of different cultural groups into their teaching of the Life Sciences through the utilization of ICTs?
- What teaching approaches are Life Sciences teachers utilizing to improve the teaching of IK through ICTs?
- To what extent are teachers' classroom practices consistent with what was practiced in the SLPs in terms of integrating IK through ICT-supported teaching?
- What are Life Sciences teachers' lived experiences with integrating IK when using ICTs to teach and what challenges do they face in this regard?

5.2.1 Focusing on the primary question:

How do teachers integrate IKS into the teaching of Life Sciences using ICTs?

The short learning programmes did sensitize teachers regarding the affordances of indigenous knowledge in the Life Sciences classroom, in terms of better contextualising curriculum topics, and addressing affective outcomes. A few teachers excelled in this regard, e.g., one teacher who investigated in her classroom how Rooibos tea (*Aspalathus linearis*) could possibly assist in the fight against cancer. However, following these courses, post-intervention classroom findings revealed that the learned skills were deficient in the delivery of lessons. Many of the teachers resorted back to pedagogies that they have used prior to the intervention. Teachers mentioned the complexities of curriculum demands, such as annual teaching plans and assessment standards, in their reflections and interviews. It was also very disappointing to notice how ineffectively teachers have utilised ICTs and the Smartboards after the intervention, i.e., mainly for the transmission of information, rather than for supporting skills development. Teachers' smooth transition to using ICT is hampered by a lack of connectivity, expertise on how to use data free, online teaching and assessment tools.

5.2.2 How are teachers integrate IK into the teaching of Life Sciences through of different cultural groups through using ICTs?

There are various barriers to teacher professional growth and a lack of high-quality continuous professional development opportunities for teachers, as well as shortcomings in the education system for significantly improving the quality of teaching and learning. Even though the short learning programme provided teachers with some information and ability in using relevant IK in ICT supported learning, most teachers continue to teach in the conventional manner. As shown by the data on VNOIK pre and post intervention test in table 4-16 in the previous chapter, teachers developed more nuanced understandings of indigenous knowledge during the SLP. However, post-intervention data showed very little transfer of knowledge and skills to the classroom. Literature refers to this phenomenon as the “wash-out effect” (Zeichner & Tabachnick, 1981), where teachers, after professional development interventions, continue with their dominant pedagogical orientations. Mentz and De Beer (2019:82) recorded similar findings, and state that ‘teachers discard the academy for what is perceived as the real world of teaching’. There were refreshing exceptions, as in the case of Teacher E1, who effectively utilized indigenous knowledge (rooibos tea) in her lesson.

5.2.2 What approaches are Life Sciences teachers utilizing to improve the teaching of IK through ICTs?

The Life Sciences curriculum advocates for inquiry learning which should provide learners with opportunities to be critical thinkers and problem solvers. This study shows that teacher-centred passive teaching strategies are predominant despite the well documented affordances of including IK in teaching the subject. In this study, learners' cultural interactions are rarely used to help in intellectual comprehension at higher cognitive level. In Chapter 2, the merit for the inclusion of indigenous knowledge was discussed from an embodied, situated, and distributed cognition perspective. It was shown that the inclusion of indigenous knowledge as a way of contextualising ‘western’ curriculum content, could enhance conceptual understanding. Authors such as Dubinsky, Roehrig and Varma (2013) show that learning with an “emotional stamp” improves cognition. By tapping into learners’ interest, not only affective outcomes are achieved, but also higher order cognitive outcomes. However, little of these benefits seem to have materialised in the post-intervention classroom. The CHAT analysis in Chapter 4 showed how systemic pressures erode the possible affordances of such epistemological border-crossing.

5.2.3 To what extend are teachers’ classroom practices consistent with what is learnt through the SLPs?

Teachers recognize the potential that ICTs can bring to learning, but most lack the skills to improve technology, pedagogy, and content (TPACK) and therefore are not taking full advantage of this

opportunity. In this regard, it is also important to realise that relatively short learning programmes/ interventions have limited success in changing pedagogical orientations of teachers. I will further discuss this under recommendations.

5.2.4 What are teachers' lived experiences of ICTs to teach IK and what challenges do they experience in this regard?

While the Department of Education advocates for the incorporation of ICTs, the digital divide in South Africa continues to hinder internet access. Teachers face a variety of difficulties in ICT supported learning environments, including a lack of expertise to effectively use the available resources. There is a lack of internal and external support for teachers to develop skills to effectively use the available resources. Also, the data of this study clearly showed that, with some refreshing exceptions, most teachers utilise ICT technologies to disseminate information, and not as a vehicle to promote self-directed learning, higher order thinking or 21st century skills.

5.3 Limitations of the study

The study had several limitations, i.e.,

5.3.1 This study had a limited sample size since it only included fifteen Life Sciences teachers from one educational district in the Gauteng province. The findings of this research cannot be generalised to all South African schools in similar situations.

5.3.2 Since the researcher is a subject advisor in the district, some teachers may have participated out of a sense of duty to avoid failing their supervisors.

5.3.3 The interviews and reflections were conducted after school, which imposed additional time constraints for both the teachers and the researcher. Some discussions had to be rescheduled to the teachers' break time on a different day, which resulted in increased travel costs for the researcher.

5.3.4 Since the researcher is located in Gauteng province while the study institution is in North West province, there was time constraint because the institution was not readily accessible for additional support. To complete the short learning courses, the researcher had to work independently.

5.3.5 Since this is an inexperienced researcher, it was difficult to maintain a good balance and do justice to the subject because this study has two foci: IK and ICT supported learning.

5.3.6. Covid-19 had a negative impact, in so far that data collection was not always possible, due to the closing of schools.

5.4 Recommendations

Teachers must be given ongoing support to be able to apply newly acquired skills in the classroom for teacher development programs to be sustainable. Short learning courses for teachers should be conducted in communities of practice to allow for peer reinforcement and increased support at all

levels of teaching. There is need to strengthen the Life Sciences Professional Learning Communities (PLCs) to ensure shared accountability at all teaching levels.

Teacher centers should be utilized as they are strategically located and are easily accessible for continuous short learning programs. A big problem with short learning programmes, is that teachers often leave such SLPs energized and inspired, but when they return to the “coalface of teaching” in their classrooms, and systemic pressures often result in these teachers returning to their old ways of teaching. For example, Mentz and De Beer (2019) showed that different members in the community (refer to the CHAT activity system), e.g., principals and parents, often encourage teachers to “teach to the test”, to ensure good marks/ throughput. “Such tensions often lead to a “contradiction of control” (De Beer, 2019:18-19), e.g., teachers presenting “chalk and talk” lessons, despite their positive experiences during teacher professional development programmes”. Mentz and De Beer (2019) show that the different stakeholders (in the CHAT ‘community’) hold different views of what the ‘object’ should be in teacher professional development. Engestrom (2009) speaks of “runaway objects” in this regard. For this reason, Mentz, and De Beer (2019:15) suggest that “Change Laboratories” should be done, when teacher professional development programmes are developed. Such Change Laboratories entail that workshops should be conducted where all stakeholders; teachers, the Department of Basic Education officials, school principals, parents, teacher unions, etc. should enter dialogue on what the ‘object’ should be of any teacher professional development programme. The implementation of a cooperative transformation can assist in influencing and shaping reformed education. Teachers should be given more help in terms of technology access. There is need for continued teacher support from schools, higher education institutions, and the Department of Education for professional development.

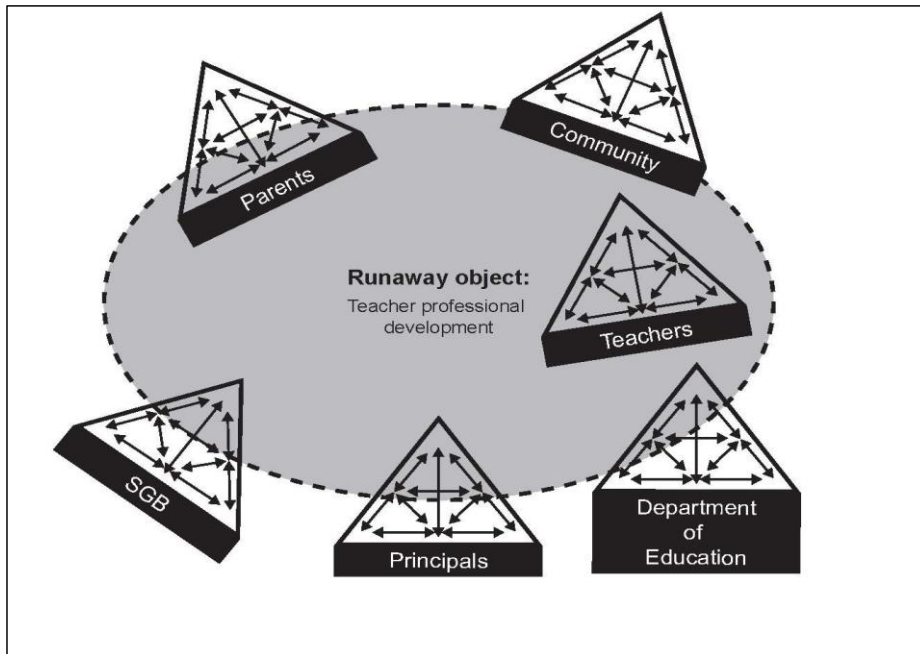


Figure 0-1 Change Laboratories, as conceptualized by Mentz and De Beer (2019, p. 263)

It is therefore recommended that such 'change laboratories' should accompany the development of teacher professional development programmes.

Furthermore, the Department of Basic Education should provide more guidance and resource materials, on how IK could be infused in the CAPS curriculum themes. Such guidance should not merely be examples of indigenous knowledge practices but should also provide learners with nuanced understandings of the tenets of indigenous knowledge. Two examples of "such approaches are the Kirby Bauer technique (De Beer, 2019:120), where learners can use the tenets of science (scientific process), to explore the antimicrobial activities of muthi plants (plants used for medicinal reasons by cultural groups)." Another example is the use of the Rationality Index of Plant Use (RIPU) instrument (De Beer, 2022), which provides students the opportunity to explore the tenets of respectively science and indigenous knowledge, and how it differs from pseudoscience.

5.5. Contribution of the study

This study contributes on two levels:

5.5.1. Epistemological contribution

This study investigated the complex link between indigenous knowledge, western science, ICT technology, and self-directed learning, and looked at the teachers are integrating IK through ICTs.

Both ICTs/ blended learning, and indigenous knowledge, are receiving considerable attention now in South Africa. The Covid-19 pandemic has resulted in a renewed interest in blended learning approaches, and the big digital divide in South Africa has been exposed. The student unrests of 2015, in which demands were made for the 'decolonisation of the curriculum', has again started a national discourse on the value of indigenous knowledge in the decolonization process. This study, located in what Balfour (2019, p. xxxvii) calls "the nascent scholarship concerning the decolonization of the curriculum, and positioning IKS as a means through which curriculum and curriculum making, pedagogy and teaching methodologies come to be revisioned", contributes in terms of distilling design principles for teacher professional development (see 5.5.3).

5.5.2. Practical contribution

The study created awareness amongst teachers about the value of indigenous knowledge and ICTs in the Life Sciences classroom and assisted teachers in their professional development.

5.5.3. Design principles for such short learning programmes

As was shown with the CHAT analysis, there was limited evidence of reformed teaching, in the post-intervention classroom. Based on the findings of the study, the following design principles are distilled for future SLP's.

(a). Self-directed learning should form the foundation for such professional development. In-service teacher professional development programmes should be built around the teacher's needs, according to authors like Louws, Meirink, Van Veen and Van Driel (2017). Teachers should also actively participate in developing the programmes. These authors, therefore, advocate for SDL as the foundation for professional development. This means that such programmes should emphasise personal autonomy, and teachers should take ownership of their own professional development (Garrison 1997). Although elements of this was present in this intervention, the SLP still had characteristics of a "top down" approach.

(b) Realignment of SLP objectives; Content activities during SLPs should be aligned to the CAPS curriculum. Teachers' value professional development activities which are directly linked to their everyday teaching, and the curriculum they use.

(c) Communities of practice (CoP) should serve as mechanism to scaffold professional development among teachers. According to Batchelor, (2018), CoPs allow different viewpoints and experiences to inform final design decisions, furthermore, if participants in a CoP value the shared experience, they are more likely to adopt and endorse teaching and learning practices that emphasize discussion and sharing of ideas. When teachers have a sense of ownership of their professional development, they are most likely to sustain the implementation of the acquired skills and knowledge.

(d) Modelling of professional behaviour; SLPs to develop skills in the use of technologies, because there is a need of the development of ICT skills, especially the use of online resources in the classroom.

Active learning strategies, such as cooperative learning and problem-based learning, should be utilised.

5.6 Conclusion and further research

According to this study, there is relatively little integration of IK in the teaching of Life Sciences using ICTs. Even though teachers gained knowledge and skills from the SLPs on indigenous knowledge using ICTs, the "wash-out effect" (Zeichner & Tabachnick, 1981:7; De Beer, 2019:8) was evident, particularly in the post-intervention lessons, in which "teachers reverted to their old methods of teaching." Teachers must be made aware of the importance of indigenous knowledge and ICTs in the Life Sciences classroom. As a result, it is critical that teachers receive ongoing support from well-functioning communities of practice to argument the knowledge and skills gained through SLPs. The Department of Basic Education should provide more direction and resources on how IK can be integrated into the different CAPS subjects and how ICTs can best support the teaching and learning. Teachers should be guided in such a way that their learners gain a nuanced comprehension of the tenets of indigenous knowledge.

Teachers should recognize the significance of promoting meaningful integration of indigenous knowledge using ICTs, by making Life Sciences lessons more relevant to learners and providing activities that assist learners in constructing new knowledge thereby, assisting learners to be critical thinkers and problem solvers. In South African education system, there is a need for more research into the profound understanding and appreciation of indigenous knowledge and how it can be integrated into teaching and learning using ICTs.

According to this study, the digital divide affecting both teachers and learners is mostly a matter of variations in meaningful access, in this case home access, as well as the skills to meaningfully use ICTs for successful teaching and learning. It is therefore critical that education stakeholders reconsider how teachers and learners may be supported to overcome the difficulties arising from the digital divide. Because of the diversity of our society, more research is needed in this area, with a particular emphasis on the South African setting.

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APPENDICES

Appendix A: Ethical clearance (NRF)



2016-06-287

ETHICS APPROVAL CERTIFICATE OF STUDY

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

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

Special conditions of the approval (if applicable):

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

General conditions:

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

- The study leader (principle investigator) must report in the prescribed format to the NWU-IRERC via ESREC:
 - annually (or as otherwise requested) on the progress of the study, and upon completion of the project
 - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
 - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the proposal as stipulated in the application form. Would any changes to the proposal be deemed necessary during the course of the study, the study leader must apply for approval of these changes at the ESREC. Would there be deviation from the study proposal without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-IRERC via ESREC and new approval received before or on the expiry date.
- In the interest of ethical responsibility the NWU-IRERC and ESREC retains the right to:
 - request access to any information or data at any time during the course or after completion of the study;
 - to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process.
 - withdraw or postpone approval if:
 - any unethical principles or practices of the project are revealed or suspected,
 - it becomes apparent that any relevant information was withheld from the ESREC or that information has been false or misrepresented,
 - the required annual report and reporting of adverse events was not done timely and accurately,
 - new institutional rules, national legislation or international conventions deem it necessary.
- ESREC can be contacted for further information or any report templates via Ema.Cooradi@nwu.ac.za or 018 299 4856

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 B: Ethical clearance for the study



Private Bag X6001, Potchefstroom
South Africa 2520
Tel: +27 18 299-1111/2222
Web: <http://www.nwu.ac.za>

North-West University Education, Management
and Economic Sciences, Law, Theology,
Engineering and Natural Sciences Research
Ethics Office (NWU-EMELTEN-REC)
Tel: +27 18 299 4707
Email: lukas.meyer@nwu.ac.za

5 June 2019

Dear Prof de Beer

NOTIFICATION: APPROVAL OF YOUR APPLICATION BY THE NWU-EMELTEN-REC

Ethics number: NWU-0066-NWU-19-S2

Kindly use the ethics reference number provided above in all correspondence or documents submitted to the NWU-EMELTEN-REC secretariat. Please provide the ethics office an electronic copy of your final ethics application. Upon the receipt of the documents, a final approval letter will be issued.

Study title: The integration of indigenous knowledge systems in teaching and learning of Life Science through self-directed online learning

Study leader/supervisor: Prof CP van der Westhuizen

Student: Ms. M Sitsha

Application type: Single study

Risk level: Minimal

You are kindly informed that your application was re-reviewed and that it will be formally approved by NWU-EMELTEN-REC on the meeting of 10 June 2019.

The commencement date for this study is 6 June 2019 dependent on fulfilling the conditions indicated below. Continuation of the study is dependent on the receipt of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation up to a maximum period of one year when extension will be facilitated during the monitoring process.

After ethical review:

Translation of the informed consent document to the languages applicable to the study participants should be submitted to the NWU-EMELTEN-REC (if applicable).

The NWU-EMELTEN-REC requires immediate reporting of any aspects that warrants a change of ethical approval. Any amendments, extensions or other modifications to the proposal or other associated documentation must be submitted to the NWU-EMELTEN-REC prior to implementing these changes. Any adverse/unexpected/unforeseen events or incidents must be reported on either an adverse event report form or incident report form.

A monitoring report should be submitted within one year of approval of this study (or as otherwise stipulated) and before the year has expired, to ensure timely renewal of the study. A final report must be provided at completion of the study or the NWU-EMELTEN-REC must be notified if the study is temporarily suspended or terminated. The monitoring report template is obtainable from the NWU-EMELTEN-REC Office at Ethics.EMELTEN-mon@nwu.ac.za. Annually a number of studies may be randomly selected for an external audit.

Appendix C: Language editing certificate

LET'S EDIT

EDITING CERTIFICATE

07 April 2021

TO WHOM IT MAY CONCERN


DECLARATION: Editing of Dissertation

This is to certify that the Master of Education in Natural Sciences Education dissertation entitled **“EXPLORING THE INTEGRATION OF INDIGENOUS KNOWLEDGE SYSTEMS (IKS) INTO THE TEACHING OF LIFE SCIENCES THROUGH SELF-DIRECTED ONLINE LEARNING”** submitted by **Margaret Sitsba** was edited for English language, grammar, punctuation, and spelling by the undersigned. Editing also included addressing the layout and formatting of the document.

The editor will not be held accountable for any later additions or changes to the document that were not edited by the editor, nor if the client rejects/ignores any of the changes, suggestions or queries, which he/she is free to do. The editor can also not be held responsible for errors in the content of the document or whether or not the client passes or fails. It is the client's responsibility to review the edited document before submitting it for evaluation.

Name of Editor: Shirley Wilson

Qualification: Bachelor of Arts (in Education)

Signature: 

Let's Edit is a Level 1 EME B BBBF Contributor (Proficiency Recognition Level = 135%

Address: **570 Fehrsen Street, Brooklyn Bridge Office Park, Brooklyn, Pretoria, 0181**
Tel No.: **012 433 6584**, Fax No.: **086 267 2164** and Email Address: **editor@letsedit.co.za**

Appendix D: GDE permission to do study



GAUTENG PROVINCE
 Department: Education
 REPUBLIC OF SOUTH AFRICA

814/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	27 August 2018
Validity of Research Approval:	05 February 2018 – 28 September 2018 2018/260
Name of Researcher:	Sitsha M.
Address of Researcher:	13 Rob Louw Street The Reeds Pretoria, 0157
Telephone Number:	012 855 0922 082 951 1481
Email address:	Margaret.sitsha@gauteng.gov.za maggysit@gmail.com
Research Topic:	The integration of Indigenous Knowledge System (IKS) in the teaching of Life Science through self-directed online learning
Type of qualification	Masters
Number and type of schools:	Six Secondary Schools
Districts/HO	Tshwane North.

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

Sitsha M. 27/08/2018

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

Making education a societal priority

Office of the Director: Education Research and Knowledge Management

7th Floor, 17 Simmonds Street, Johannesburg, 2001
 Tel: (011) 355 0488
 Email: Faith.Tshabalala@gauteng.gov.za
 Website: www.education.gov.za

Appendix E: Turnitin report

MS Sitssha Study December 07 2022.docx

ORIGINALITY REPORT

26% SIMILARITY INDEX	23% INTERNET SOURCES	9% PUBLICATIONS	7% STUDENT PAPERS
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PRIMARY SOURCES

1	repository.nwu.ac.za Internet Source	4%
2	ujcontent.uj.ac.za Internet Source	2%
3	books.aosis.co.za Internet Source	2%
4	hdl.handle.net Internet Source	2%
5	Submitted to University of the West Indies Student Paper	1%
6	uir.unisa.ac.za Internet Source	1%
7	researchspace.ukzn.ac.za Internet Source	1%
8	researchonline.nd.edu.au Internet Source	1%
9	Submitted to North West University Student Paper	1%

Appendix F: Teachers' consent form



Private Bag X05, Noordbrug
South Africa 2522
Tel: 018 299-2000
Fax: 018 299-2999

**School for Natural Science and Technology for
Education**

Tel: 018 285 2626
Email: josef.debeer@nwu.ac.za

Life Sciences teacher

Dear Teacher

THE INTEGRATION OF INDIGENOUS KNOWLEDGE SYSTEMS (IKS) IN THE TEACHING
OF LIFE SCIENCES THROUGH ICTs:

PARTICIPATION IN THIS RESEARCH PROJECT AND INFORMED CONSENT

I trust that your participation in curriculum Short Learning Programmes (SLP) has an influence on your teaching of Life Sciences. I invited you to take part in my research as described underneath. It is therefore important that you read and understand the following general principles, which are applicable to the research project. After reading the information, I hope that you will positively consider participating, in which case you please need to sign the consent form.

1. FOCUS OF THE RESEARCH

This research focuses on Life Sciences teachers' perceptions of indigenous knowledge and its integration in the Annual Teaching Plan (ATP). There are no right or wrong answers or views, and I would appreciate it if you could share your thoughts with me. I would like to establish, your experiences on including indigenous knowledge in your lessons. I would also want to get a sense of how ICT has affected or influenced your ways of teaching.

2. ETHICAL GUIDELINES FOLLOWED IN OUR RESEARCH

- Participation in this research is completely voluntary and no pressure, however subtle, will be used for you to take part. You are more than welcome to attend the short course, even if you choose not to participate in my research.
- The research will not hold any potential risks or discomfort for you as a participant.
- By agreeing to take part in the research, you are also giving consent that the data may be used for publication purposes. However, you are assured of confidentiality, and your name will not be used at all (pseudonyms will be used).
- If you so wish, I would like to invite you to also participate in this research after this short course. I am interested in your experiences in teaching IK in your classroom and the use of ICT.
- You may withdraw from this research at any stage, and there will be no consequences in doing so.
- If you would be interested, I will share the outcomes of this research with all participants and to ensure confidentiality I will not mention your or your schools' name(s).
- No financial compensation will be made to participants in the study.
- You are more than welcome to contact me or my research supervisor (Prof J de Beer: 082 923 2865) if anything is unclear to you.

Thank you very much!

Regards

MARGARET SITSHA
(CELL: 082 951 1481)



CONSENT LETTER

Research Title: The integration of Indigenous Knowledge Systems (IKS) in the teaching of Life Sciences through ICTs

Name of Researcher: Margaret Sitsha

Cell: 082 951 1481

Maggyisit@gmail.com

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

With this declaration I give my voluntarily consent to take part in the research. I also take note of the fact that I may withdraw from this research at any point, without any consequences for me. I understand that my participation in this research will mean that a personal interview will be conducted with me, and I will be asked to complete a lesson reflection. I understand that the researchers will study my lesson plans where I incorporated indigenous knowledge and may observe one of my lessons.

Signature _____

Date _____



Appendix G: Pre and Post SLP / intervention questionnaires



Pre-intervention questionnaire

Dear Colleagues

Thank you for participating in this exciting short learning program. I would be grateful if you could take the time to complete this questionnaire. Please keep in mind, that all information submitted in this questionnaire is strictly confidential, and you have the option to withdraw from this study at any time. Answering this quiz will not jeopardize your integrity. There are no 'correct' or 'wrong' responses; your initial reaction is most valid; do not think deeply about the questions for too long.

Thank you for your time and your co-operation.

Margaret Sitsha

Name or Pseudonym: _____

1. As a Life Sciences teacher, what is your understanding of your role and responsibility of teaching indigenous knowledge in your classroom?

2. Briefly explain your understanding of teaching for the importance of integrating indigenous knowledge when teaching Life Sciences.

3. Do you currently include indigenous knowledge in your lessons?

YES or NO (Please circle)

Briefly explain why your lessons have OR do not have aspects of indigenous knowledge.

4. What are the **biggest** challenges or hurdles that a Life Science teacher experience in teaching indigenous knowledge?

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

YES or NO (Please circle)

Motivate why?

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

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

8. Rate the following outcomes in terms of importance:
With 1 being the LEAST important, and 6 being the MOST important:

ITEM	RATING
Learners should have a sound knowledge of Life Sciences	
My biggest role as a teacher is to ensure that most learners pass the exam	
Learners should be able to think critically and substantiate opinion with relevant data	
Learners should be able to plan and execute experiments in Life Sciences	
Learners should appreciate value of learning Life Sciences in everyday life	
Learners should be able to analyse and synthesise information when studying Life Sciences	
I am motivated to use ICTs to teach indigenous knowledge in my lessons	
I main role is to ensure that learners develop an interest in learning Life Sciences	
Learners should value the contribution of Life Sciences in modern society	
Learners should be scientifically literate citizens who can compete in a global society	
Learners should be scientifically literate citizens who can compete in a global society	
Learners should appreciate science underpinning many indigenous knowledge practices	

Your participation in this questionnaire is highly appreciated!
Margaret Sitsha
Cell: 082 951 1481 / Maggysit@gmail.com

Appendix H: FIT:COM Classroom observation instrument

**Focus on Integrated Technology:
Classroom Observation Measurement (FIT:COM)**

Developed by:
Eugene Judson, Ed.D.

I. BACKGROUND INFORMATION

Name of teacher _____

Location of class (district, school, room) _____

Lesson setting (classroom, lab, other) _____

Years of Teaching _____ Announced Observation? _____

Subject _____ Grade level _____

Observer _____ Date of observation _____

Start time _____ End time _____

Total time _____

FIT:COM score (items 1 - 25): _____

II. CLASSROOM 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. You are encouraged to transcribe pertinent dialogue.

III. TECHNOLOGY CONTEXT

Number of computers (or other media) _____ Number of students _____

In the space provided below please give a brief description of the technology incorporated into the lesson. This should include hardware and software specifications, student to media ratio, locus of control in terms of technology.

The following points are provided as indicators to consider when reflecting on the technology context of the classroom:

Amount of Use - Though a quality technology integrated lesson needn't require a majority of time devoted to using technology, it is noteworthy to comment on what portion of the lesson did indeed involve the use of technology.

Kinds of Use - Describe if the technology is utilized as an instructional game, drill and practice, presentation method, exploration, productivity, etc.

Context for Use - Consider if the technology is being used as a presentation device for a whole class? Do students utilize the technology independently? Is the technology used within the context of a learning station? What role has the technology been assigned within the context of the teacher's lesson?

Provide a generalized sketch of the physical layout of the classroom. Indicate placement of technology. If the teacher, students or technology are customarily mobile during the lesson, please indicate this in the sketch.

Symbols to use:

S = Student **T** = Teacher **C** = Computer **M** = other Media (please specify)

IV. DESIGN OF TECHNOLOGY INTEGRATION

	Never Occurred				Very Descriptive
The design of the technology integration					
1) allowed students to learn in ways not otherwise possible.	0	1	2	3	4
Technology was a means for supporting					
2) curricular objectives, as opposed to being a separate curricular focus.	0	1	2	3	4

The selection of the technology (hardware & software) was appropriate to meet the learning objectives.

3) 0 1 2 3 4

This lesson embedded basic student operation of technology.

4) 0 1 2 3 4

The integration of technology was designed to promote intellectual challenge (students pose questions, direct their own work, and assess their own work).

5) 0 1 2 3 4

Section score _____

V. CLASS DYNAMICS

	Never Occurred				Very Descriptive
6) The teacher and/or the use of technology prompted students toward higher-order thinking.	0	1	2	3	4
7) Students had a voice in the selection of technology tools and how the technology was to be utilized.	0	1	2	3	4
8) Interaction with technology provided students with a sense of independent control and mastery over an environment.	0	1	2	3	4
9) The teacher provided appropriate assistance to guide student activity.	0	1	2	3	4
10)	0	1	2	3	4

Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.

Section score _____

VI. MEANING AND PURPOSE

- | | Never
Occurred | | | | Very
Descriptive |
|---|-------------------|---|---|---|---------------------|
| 11) Connections within the content and to other content disciplines were explored and valued. | 0 | 1 | 2 | 3 | 4 |
| 12) Students took pride in new learning and/or work produced with the aid of technology. | 0 | 1 | 2 | 3 | 4 |
| 13) Technology was used to investigate real phenomena and real-world situations. | 0 | 1 | 2 | 3 | 4 |
| 14) Students developed problem-solving strategies. Where appropriate, technology tools aided the development of these strategies. | 0 | 1 | 2 | 3 | 4 |
| 15) Students used technology to solve problems and make informed decisions. | 0 | 1 | 2 | 3 | 4 |

Section score _____

VII. CONTENT AND KNOWLEDGE

Never Occurred	Very Descriptive
-------------------	---------------------

- 16) The lesson emphasized fundamental concepts outlined in state and national standards. 0 1 2 3 4
- 17) The integration of technology into the lesson promoted strong coherent conceptual understanding. 0 1 2 3 4
- 18) The teacher had a solid grasp of the subject matter content and the use of technology. 0 1 2 3 4
- 19) Students were reflective about their own learning. 0 1 2 3 4
- 20) It can be characterized of this lesson that students used technology to aid in the construction of meaningful knowledge. 0 1 2 3 4

Section score _____

VIII. TECHNOLOGY AS TOOLS

- | | Never
Occurred | Very
Descriptive |
|---|-------------------|---------------------|
| 21) The use of technology aided the clarification and communication of ideas. | 0 1 2 3 4 | |
| 22) Students employed technology to develop strategies for solving problems. | 0 1 2 3 4 | |

23) Students used technology to construct 0 1 2 3 4
models, increase productivity, and produce
creative work.

24) Students utilized technology to collect 0 1 2 3 4
information, process data and report results.

25) Students used technology for inquiry and
exploration. Students made predictions, 0 1 2 3 4
estimations and/or hypotheses and devised
means for testing them.

Section score _____

TOTAL SCORE _____

(Transfer score to front page)

Appendix I: Interview questions

UNIVERSITY RESEARCH STUDY

Title: The integration of Indigenous Knowledge Systems (IKS) in the teaching of Life Sciences through ICTs

Researcher:	Margaret Sitsha	maggysit@gmail.com
Supervisor:	Prof. J. J. J. De Beer	JosefDeBeer@nwu.ac.za
Co-supervisor:	Prof. C. van Der Westhuizen	Christo.Va.DerWesthuizen@nwu.ac.za

Introduction:

I appreciate your willingness to participate in this interview session. I am a master's student from the North-West University. The purpose of this study is to explore your experiences in including Indigenous Knowledge (IK) in teaching Life Sciences as well as your experiences of the integrating of Information and Communication Technologies in the teaching of Life Sciences.

This interview will be conducted as a semi-structured interview in which I am going to use a set of questions as a guideline. I will not strictly follow the list of these questions, so as to allow us to have a conversation with you so that we can get a sense of your personal experiences in including indigenous knowledge in the teaching of Life Sciences and what opportunities the introduction of ICT has presented you in achieving your teaching and learning outcomes. The information that is gathered in this study is for research purpose only.

Consent:

It is important to remind you that your participation in this interview is voluntary and although you have signed the consent form, I would want to highlight that the information gathered is confidential, neither yours nor the school's name will appear in the research report. In any case if you feel not comfortable to continue with the discussions feel free to indicate it to me.

Notes taking and Audiotaping of the interview:

We are going to engage in a conversation, I will write down some points. Considering the importance of the knowledge and personal experiences that you have, if I rely on writing all your answers, I might miss some important points. I therefore request for your permission that I audiotape the interview. I trust that your participation in this study is valuable in improving our education system since you are directly involved in teaching and learning of Life Sciences.

Interview outline:

This interview session will take us thirty to forty-five minutes. I really appreciate your willingness to dedicate your precious time to this interview. The first session is your experiences in including indigenous knowledge in Life Sciences teaching and the other part is on the integration of ICT in teaching and learning of Life Sciences. I will need your general information, but I am not going to use your personal details. Your openness, honesty and dedication to share your personal experiences is very important in adding value to our education development.

Section B:

Integration of indigenous knowledge and ICT in Life Sciences lessons.

Guiding questions	Notes / Probing
1. What do you think about the inclusion of indigenous knowledge in Life Sciences.	
2. What is the is the general cultural representation in your Life Sciences classes?	
3. How do you include indigenous knowledge when teaching Life Sciences.	<i>Probing:</i> <ul style="list-style-type: none"> In your opinion what can be done to sustain the meaningful inclusion of IK in the curriculum?
4. What are the challenges that you encounter in your Life Sciences lessons when you integrating IK?	
5. How do you address these challenges?	<i>Probing:</i> <ul style="list-style-type: none"> In your opinion what can be done to alleviate these challenges?
6. How do you integrate the relevant IK of different cultural groups in the teaching of Life Sciences content? You can give me a few examples.	
7. How do you enable learners to translate their cultural experiences to assist in gaining conceptual understanding at higher cognitive levels in the subject?	
8. What are your experiences in students' IK and what is your role in developing some scientific concepts?	
9. How is the introduction of online learning environments facilitating your professional development of the Technological Pedagogical Content Knowledge (TPCK)?	<i>Probing:</i> <ul style="list-style-type: none"> What is your personal opinion about "the paperless classroom"?

10. What ICT devices are available for use in your Life Sciences the classrooms?	<i>Probing:</i> <ul style="list-style-type: none"> • How user friendly are the devices? • Which of these devices do you use most and why?
11. What are your experiences of online learning environments?	
12. How has these technological platforms enabled you to integrate IK in your Life Sciences lessons.	
13. What are the challenges that you face in utilizing technological platforms?	
14. How do you address these challenges?	
15. How can these challenges be minimized?	
16. What are your experiences of both face-to-face and online communities of practice in their own professional development?	

Do you have any experiences with regard to the topic that we discussed that you would like to share with me? I highly appreciate your honesty and willingness to participate in this important study.