Cape Peninsula University of Technology

THESIS

A thesis submitted in partial fulfilment of the requirement for the degree of

MASTER OF EDUCATION

In the field of

KNOWLEDGE INTEGRATION IN LIFE SCIENCES

With the title:

Teaching the Principle of Knowledge Integration in Life Sciences in the Further Education and Training Phase

By

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ABSTRACT

The principle of knowledge integration has been a strong focus in the field of science education around the world, where teachers and administrators are encouraged to take an interdisciplinary, multidisciplinary, and transdisciplinary approach to the teaching of science in the field of education. In the South African education system, knowledge integration as a principle in curriculum research in education was introduced as an important pillar of outcomes-based education in the post-apartheid educational system, which the implication of moving from a subject-based discipline to a multi-disciplinary knowledge design. The paradigm of this study is grounded in Karl Maton's Legitimation Code Theory that uses semantic waves to demonstrate a strong 'discourse' on and the potential of educational knowledge structures to enhance cumulative learning where knowledge is transferred and shared across the content of different learning areas of a school curriculum and built over time to promote lifelong learning in learners. This qualitative case study is confined to three metro east schools in the Western Cape and a purposive sample of seven Life Sciences educators. Data collected through semi-structured interviews and observations was analysed by utilising the principles of grounded theory. This study has employed an inductive approach to analysing research data in order to answer the research questions, aims, and objectives during the research process. The purpose of this case study research was to investigate teacher perceptions and views and explore strategies of knowledge integration within the field of Life Sciences and subsequently recommend how Life Sciences teachers can be trained to teach knowledge integration in the FET phase. The findings of the study show that Life Sciences teachers have a lack of understanding of curriculum models that are used to bridge the content knowledge gap in the teaching and learning of Life Sciences. The views and perceptions of the participants attest that most Life Sciences teachers when teaching the subject, do not necessarily consider knowledge integration and this results in the poor implementation of knowledge integration in the Life Sciences subject discipline. A poor teaching approach such as the teacher-centred approach that only benefits teachers in finishing the syllabus but is disadvantageous for learners as well as the lack of suitable teaching and learning materials were among the key problems that the researcher picked up during the observations. This study has revealed the need for the training of Life Sciences preservice teachers and for curriculum advisors and professional development workshops of Life Sciences teachers to empower them on how to use the multidisciplinary approach to teach Life Sciences as an integrated subject discipline by using the Life Sciences

syllabus and thereby address their learners' needs and improve their performance.

This study further concludes that educators' reluctance to consider multidisciplinary knowledge structure hampers the adequate teaching and learning of Life Sciences. For Life Sciences discipline to be adequately taught, knowledge of sub-disciplines such as chemistry, geography, physics, and biological sciences could contribute to knowledge acquisition of concepts and topics that are prescribed in the Life Sciences school curriculum. Curriculum Advisors as people given the responsibility of oversight on how the subject should be taught at schools need to empower educators with how to model and sequence knowledge to enable teachers to teach Life Sciences curriculum in its entirety to curb the challenge of poor performance of learners in the discipline

DECLARATION

I, Mfundo Nyunguza, declare that the work presented in this dissertation with the title "Teaching the principle of knowledge integration in Life Sciences in the Further Education and Training phase" is my work, and where other sources were used for reference they were acknowledged according to the Harvard system of referencing.

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CHAPTER 1: INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction

The principle of knowledge integration has been a strong focus in the field of science education around the world, where teachers and administrators are encouraged to take an interdisciplinary, multidisciplinary, and transdisciplinary approach/model to the teaching of science in the field of education (Nsubuga, 2008). This study seeks to understand the phenomena of Life Sciences teaching and learning using curriculum models that embrace knowledge integration in science education. The issue of knowledge integration in Life Sciences/science education is an international problem that impact teaching and learning of Life Sciences as an integrated subject discipline. In the South African education system, knowledge integration, as a principle in curriculum research in teacher education and training, was introduced as an integral part of outcomes-based education in the post-apartheid education, which had implications which moved the system from a subject-based discipline to a multi-disciplinary knowledge design (Booi, 2018). The main aim to address the lack of integration in science education is to promote teaching and learning that support and encourage Life Sciences teachers to consider integration of science subject during the teaching of Life Sciences. Knowledge integration has been defined in different ways; Marshal (2018) defines knowledge integration as an instructional teaching approach using different teaching strategies wherein different subject content areas are taught simultaneously whilst according to Kyslika (1998), knowledge integration is the connection between two separate subjects' content areas or skill areas.

1.2 Background

The paradigm of this study was grounded in Basil Bernstein's theory of discourse and knowledge structures which explores the potential of educational knowledge structures in enhancing cumulative learning where knowledge is transferred and shared across the content of different learning areas of a school curriculum and built over time to promote lifelong learning in learners (Maton, 2017). Integration is all about combining the knowledge that is acquired through the use of various teaching strategies in the educational curriculum.

A curriculum should enable the design of teaching and planning approaches to the process of teaching and learning in science education to motivate and enhance learner performance and address their educational needs in the school curriculum and their world experiences. The extant and most common approaches to knowledge integration within the school curriculum used worldwide are multidisciplinary, interdisciplinary, and transdisciplinary as processes of curriculum integration and implementation (Helmore and Briska, 2017). These three approaches have been suggested and recommended by many researchers and used in other countries to address the challenges that face educational systems worldwide (Helmore and Briska, 2017). Knowledge and curriculum integration is the leading challenge in education sector worldwide, to investigate teachers' perception on current issue raise awareness to science teachers to address integration of knowledge in science education to promote and develop science students in the field of science education. Multidisciplinary, interdisciplinary and transdisciplinary are used as methods of planning and teaching in high school science education to enhance the teaching and learning of Life Sciences in the FET phase where teachers are expected to teach an integrated curriculum to address the learners' needs. This planning includes the combination of different subjects areas and skills into a single lesson in order to encourage learners to acquire knowledge by themselves through the use of teacher instruction (Helmore and Briska, 2017). In finding ways to help teachers and teacher educators to understand curriculum integration, many research studies have presented different ways of approaching an integrated curriculum that can be used in South African schools to enhance the educational system and to produce lifelong learners. For example, in his discussion of knowledge integration, Fogarty (1991) explains ten methods of curriculum integration that teachers can use in their classes during their lessons. These images/methods are aimed to explain the different stages of knowledge integration and addressing teachers' concerns about blending content knowledge across a variety of knowledge disciplines (Forgarty, 1991; Kyslika, 1998).

Different studies have shown that some of the teachers do not even understand what is meant by knowledge integration and that the majority of teachers have no confidence in their perception or their perceived understanding of the concept of knowledge integration. (Hafizan, Halim and Meerah .2012). This study therefore aims to investigate teachers' perceptions on knowledge integration in the Life Sciences curriculum.

1.3 Problem Statement

This research study undertakes to explore the perceptions of Life Sciences teachers and their knowledge about the teaching of Life Sciences using a curriculum embracing the principle of knowledge integration to enhance learner performance and improve content areas in the FET phase Life Sciences school curriculum. One of the factors that contribute to this problem is the teachers' poor understanding of what is meant by knowledge/curriculum integration. Curriculum integration is worldwide problem that affect/deprive science students and teachers who has knowledge gap in science subject especial Life Sciences. Different curricula have been used in the South African education system (Jansen, 1998) but knowledge integration is still a challenge in the teaching and learning of Life Sciences because it is still taught as a separate discipline of science, even though the name of the subject Biology was changed to Life Sciences. Failing to integrate Life Sciences with other learning areas of the school curriculum creates a gap in the knowledge transferred from other subjects and limits the connections between what is taught in school and real-world experiences (Boyce, 2011; Plummer & Kuhlman, 2008). This study can raise the level of awareness to teachers and teacher educators to plan and bridge the existing knowledge gap in Life Science subject content.

1.4 Research Question

The main research question for this study is:

How can the principle of knowledge integration in Life Sciences be taught in the Further Education and Training (FET) Phase?

Sub-Research questions

1. What are teachers' perceptions regarding teaching knowledge integration in Life Sciences?
2. How can teachers be trained to teach knowledge integration in the implementation of Life Sciences curriculum?

1.5 Research Aim

The main aim of this study is to establish how the principle of knowledge integration in Life Sciences can be taught in the Further Education and Training Phase.

1.6 Research Objectives

1. To establish teachers' perceptions regarding teaching knowledge integration in Life Sciences.

2. To explore how teachers can be trained to teach knowledge integration in the implementation of the Life Sciences curriculum.

1.7 Literature Review

1.7.1 Introduction

This section contextualizes the study within the theories and research of other experts on teacher's perceptions and their use of images/models of knowledge integration in the teaching and learning of Life Sciences as an integrated science subject. The main reason for this literature review is to acquaint the researcher with the field of study and to gain a deeper understanding of effective implementation of knowledge integration.

1.7.2 Knowledge Integration

Before teachers and teacher educators successfully plan for knowledge integration in Life Sciences, a much clearer concept of what is meant by knowledge integration is needed (Kyslika, 1998). Teacher and teacher educators can achieve the integration of knowledge by integrating the science subjects with other learning areas of a school curriculum to close the gap for science being learnt as single discipline (Fogarty, 1991).

Knowledge integration is a worldwide focus area of research in curriculum development in the field of education and it has been defined in different ways by different researchers. The one which best fits the purpose of the study is that of Beane (1995) which describes curriculum integration as a way of thinking that needs people to ask themselves what schools are for, the source of a curriculum, and use of knowledge. It has been noted that students are encouraged to integrate knowledge and their learning experience into their scheme of meaning so as to broaden and deepen their understanding of themselves and their world (Beane, 1995).

1.7.3 Life Sciences Teachers' Perceptions Regarding Knowledge Integration in the Teaching and Learning of Life Sciences

The Life Sciences curriculum emphasises the integration of knowledge and the teaching of different skills that help learners to acquire and understand information to improve their science – and cognitive skills such as critical thinking and decision making (DoE, 2011), and to produce students who can sustain life using their skills learned through science. For these reasons teachers should be competent and be able to conceptualise their understanding of knowledge integration and an integrated curriculum. A science syllabus requires teachers to use a learner-centred approach to teach and provide students with investigation and experimental skills. Teachers are considered important factors in curriculum development. Many studies show that it is necessary to determine the level of competence of science teachers and their conceptual understanding of curriculum integration (Hafizan *et al.*, 2012).

1.7.4. The Use of the Principle of Knowledge Integration in the Life Sciences Curriculum

Knowledge integration from various disciplines, which then become curriculum integration, range from fragmented discipline teaching to a network approach (integrating knowledge from various disciplines into a network of knowledge which thus becomes curriculum integration) to address students' twenty first century needs. The ways of, or approaches to knowledge integration belong to three different categories namely, multidisciplinary, interdisciplinary, and transdisciplinary knowledge integration. According to Kyslika (1998), these ways of, or approaches to, knowledge integration can be classified as follows:

- Fragmented approach: a traditional design for organising a curriculum which has direct focus on a single discipline.
- Connected approach: while the discipline remains separate, this strategy focuses on making explicit connections within each subject area.
- Nested approach: this approach focuses on natural combination; the content area remains the major focus of the lesson plan, but the skills of thinking and of organising are highlighted within the lesson.
- Sequence approach: topics within a discipline are rearranged to coincide with those of another discipline.
- Shared approach: bringing two different subject disciplines together into a single discipline; disciplines are partnered, and units planned to focus on overlapping concepts.
- Webbed approach: disciplines use the themes to teach a specific topic. Teachers may use 'ethics' as a term to address and discuss the issue of plagiarism in writing up assignments.
- Threaded approach: the curriculum is designed around specific aims and content serves as a vehicle for those aims and skills. Designing a hypothesis for life sciences experiments or investigation is an example of the thread approach.
- Integrated approach: a group of teachers from different disciplines work together to find overlapping concepts which they can plan as a unit of study and implement in common teaching time.

- Immerse approach: integration takes place within learners with little or no intervention from the teacher.
- Network approach: requires learners to reorganise relationships of concepts within and between the separate disciplines (Forgarty, 1991), and ideas and learning strategies within and between learners.

Whether teachers work as individuals or as groups these ways of knowledge integration can function as a useful tool to enhance the teaching and learning of Life Sciences in all grades.

1.8 **Theoretical Framework**

1.8.1. Introduction

This study was grounded in Basil Bernstein's theory of discourse and knowledge structure that explores the potential of educational knowledge structures to enhance cumulative learning where knowledge is transferred and shared across the context of different learning areas of a school curriculum and built over time to promote lifelong learning in learners (Maton, 2017).

1.8.2 Legitimation Code Theory

Maton (2017) explains that his theory known as the Legitimation Code Theory (LCT), is a model designed to overcome the dichotomies of socially constructed and real knowledge building using principles or dimensions such as semantics and its underlying legitimation codes such as semantic gravity. This developed theoretical framework is used to analyse two contrasting examples of curricula in universities and secondary schools (Maton, Hood and Shay. 2016) that utilise cumulative learning. Dichotomous thinking is deeply debilitating to knowledge-building regarding education and society. Maton *et al. (ibid.*) argue that the Legitimation Code Theory (LCT) enables both the explanation of knowledge-building and the cumulative building of knowledge. The emergence of LCT at the turn of the twenty-first century has evolved into a multidimensional concept (Maton *et al.*, 2016). LCT is being used to interpret education around the world in different ways, but it changes the approach in the field of education (Maton, 2017). Bourdieu, in his writing, has called this theory the 'rules of the game' (Maton *et al.,* 2016) because concepts from this framework reveal different dimensions.

One of the dimensions of the Legitimation Code Theory is that of Semantics which is rooted explicitly in the work of Bernstein, who claimed that knowledge structure can be horizontal and hierarchical (Blackie, 2014; Maton, 2009). A horizontal knowledge structure is regarded as general knowledge that humans possess and hierarchical knowledge refers to the natural science knowledge structures (Blackie, 2014; Maton and Doran, 2017; Maton, 2009; 2014) which can be acquired. Semantics employs several codes such as Semantic Gravity, Semantic Density, and Semantic Waves (Maton, 2014, Blackie, 2014). For the purpose of this study these codes are used to explain the building of knowledge structures as a prerequisite for knowledge integration (Hipkiss and Vargas, 2018; Maton, 2009).

1.8.2.1 Semantic Gravity

Semantic gravity (SG) is one of the codes found within this framework and it is defined as a degree of meaning which is context-dependent and it may be strong or weak (Maton, 2014; Maton and Doran, 2017). In strong semantic gravity (SG+) the meaning of knowledge is more dependent on its context and in weak semantic gravity (SG-) meaning is less dependent on its context (Maton, 2009; 2014; Maton and Doran, 2017; Hipkiss and Varga, 2018). Hipkiss and Varga (2018) have described SG+ with examples such as lab-work in a classroom where learners only need to use demonstrative pronouns to communicate which sample to use. An example of SG- is the use of textbooks that describe a general protocol for lab-work. In relation to semantic gravity and the context within which it can be interpreted, Maton (2017) uses the two types of knowledge discourse distinguished by Bernstein which was discussed previously namely, horizontal discourse and vertical discourse.

1.8.2.2 Semantic Density

A second code of Maton's LCT employed in this study is semantic density (SD) which is defined as the degree of the knowledge condensation of meaning within practice and it can be strong or weak (Maton, 2014). Strong semantic density (SD+) meaning is more condensed within practice, and in weak semantic density (SD-) meaning is less condensed (Maton, 2014; Maton and Doran, 2017; Hipkiss and Varga,2018). Semantic density relates to the degree of complexity of knowledge where the amount of meaning can be condensed within symbol, text, and concepts (Blackie, 2014; Hipkiss and Varga, 2018) (See Figure 1).

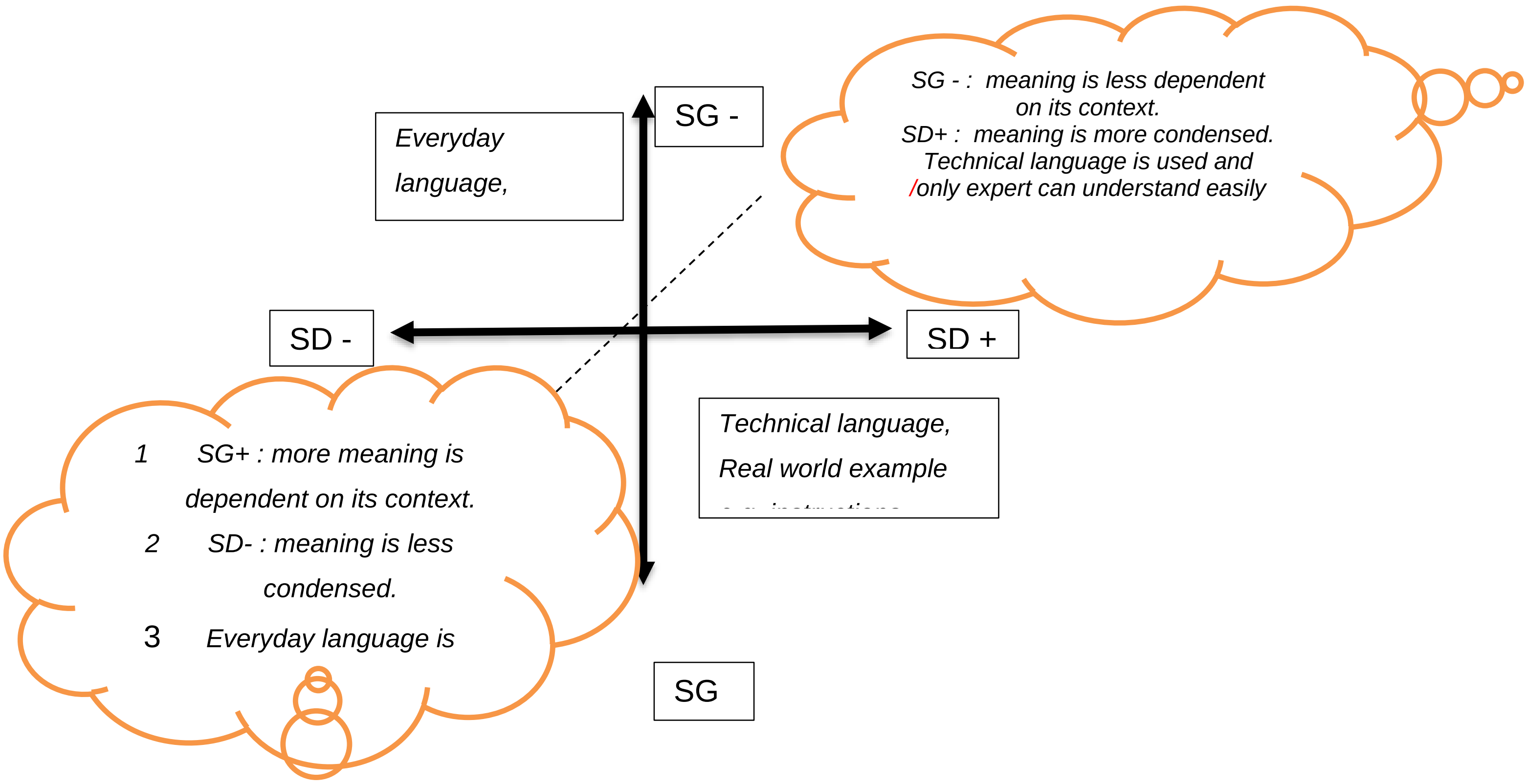

Figure 1: Semantic Gravity (SG) and Semantic Density (SD) (Waite, Maton, and Tuttiett. 2019)

The continuum of the relationship between semantic gravity and semantic density in the learning of science concepts can be diagrammatically represented by means of a semantic wave as in Figure 2 below:

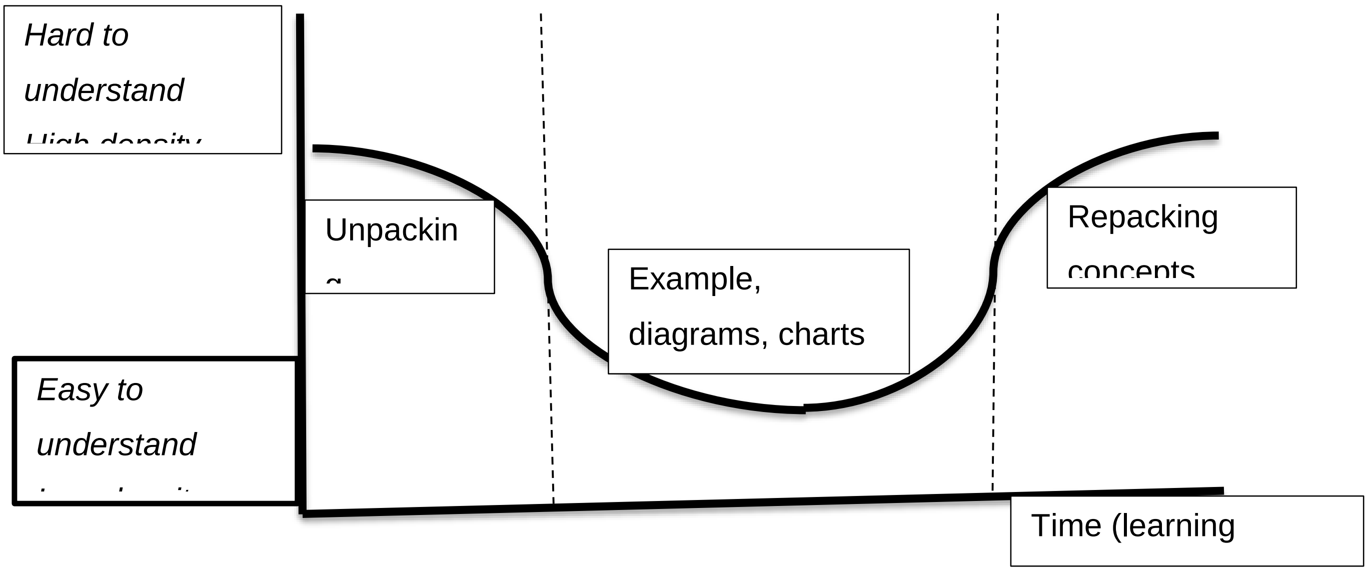

Figure 2: Semantic Waves (Waite *et al*., 2019)

When explaining and unpacking a concept a teacher moves from abstract and complex meanings (high SD, low SG) down to more grounded and simpler meanings (low SD, high SG) to help learners to understand easier, and then moves back to abstract meanings (high SD, low SG) again. A good teaching and learning experience consists of a lesson plan that uses a movement of semantic waves to unpack abstract and complex concepts into simple forms of knowledge that are easily understood by learners. It is strongly believed that rather than assuming that once a technical and abstract concept has been explained it is a risk to learners not to make use of the continuum of the semantic wave (Waite *et al*., 2019).

1.9 Research Design and Methodology

1.9.1 Research Design

This research study employs a qualitative case study research approach because it provides the researcher with the means to unravel and understand intricate social phenomena (Baxter and Jack, 2008). According to Igwenagu (2016), the qualitative research method is based on the beliefs, views and perceptions that humankind possess as well as experiences which provide the most meaningful data from participants. Another advantage of the qualitative method is that a huge amount of data is harvested from a limited number of participants (Igwenagu, 2016).

The purpose of this case study research was to investigate teachers' perceptions and views and explore strategies of knowledge integration within the field of Life Sciences (Snyder, 2012) and to understand the world view of participants through the lens of their experiences (Igwenagu, 2016). To this end a qualitative case study endeavours to answer the research question using not only one lens but several lenses which allows for multiple phenomena to be uncovered and explained (Baxter and Jack, 2008). Furthermore, this research study embedded in the constructivist paradigm as proposed by Baxter and Jack (2008) that views reality as being constructed by individual teachers interacting with their social world (Snyder, 2012) informed the method of data collection and data analysis procedures. According to Baxter and Jack (2008) and Snyder (2012), a qualitative case study is suitable for exploring the meaning teachers have constructed based on their experiences.

1.9.2 Research Methodology

1.9.2.1 Research Site

The sites of this research study were three secondary school situated in the Metro South District of in the city of Cape Town. These schools each has a capacity of more than one thousand learners and more than forty staff members with two deputy principals. They offer schooling only from grade ten to grade twelve.

Most of the South African schools are arranged in terms of quintiles from one to five, as determined by the location of the school and the wealth of the community (Blease and Condy, 2014). Schools categorised as quantile four to five are regarded as well-resourced and well performing schools while quintile one to three schools are regarded as under resourced schools that perform at an average of 40 per cent to 75 per cent. All the schools that formed part of this research are categorised from quintile one (no fee school) to quintile three and learners are provided with two meals, one in the morning and one at noon. The choice of these sites was also based on their performance in the Life Sciences learning area. Two of the three schools have demonstrated poor performance in Life Sciences over the past three years.

1.9.2.2 Sampling and Population

Convenience and purposive sampling were best suited to this study. Convenience sampling is a rigorous sampling strategy that is based on the availability and accessibility of the participants. Purposive sampling allows the researcher to target the best candidates for data collection and which best suits the nature of the study (Keilmann, Cataldo, and Seeley. 2012). The choice of three Life Sciences educators per school was based on ease of access and the proximity of the schools they teach at and where the researcher could easily travel to at any given time. These Life Sciences teachers are qualified to teach Grade 8 and 9 Natural Sciences and Grade 10 to 12 Life Sciences and all of them are currently teaching Life Sciences in the Further Education and Training phase (from Grade 10 to Grade 12). For data collection purposes these Life Sciences teachers were interviewed and observed in order to obtain information about how they teach Life Sciences in the FET phase using knowledge integration.

1.9.2.3 Data Collection

Interviews

Semi-structured interviews were employed to obtain information from the teachers about their knowledge and perceptions of teaching knowledge integration in Life Sciences. The interviews were audio-recorded and transcribed to secure the accuracy of the data collected during the interviews.

Observations

Classroom observation was chosen as the second method for data collection to ensure the trustworthiness of the results from the study. The aim of this data collection method is to observe how Life Sciences teachers teach Life Sciences through knowledge integration from other school subjects. The researcher observed three Life Sciences teachers per school in the FET phase using an observation checklist (compiled from the literature above) regarding the ways of teaching knowledge integration as well as the aspects in the Legitimation Code Theory, to compare how the Life Sciences teachers say they teach knowledge integration in Life Sciences and how they actually teach it in their lesson presentations.

1.9.2.4 Data Analysis

Coding and themes were used to extract the key concepts that emerge from the interviews and the observations. The aim and purpose of coding and developing themes is to make it easy to find the common aspect and concepts from both respondents and to enable the researcher to analyse the findings. During the data analysis personal identification will not be used, instead participants are given pseudonyms to protect their identity (Douglas, Hamilton, and Grub. 2009). Thematic analysis was used in this study to analyse the data collected during the interviews and this is a method for identifying, describing, analysing, and reporting themes and patterns within the data (Douglas *et al.,* 2009).

1.9.2.5 Trustworthiness

Reliability and validation are a point of discussion and debate, but qualitative research can be trusted based on how it is conducted and analysed (Blease and Condy, 2014). Reliability is generally understood to concern the validity and credibility of the research study in obtaining similar findings if another study was undertaken using the same research method and approach (Kielmann *et al.,* 2012). Triangulating research ensures the credibility and the validity of the data obtained during data collection (Kielmann *et al.,* 2012). In this study methodological triangulation will be ensured by using more than one data source to increase confidence in the results (Bowen, 2009; Kielmann *et al.,* 2012). According to Bowen (2009), by triangulating data the researcher provided evidence that strengthened the credibility of the study and helped the researcher guard against the accusation that the findings were simply an artefact of a single method and bias. The results from the interviews and observations provided the necessary triangulation for this study (Bowen, 2009).

Member checking as a triangulation method was also used. The participating teachers received a copy of the transcribed data to allow them to check if the information gathered from them was accurately and truthfully described (Blease and Condy, 2014).

1.9.2.6 Ethical Issues

The researcher ensured that the rights and safety of the participants participating in this research study are protected. Clearance was obtained from the Cape Peninsula University of Technology ethics committee and a letter of permission was requested and granted by the Western Cape Department of Education. Informed consent was also obtained from the school principal and the participating teachers. The confidentiality and anonymity of the participants were respected, and participants were made aware that they may withdraw or refrain from participating if they did not feel comfortable. As indicated, the data transcripts were also made available to the participants for reasons of transparency. Data collection was conducted in an environment where the participants felt comfortable. The information collected is regarded as confidential and was used for research purpose only (Blease and Condy, 2014).

19.2.7 Position of the Researcher in the Study

The researcher was directly involved in driving the process of data collection, in the analysis of the data and the writing up of the research outputs alongside with the collaborators.

3.1. Preliminary Chapter Division

Chapter One: This chapter presents an overview of the study.

Chapter Two: A detailed synthesis of the relevant literature for the conceptual framework of this study is provided in this chapter, consisting of both the conceptual and theoretical frameworks.

Chapter Three: The research design and methodology adopted for this study are discussed in depth in this chapter.

Chapter Four: This chapter draws up summaries of data generated in the process of data analysis. In this chapter data are interpreted within the context of the purpose of the research tools.

A summary of findings is discussed in the context of each of the research questions and problem statements. Furthermore, a synthesis of the findings of the study is presented in the context of the research aims and objectives of the study. Conclusions and recommendation are made.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents a synthesis of literature that is relevant to the current study. Key concepts highlighted briefly in chapter one; are unpacked and explained in an in-depth manner in this chapter. Furthermore, this chapter clarifies the theoretical framework selected as a lens to collect data as well as to present the results and findings of the study that will answer the research questions presented in chapter one. In chapter one, the principles of knowledge integration in curriculum studies are introduced to pinpoint integration teaching approaches that can enhance the teaching and learning of FET life sciences and this is further explained in chapter two of the literature review.

Knowledge integration is a focus area of research in curriculum development in the field of education around the world. Knowledge integration has been defined in different ways by different researchers. Beane (1995) describes knowledge integration as a way of thinking through the form of curriculum integration that needs people to ask themselves what schools are for, the source of a curriculum, and use of knowledge. It has been noted that students are encouraged to integrate knowledge and learning experiences into their scheme of meaning to broaden and deepen their understanding of themselves and their world (Beane, 1995).

This research reviews theories and teachers' perceptions on the use of the images and models of knowledge integration as a principle that drives the curriculum development process in the teaching and learning of life sciences as an integrated science subject. The main intention for the literature of this study is to acquaint readers with what other research within the field of science education has to offer to support the growth in the research of knowledge integration in science integrated subjects, such as life sciences, in order to ensure effective knowledge integration when implemented with understanding.

2.2 Historical Review and Conceptualisation of the Life Sciences Curriculum

Biology as a school subject discipline descended from European countries, such as Britain in the nineteenth century, to be third in the leading scientific subjects in the secondary school curriculum in the nineteenth century (Le Grange, 2008). Physics and chemistry were the leading science subjects in the world in the school curriculum, followed by botany and zoology. At the beginning of the above stated era of biology, the number of students taking biology showed no growth until the decline in students taking zoology and botany as their secondary school subjects (Le Grange, 2008). Since then, biology began to emerge in secondary school curriculum across the world.

Le Grange (2008) states that the growth of the subject depended on the extent to which it could fulfil a dual purpose and their utilitarian potential. Across the world students studying biology as a school subject have increased in number, as one of the subjects that study living and non-living organisms within science disciplines, called the science of life. Biology, as a branch of science is, therefore, viewed as a study of social and cultural activity through which explanations of natural science phenomena are generated. Literature argues that biology incorporates ways of thinking that are critical and creative to students (Le Grange, 2008). Hence, the Queensland Authority (2014) describe Biology as a study of life in its manifestation which provides students with opportunities to:

- gain insight into specific manner of investigating problems pertaining to the living world,
- experience the process of science that leads to the discovery of new knowledge, and finally,

- develop a deeper understanding and aesthetic appreciation of the living world.

2.3 Teaching approaches of Biology/Life Sciences During and After Outcomes Based Education (OBE) in South Africa

According to Jansen and Christie (1999), in the old curriculum (prior to 1994) biology teaching approaches focused only on the content of the subject that is taught in the syllabus and what the teacher or textbook had to say was important. Learners received information from the teacher, and they did not play any active role in teaching and learning. The learning was based on the memorising of facts (rote-learning) and it was important that learners remembered and regurgitated the facts that were taught, and the understanding of knowledge was not at the centre of the teaching and learning process. This strategy did not enable learners to use what they had learned in different ways (Jansen and Christie, 1999; Lizer, 2013).

Several school curriculum reforms since 1994 were established at the advent of democracy, one of them being a comprehensive curriculum called Curriculum 2005 which was a progressive model of Outcomes Based Education (OBE). This curriculum had, as one of its pillars, some form of learner-centred approach to education which would allow teachers to assume the role of being facilitators instead of being authoritarian as they were when promoting rote learning and teaching (Jansen and Christie, 1999; Hoadley, 2010). Jansen (2002) pointed out in his ten major reasons why OBE has negative impacts in its implementation as follows: 1) it was because of the language innovation associated with OBE, which was too complex, confusing, and at times contradictory; 2) Teachers spent a lot of their teaching time attempting to make sense of life sciences terms and concepts (Jansen and Christie, 1999); 3) The implementation of the curriculum (OBE) was based on the resources, such as school infrastructure, laboratory apparatus, and textbooks, yet did not take into consideration teacher development as resource to convey any form of curriculum to students worldwide (Lizer, 2013). However, teachers as the key resource in the educational system for curriculum change and its implementation were not made part and parcel of the design and development of curricula, and even in the curriculum implementation it was given to them as a product and was not appraised on its nature, contributing to some ideological sidesteps as they did a cut-and-paste of the new curriculum concepts into the old apartheid syllabus (Booi, 2007; Lizer, *ibid.*). This furthers claims that challenges of curriculum change in science education are a result of a shortage of skilled science teachers, leading to inadequately qualified teachers teaching life sciences and other science subjects.

2.3.1 The Use of Traditional Teaching and Learning Approaches in the Life Sciences.

The international shift in the education system advocated for a consideration of what is important for students to Know, Do, and Be (KDB) in the future (Drake and Reid, 2018). Traditional teaching and learning approaches have been seen to not be working properly in the new generation of learners as it requires them to further move with the pace of the fourth industrial revolution to address the current needs of students (Drake and Reid, 2018). Hence, traditional curriculum expectations were more in the cognitive realm, including the requirements and needs of the curriculum for the enablement of knowledge by both teachers and learners (Drake and Reid, 2018).

The 21st century curriculum shift is more about knowledge integration which focuses more on the application of conceptual thinking across knowledge domains rather than a memorisation of facts for test and examinations (summative assessment), which has been a dominant practice for decades. This leads to developing critical thinking and the consideration of more skills and competencies that are determinants of the life sciences discipline (Arrowsmith, 2013; Drake and Reid, 2018). The urgent focus on integrated knowledge in the area of the science education curriculum has been made clear by research studies conducted in the field of education (Barcelona, 2014). Students need to be life-long learners who can manage to make sense of a huge amount of data and be able to have problem-solving skills in the complex issues of everyday life situations.

The change in the means of acquiring knowledge in recent time is argued to be a key reason why our education system still needs to consider knowledge integration across a variety of subject disciplines when teachers prepare their lessons (Arrowsmith, 2013). Arrowsmith (2013) further asserts that the new knowledge is distinct from the traditional philosophical understanding of knowledge and, therefore, a need for the integration of knowledge to be acquired by students from multidisciplinary knowledge disciplines. Embo reports compiled by Green and Wolkenhauer (2012) support knowledge integration in life sciences and biomedicine as a sustainable solution for medical students in Sydney university as it has demonstrated the possibility of the integration of knowledge across knowledge domains.

Thus, the integration of data has always been important in the field on biology/life sciences and other social science subject disciplines to form an integrated life science for its importance and for meaningful learner understanding. The need to discuss the integration of knowledge in life sciences has become more urgent as the amount of data required for understanding any given problem in the acquisition of disciplinary knowledge is increasing rapidly and can no longer be postponed. A multiple disciplinary knowledge mix requires careful sequencing of multidisciplinary knowledge to form an integrated discipline, such as life sciences (Green and Wolkenhauer, 2012). Moreover, many scientific questions require a range of expertise from different fields and, as such, integrating knowledge across disciplinary boundaries is crucial for adequate education in the life sciences (Green and Wolkenhauer, 2012). In the recent South African National curriculum statement, teachers are required to provide students with unique knowledge and skills that are necessary for their informed decision making about sustainable lifestyles (Nsubuga, 2008; Lizer, 2013).

2.3.2 Knowledge Integration

Knowledge integration is one of the key principles that underpins curriculum reform in post-apartheid South Africa (Booi, 2017; Nsubuga, 2008). Integration, as a principle in curriculum research in teacher education and training, was introduced as an integral part of Outcomes Based Education in the post-apartheid education system. This had the implication of a move from subject based discipline into a multi-discipline knowledge design (Booi, 2017). The principle of knowledge integration has been a strong focus in the field of education where teachers and teacher educators are encouraged to take an interdisciplinary approach to the field of education (Nsubuga, 2008). According to Nsubuga (2008), the white paper from the department of education of 1995 presented that education involving an interdisciplinary, integrated, and active approach to learning is vital to all levels and educational programs in the field of education and training.

Knowledge integration further refers to the process of adding, differentiating, organising, and evaluating phenomena and situations which are abstract (Marcia *et al.*, 2004). Many theorists, such as Dewey, Piaget, and Vygotsky, describe the process of knowledge integration by emphasising different aspects of it (Linn and His, 2000; Dewey, 1966). When the principle of knowledge integration is embedded in the disciplinary structure, learning is viewed as resonating with extensive research and theorising the learning of science by viewing knowledge integration as a source of different potential conflicts of views held by learners in the scientific phenomena (Clark and Linn, 2003; Booi and Kuzwayo, 2019). During this process, students develop a so-called repertoire of ideas and a knowledge web to facilitate communication about the knowledge integration across disciplines (Linn *et al.*, 2004).

Repertoire idea: students add some ideas spontaneously from observing real world scenarios and they also use ideas from the media, peers, schoolteachers, and experiments and investigations. Researchers suggest that repertoire ideas expand or contract depending on the context of the investigation given to students (Linn and His, 2000:417).

Knowledge web: this refers to a relationship among ideas in the repertoire of a knowledge web (Linn and His, 2000). Students may, therefore, connect ideas based on the scientific principles. This connection may come from the proximity in a course, experiments, and also from the critical analysis of similarities and differences (Linn and Eylon, 2006).

2.4 Principles of Knowledge Integration in Life Science Curriculum Development

Principles of knowledge integration are regarded as a framework that is organised around four different levels of knowledge integration that seek to:

I. Make science accessible to students
II. Make thinking visible for students
III. Provide social support for students
IV. Promote lifelong learning (Williams and Linn, 2002).

2.5 Images and Models of Knowledge Integration in Life Sciences

Knowledge integration from various disciplines, which then become curriculum integration, ranges from fragmented discipline teaching to a network approach (integrating knowledge from various disciplines into a network of knowledge which becomes curriculum integration) to address students' twenty first century needs (Booi, 2017; Forgarty. 1991). The ways of, or approaches to, knowledge integration belong in three different categories: multidisciplinary, interdisciplinary, and transdisciplinary. These approaches to knowledge integration can be classified as follows:

- Fragmented approach: a traditional design for organising a curriculum with a direct focus on a single discipline.
- Connected approach: while the discipline remains separate, this image focuses on making explicit connections within each subject area.
- Nested approach: this approach focuses on natural combination; the content area remains the major focus of the lesson planning but the skills of thinking and of organising are highlighted within the lesson.
- Sequence approach: topics within a discipline are rearranged to coincide with those of another discipline.
- Shared approach: bringing two different subject disciplines together into a single discipline. Disciplines are partnered and units planned to focus on overlapping concepts.
- Webbed approach: disciplines use the themes to teach a specific topic. Teachers may use 'ethics' as term to address and discuss the issue of plagiarism in writing up assignments.
- Threaded approach: a curriculum is designed around specific aims and content serves as a vehicle for those aims and skills. Designing a hypothesis for a life sciences experiment or investigation is an example of the thread approach.

- Integrated approach: a group of teachers work together from different disciplines to find overlapping concepts which they can plan as a unit of study and implement in common teaching time (Kyslika, 1998).
- Immerse approach: integration takes place within learners with little or no intervention from the teacher
- Network approach: requires learners to reorganise the relationship of concepts within and between the separate disciplines (Forgarty, 1991) and ideas and learning strategies within and between learners (Kyslika, 1998).

Whether teachers work as individuals or as groups, the images listed above as ways of knowledge integration can function as a useful tool to enhance the teaching and learning of Life Sciences in all grades (Booi, 2018).

2.6 Curriculum Models in the Process of Curriculum Development

Since the beginning of the development of the curriculum studies as a discipline there were lot of models for curriculum development created by many scholars and researchers (Palupi, 2018). Curriculum developers and academicians who are in the curriculum field have to be concerned about the many areas of knowing and mastering different curriculum models as well as understanding the foundations, principles, and issues around the current and old curriculum (Polupi, 2018). According to Fraenkel (1969), curriculum models have several roles to play in the development of a curriculum and provide direction where curriculum developers consider the previous experience and challenges faced by an old curriculum. Hence, curriculum designers must consider how knowledge to be used for teaching and learning is sequenced, how teaching activities or strategies are to be used to implement the curriculum, and the context, which includes who the student the curriculum is for and the societal issues that will act as enablers or hinderances for the learning process. For the development of scientific knowledge, curriculum models have been used to demonstrate how knowledge is sequenced and structured for the vertical and horizontal articulation of knowledge (Drechsler, 2007; Ornstein and Hunkins, 2011; Pinar, 2014). The use of curriculum models, therefore, assists curriculum developers to link the theories with their targets (students) through the process of determining what content must be included to enable learning and teaching as well as considering the assessment of knowledge acquisition (Drechler, 2007). Curriculum models have been derived from traditional curriculum models such as Tyler's model, which was later modified by Taba and extended by Saylor, Alexander, and other scholars (Palup, 2018).

This study draws from literature which asserts that curriculum models are the centre of models/images and modelling that increases the authenticity of the science education curriculum (Apple, 2004; Chisholm, 2012; Schubert, 1986). Teaching and learning within a curriculum entail acquiring knowledge; an acceptable understanding of what curriculum models are and how scholars have designed models as they structured teaching and learning activities as they develop and design a curriculum for the progressive learning of content; and developing specific competencies as required by the country for which curriculum is developed (Apple, 2004; Girlbert, 2004). Hence, models are considered during the design and development of curriculum resulting in the sequencing of scientific knowledge according to appropriate stages of learner development (Girlbert, 2004; Woolfolk, 2009). Although, the epistemological status is open for discussion and debate. In this case, therefore, curriculum models serve as a bridge between scientific theory and the world of experience in science education classes (Girlbert, 2004). Curriculum models help to simplify the abstraction of theory to an idealisation of a possible reality and provide descriptions of complex scientific phenomena (Girlbert, 2004:115-130).

Models are critiqued based on the key features they contribute towards in student learning, teacher use, and contextual fitting (Baska and Brown, 2007). For life science teachers, teaching and learning science requires an understanding of issues such as science concepts that shape and change science. It is, therefore, important for life science teachers to be competent in content knowledge and understand learners' contextual backgrounds as well as their prior knowledge of science concepts in order to use the curriculum models to break the barriers in teaching and make it easy for students to understand science (Baska and Brown, 2007; Drescher, 2007). The most important aspect in developing scientific knowledge is to help students to develop a better understanding of scientific issues (concepts, terminology, etc) when designing and using curriculum models. Hence, curriculum models serve as a link between subject theory and a target (students) to develop a description, explanation, and predict aspects of their real-world experiences (Drescher, 2007, Girlbert, 2000). Girlbert (2000) has argued that curriculum models as a readily perceptible entity which use abstractions of a theory could then be used to integrate content knowledge taught in class to bring forth some aspects of the world as experienced by learners within their context in attempting to understand content knowledge (Drescher, 2007).

2.7 Types of Curriculum Development Models in the Processes of Curriculum Planning

Curriculum development is the process of planning, implementing, and evaluating a curriculum that becomes a curriculum plan for either secondary or primary education (Luneburg, 2011). In the process of curriculum design and development, models and images have been used as an important tool to assist curriculum developers and planners to consider the target (students). Hence, models are essential tools and patterns that serve as guidelines to action curriculum development (Luneburg, 2011).

Using curriculum models in teaching and learning to develop a curriculum can result in greater efficiency and productivity for quality education for all citizen (Luneburg, 2011). Curriculum development models are classified and explained in different types of models in the process of curriculum development (Palupi, 2013, Luneburg, 2011). Luneburg (2013) explains, categorises, and analyses several models of curriculum development and further explores three curriculum models, the inductive, non-linear, and descriptive models. The inductive model begins with the development of curriculum material and leads to a generalisation of content while non-linear models permit curriculum planners to enter a model at different points (Luneburg, 2011). Descriptive models are said to be naturalistic models because they consist of elements such as platforms (principle), deliberation, and design (Palipi, 2013; Luneburg, 2011).

Tylers' models have been categorised as descriptive curriculum models in their classification, evaluated by Tilda Taba in 1962 (Palupi, 2018; Lunenburg, 2011). The early development of curriculum was more of subject-matter curriculum model which focuses on addressing the learning process on certain basic textbooks that should be mastered by students (Palupi, 2018). This type of curriculum model has a limited effect in the teaching and learning process as it is nothing other than a collection of textbook topics for students to learn.

In 1949, Tyler developed a curriculum development model based on Tyler's scientific management models (Palupi, 2018; Lunenburg, 2011). This kind of model comprised of the aims and objectives of education and learning which have been established to measure the success of the model by evaluating the students' learning outcomes (Lunenburg, 2011, Palupi, 2018).

The following section below compares three stages of the curriculum development with Tyler as deductive, Taba as inductive, and Wheeler's model as a cyclical model (Bhuttah, Tariq, Xiaoduan, Ullah and Javed .2019).

2.7.1 Tyler's Rationales Curriculum Development Model

Tyler, Dewey, and Bobbit agreed that a curriculum is a set of experiences that should be experienced by students (Palupi, 2018). Tyler's model is revolutionary because it reverses the classical model towards more demand-orientated design (Palupi, 2018:95-105). Buttah *et al*. (2019) put more emphasis on the significance of planning the development of a curriculum. Curriculum development has different curriculum approaches, such as technical-scientific approach and non-technical-scientific approach. The work of Raph Tyler (1949) was more based on the technical-scientific approach as a useful approach for curriculum development to arrange the learning environment as well as being logical and effective in transferring instructions (Buttah *et al.*, 2019; Lunenburg, 2011; Palupi, 2018).

Tyler's model presents four basic stages of curriculum development as principles of curriculum development and instruction. The four stages of this model are purpose, experience, method, and evaluation (Buttah *et al.*, 2019).

The four stages of Tyler's model are supported by four questions that seek answers what a curriculum should entail. The questions are as follow:

1. What are the learning rationales a school should try to find? This question answers the purpose, aims, and objectives of the curriculum.

2. Which learning principle can be presented that will probably achieve these rationales? This question answers what content should be taught in a school curriculum.
3. In what manner these learning experiences can be organised effectively? This refers to the learning experiences of students.
4. How to find out that whether the rationales are being accomplished or not? learners need to be evaluated after the learning has occur.

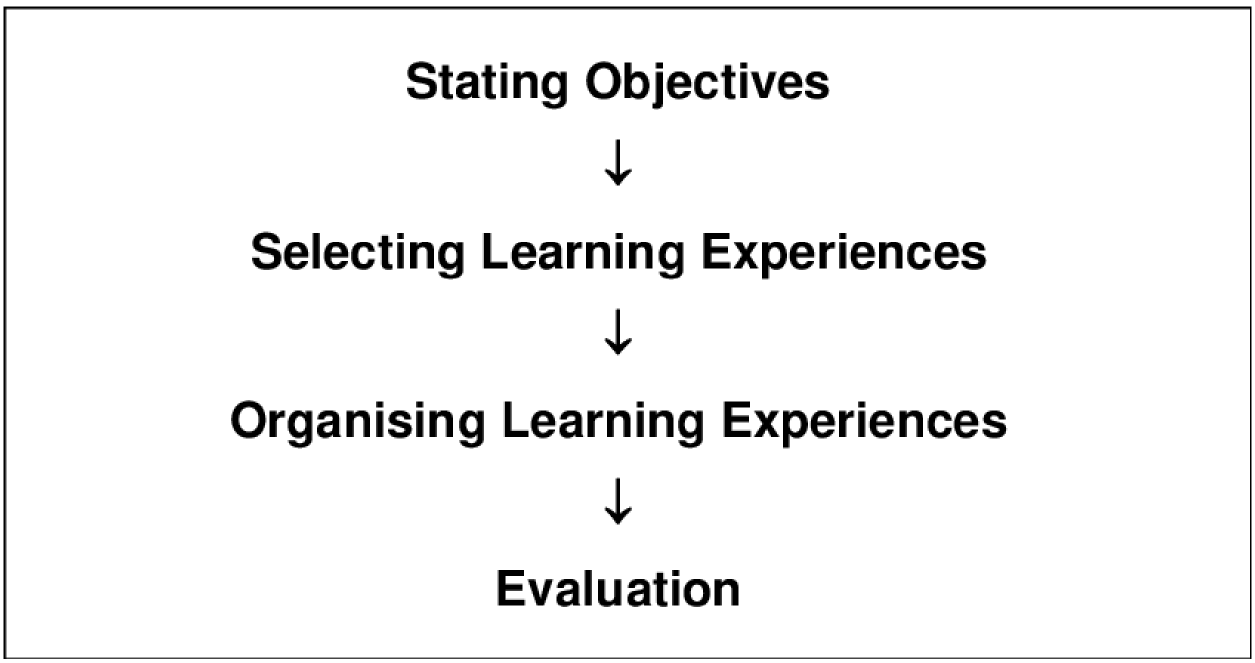

Figure 3: four basic principles of Raph Tylers' curriculum development models (Buttah *et al.*, 2019).

1. Define the purpose of the school: aims and objectives.
2. Selecting related educational experience: knowledge for problem solving.
3. Organising related educational experience: content within subject learning area.
4. Evaluating the objectives: check the effectiveness of programs.

2.7.2 Taba's Instructional Strategies Curriculum Model

According to Lunenburg (2011), Taba (1962) reversed the common accepted model by suggesting that, instead of developing a general plan for schools it would be more profitable to start with the planning of a teaching and learning unit. Taba's instructional model would provide the basis for the curriculum design that emerges from instructional strategies (Palupi, 2018; Lunenburg, 2011; Riafadilah and Mukhidin, 2017). Hilda Taba evaluated Tyler's model as a middle ground between the classical model and Tyler's rationales model to insert some details related to choosing and organising the learning material (content). The classical model's emphasis is more on the learning material while Tylers' model rationale prioritises learning experiences (Palupi, 2018, Lunenburg, 2011). Taba's model is similar to Tyler's rationales model, but Hilda Taba extended her model to allow for the importance of teachers in the process of curriculum development. Taba came up with the seven most importance steps that explain her model better than Tyler's model (Bhuttah *et al.*, 2019).

Taba's seven most important step in the process of curriculum development

1. Diagnosis: learner's requirements.
2. Formulation of objectives: goals to be accomplished by teachers.
3. Selection of content: content knowledge to be taught per grade.
4. Organisation of content: consider maturity, understanding, and interest.
5. Selection of learning experiences: methods of instruction to engage learners within the content.
6. Organisation of learning activities: link activities with the content taught during lesson presentation.
7. Evaluation: achievement of objectives through class activities.

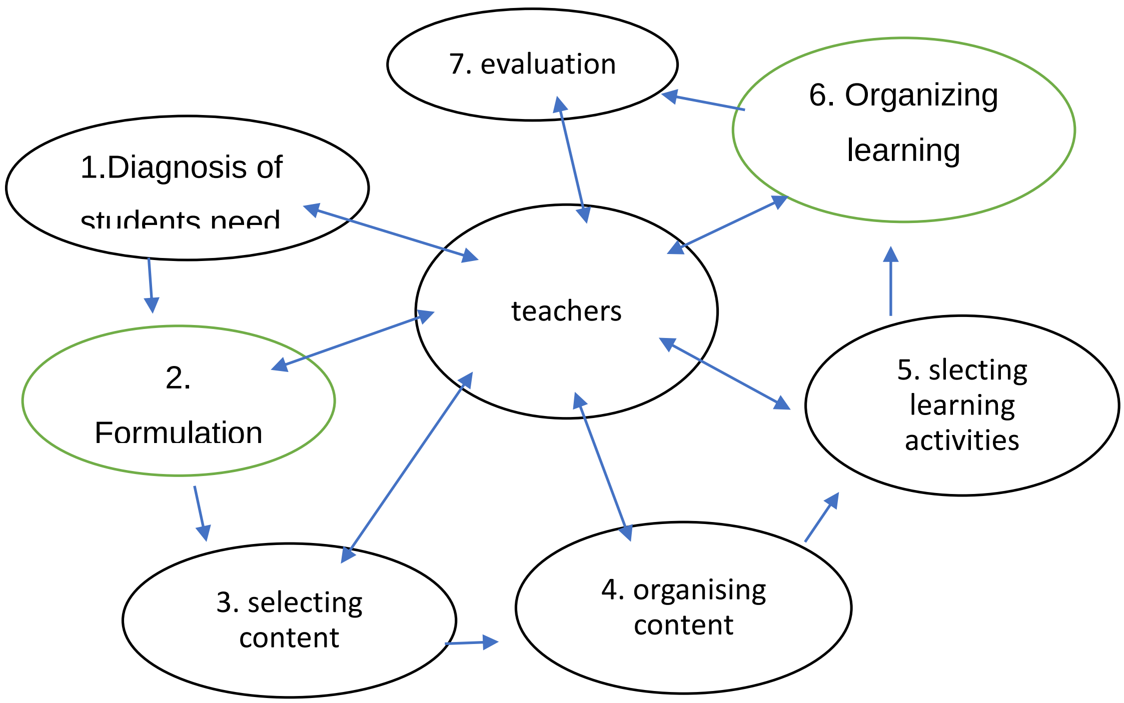

Figure 4: Taba's model of curriculum development (Buttah *et al.*, 2019).

2.7.3 Wheeler's curriculum models

Wheeler's clinical curriculum model was designed to criticise Tyler and Taba's models (Palupi, 2018). Wheeler argues that curriculum development has no starting point and ending point, it should be based on the learning experience of students (Palupi, 2018).

The critics of Tyler and Taba's models were based on the fact that learning practices in real life do not have a clear starting point and ending point. Learning activities in all subjects keep changing and there are continuous corrections or revisions. That means evaluation results become recommendations to improve the needs and purposes of the curriculum (Palupi, 2018).

Wheeler suggested that the reformulation of the next learning step depends on the evaluation results in order to achieve a curriculum's needs and purpose (Palupi, 2018). This model is known as a circular or cyclical model that changes the process of Tyler and Taba's curriculum development models by starting with learning experience before learning material (Palupi, 2018). Bhullah *et al.* (2019) state that wheelers' model is the best in flexibility and in continuity in curriculum because it shows that evaluation should not be the last stage of curriculum, rather it becomes a source of improvement in objectives and purpose.

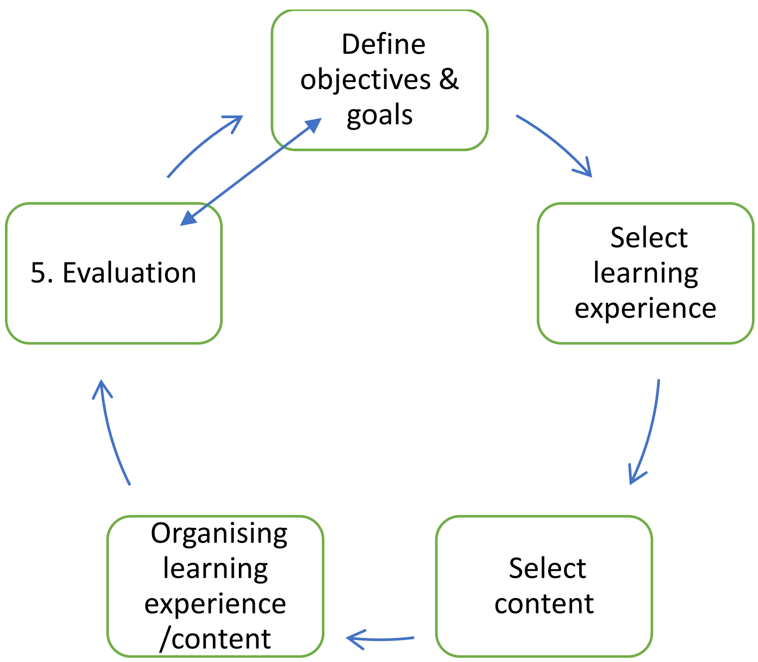

Figure 5: Wheeler's cyclical curriculum development model (Buttah *et al.*, 2019).

Wheeler's model is considered as one of the best models in the curriculum development process because of its flexibility and relevance to learner's situations. The challenge of its adoption is that it cannot always be used because of time constraints. Teachers have to finish up the prescribed curriculum on time in order to prepare learners for final summative assessments and, therefore, it cannot meet the needs of educators and administrators. Although, this model is deemed to be the best in terms of continuity as it cannot be easily put it into practice due to less time available for teachers and learners.

2.7.4 Bruner's Spiral Model

Bruner's spiral curriculum model is an approach to educational learning that encourages and involves the regular re-visiting of a previous topic/theme over the course of a learner's education (Carl, 2012; Irland and Mouthaan, 2020). Each time the teachers and learner re-visit previous content, learners gain a deeper knowledge and understanding of the content. It is seen as beneficial to learners due to its re-enforcement nature which gives teachers opportunities to do revision. Consolidation is done in each topic and theme over a period of time using prior knowledge to introduce future learning experiences (Irland and Mouthaan, 2020; Harden, 1999).

The spiral model is defined as a model that re-visits the same topic over time for the introduction of a new topic/theme and the consolidation of prior knowledge and memory (Irland and Mouthaan, 2020; Carl, 2012; Harden, 1999; Ornstein and Hunkins, 2011). This model is recommended as it is simple in repeating the same topic and it, therefore, requires a deepening of the content with a success encounter leading to a learner building on previous knowledge (Harden, 1999). The spiral curriculum development model has three key principles that conclude the approach in teaching and learning:

1. Cyclical: students should revisit the same topic/theme (content) several times to deepen their understanding (Carl, 2012; Harden, 1999).

2. Increase dept: revisiting the same topic/theme each time allows learners to learn at a deeper level and explore higher complexity (Ornstein and Hunkins, 2011; Harden, 1999).
3. Prior knowledge: student prior knowledge should be used when a topic/theme is returned to so that educators can build on it. Then, rather than stating a new topic without reflection of previous knowledge, the learner has a reference point (Killen, 2015; Carl, 2012; Harden, 1999; Ornstein and Hunkins, 2011).

The origin of this teaching method/model originated based on Jerome Bruner's teaching of the strategy of cognitive theory (Woolfolk, 2009). This is the reflection of the fact that many teachers implicitly use this teaching model (Irland and Mouthaan,2020). In 1960 Bruner documented this teaching approach and its greatness as a curriculum model for curriculum designers and planners to challenge students to deepen their understanding in each topic/theme learned in each lesson (Irland and Mouthaan, 2020; Harden, 1999). This teaching approach resulted in the concept of the spiral curriculum development model that is based on Bruner's observation, in his words (Harden, 1999).

Here is Bruner's observation in his words:

> "I was struck by the fact that successful effort to teach highly structured bodies of knowledge like mathematics, physical science and even field of history often took the form of a metamorphic spiral in which at some simple level a set of ideas or operators were introduced in a rather intuitive way and, once mastered in that spiral were then re-visited and reconstructed in a more formal or operational way, then being connected with other knowledge, the mastery at this stage then being carried on step higher to a new level of formal or operational vigour and to a broader level of abstraction and comprehensiveness.

The end state of this process was eventually mastery of the complexity and structure of large body of knowledge" (Harden, 1999:141).

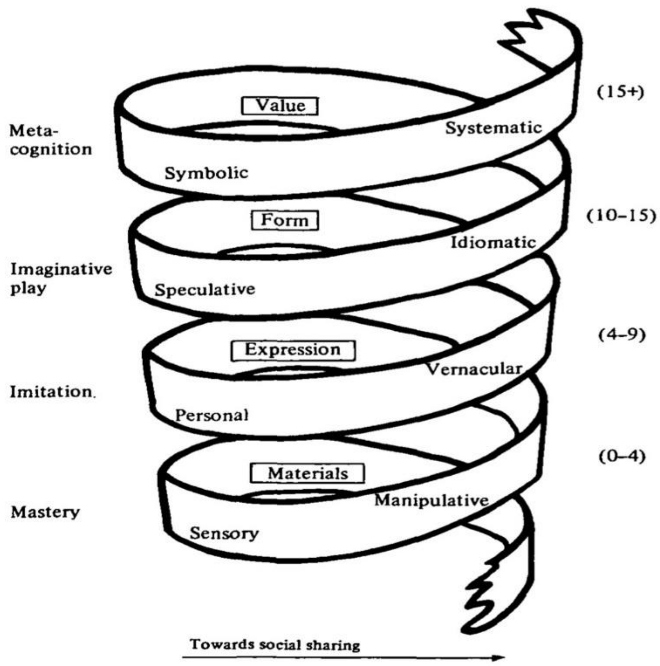

Figure 6: Bruner's curriculum model (Irland and Mouthaan, 2020).

2.8. Comparison of Tyler, Taba and Wheeler's curriculum model

Taba and wheeler's curriculum models both are extension ideas of Tyler's four principle of the curriculum rationale model. Taba edited Tyler's model by putting emphasis on the role of teachers taking part in the process of curriculum development as the important agents of curriculum dissemination, while Wheeler stated that all elements of curriculum development are interdependent (Palupi, 2018; Lunneburg, 2018; Bhullah *et al.*, 2019). Tyler's model is based on the administrator developing and planning a curriculum and teachers implementing the curriculum through the process of teaching and learning. For Taba, the emphasis is on teachers' involvement as being the most crucial step in the process of curriculum planning and development (Bhullaah *et* *al.*, 2019). Wheeler's, on the other end, promotes the continuity of the improvement after evaluation has been undertaken through the feedback that incorporates new subject knowledge. Taba's model is the best model to use in high school curriculum development in the sense that this model considers the need of students prior to the formulation of the purpose and objectives (Palupi, 2018; Lunneburg, 2018; Bhullah *et al.*, 2019). In support of this statement, secondary school curricula focus on what learners need to learner and how assessments are considered to assess what they have learned.

2.9. Teachers' Views and Perceptions on Life Sciences Knowledge Integration

Secondary school teachers are faced with challenges when there is a change in curriculum and the requirements of knowledge integration are to be met, since they are specialised in teaching one or two subjects but yet they are expected to teach and create integrated learning opportunities for learners (Tirri, 2017). Integrated learning requires a connection of a number of subjects into one lesson to help learners to understand lessons more easily. According to Tirri (2017), the discussion of Shulman's theory on the knowledge of teachers plays a huge role to discover and find out what teachers may face when teaching and implementing knowledge integration. Tirri (2017) points out that the success of knowledge and curriculum integration implementation requires special knowledge and skills from Life Sciences teachers and depend on teachers' broader knowledge in different disciplines and previous studies have pinpointed challenges faced by teachers in the teaching learning of Life Sciences as an integrated science subject (Booi and Kuzwayo, 2019). The workload of teachers, adequate disciplinary curriculum knowledge, and resources for planning a lesson play an important role in ensuring the successful implementation of knowledge integration with the secondary school curriculum (Tirri, 2017). The gap in curriculum knowledge in the teaching of life sciences is based on the fact that life sciences is composed of different subject learning areas in one integrated discipline: chemistry, physics, botany, zoology, geography, geology, biotechnology, etc.

2.10 Teachers' Professional Development and Empowerment in the Teaching of Life Sciences

Teachers as curriculum implementing agents need to be empowered through teacher education and professional development to close the gap in the lack of discipline specific knowledge that needs to be taught to learners by teachers (Booi, 2017; Jansen, 2002). Each teacher must be systematically empowered in the knowledge and how the curriculum has been developed to optimise teaching and learning events in their classroom (Carl, 2012; Niemela and Tirri, 2018). According to Niemela & Tirri (2018), Shulman's theory describes the development of a teacher as a process in which subject matter or content knowledge becomes a vehicle for acquiring pedagogical content knowledge – an aspect which has been acknowledged widely. However, not enough attention has been given to the pedagogical skills necessary for teaching certain science subject content, such as the content in Life Sciences (Niemela and Tirri, 2018).

The teaching of all subjects requires both content knowledge and pedagogical content knowledge. It is pedagogical knowledge though that provides teachers with the necessary competence to teach specific content in different ways and different contexts using appropriate pedagogical skills or approaches. These approaches must be adaptable and flexible in order to make meaning of the specific content knowledge that is to be imparted to learners (Niemela and Tirri, 2018). Teachers' views of empowerment and on how the curriculum has been developed is very important in a way that a teacher will not just regard the syllabus as a recipe for teaching Life Sciences, but as an opportunity to experiment and make it meaningful (Carl, 2012; Booi and Kuzwayo, 2019).

Teacher development requires specific knowledge, skills, and proficiencies. The recent discussion on the professional content and pedagogical development for teacher competence needed to teach science subjects, such as life sciences, has not been taken into consideration, instead the focus is on life sciences as single subject discipline. This is what Shulman calls the paradigm of today (Niemela and Tirri, 2018). Although there is so much literature of knowledge integration in the curriculum, the question is what kind of pedagogical knowledge is best useful for imparting content through the principle of knowledge integration? To teachers, this question remains unanswered (Carl, 2012; Niemela and Tirri, 2018). It is, therefore, critical for teachers to be empowered on strategies they may use to teach subject disciplines that integrate knowledge from various disciplines as well as a deliberate exposure and involvement of teachers when a curriculum is developed to ensure that they are effective curriculum implementation agents. However, teachers cannot be expected to master all subject learning areas. According to Niemela and Tirri (2018), one approach is to design instrumental material and conduct training sessions to assist in building the conceptual bridge between science subjects to build better content knowledge based on the curriculum, knowledge integration is one of the key areas for teacher development.

2.11 Theoretical Framework

This study is underpinned by Maton's Legitimation Code Theory which is an extension of Basil Bernstein's concepts of discourse and knowledge structures which explores the potential of educational knowledge structures to enhance cumulative learning where knowledge is transferred and shared across the context of different learning areas of a school curriculum and built over time to promote lifelong learning in learners (Maton, 2017). This theory helps one to a better understanding of how knowledge is shared to students using curriculum models that embrace knowledge integration in the field of Life Sciences in a secondary education.

2.11.1 Legitimation Code Theory

Maton (2017) explains that this theory, known as legitimation Code Theory (LCT), is a model to overcome dichotomies by conceptualising knowledge in terms of a legitimation code and semantic gravity. This developed theoretical framework is used to analyse two contrasting examples of curricula in universities and secondary schools (Maton *et al.*, 2016) regarding cumulative learning. Dichotomous thinking is deeply debilitating to knowledge-building in the contexts of education and society. Maton, *et al. (ibid.*) argue that Legitimation Code Theory (LCT) enables both the explanation of knowledge-building and the cumulative building of knowledge. Legitimation Code Theory explains how the knowledge descend scientific language to everyday language using semantic gravity and density to unpack science terms for science students. The emergence of LCT at the turn of the twenty-first century has evolved into a multidimensional concept (Maton *et al.*, 2016). LCT is being used to interpret education around the world in different ways but it changes the approach in the field of education (Maton, 2017). Bourdieu, in his writing, has called this theory the ‘rules of the game’ (Maton *et al.*, 2016) because concepts from this framework reveal different dimensions.

One of the dimensions of the Legitimation Code Theory is that of Semantics which is rooted explicitly in the work of Bernstein, who claimed that knowledge structure can be horizontal and hierarchical (Blackie, 2014; Maton, 2009). A horizontal knowledge structure is regarded as general knowledge that humans possess and hierarchical knowledge refers to the natural science knowledge structures (Blackie, 2014; Maton and Doran, 2017; Maton, 2009; 2014) which can be acquired. Semantics employs several codes such as Semantic Gravity, Semantic Density, and Semantic Waves (Maton, 2014, Blackie, 2014). For the purpose of this study these codes are used to explain the building of knowledge structures as a prerequisite for knowledge integration (Hipkiss and Vargas, 2018; Maton, 2009).

2.11.1.1 Semantic Gravity

Semantic Gravity is one of the dimensions found within this framework and it is defined as the degree to which meaning depends on its context and it may be strong or weak (Maton, 2014; Maton and Doran, 2017). Maton (2017) discovered that Bernstein has distinguished two types of knowledge discourses, horizontal discourse and vertical discourse. Horizontal discourse refers to everyday knowledge and vertical discourse refers to a specialised structure of explicit knowledge. In strong semantic gravity (SG+) meaning of knowledge is more dependent on its context and in weak semantic gravity (SG-) meaning is less dependent on its context (Maton, 2009; 2014; Maton and Doran, 2017; Hipkiss and Varga, 2018). Hipkiss and Varga (2018) describe SG+ examples, such as lab-work in a classroom where learners only need to use demonstrative pronouns to communicate which sample to use. An example of SG- is the use of textbooks that describe a general protocol for lab-work.

2.11.1.2 Semantic Density

Semantic Density (SD) is defined as the degree of knowledge condensation of meaning within practise and it can be strong or weak (Maton, 2014). Strong Semantic Density (SD+) meaning is more condensed within practice and in weak semantic density (SD-) meaning is less condensed (Maton, 2014; Maton and Doran, 2017; Hipkiss and Varga, 2018). SD relates to the degree of complexity of the knowledge where the amount of meaning can be condensed within symbols, text, and concepts (Blackie, 2014; Hipkiss and Varga, 2018).

2.11.1.3 Semantic Waves

In the Semantic Waves, a teacher moves from abstract and complex meanings down to more grounded and simpler meanings to help learners to understand easier and then back to abstract meanings again (Waite *et al., 2019*). A good teaching and learning experience consists of a lesson plan that uses a movement of semantic waves to unpack abstract and complex concepts into a simple form of knowledge that can be easily understood by learners. Waite *et al*. (2019) assert that rather than assuming that once a technical and abstract concept has been explained it can be used again without involving a continuing semantic wave is a risk to learners.

2.12 Summary

This review of relevant literature highlighted the importance of teaching life sciences as an integrated subject and learning area in all grades so as to accommodate knowledge integration. This literature has provided an overview of how knowledge integration can be taught in secondary school life sciences using images and models of curriculum. In this chapter, the key concepts on knowledge integration have been explained and expanded on in order to form the basis for the supporting data collected through interviews and classroom observations of life sciences teachers.

The use of images and models in the teaching and learning of life sciences has been explained in this chapter in order to investigate how life science teachers can be trained to teach the principles of knowledge integration within the discipline and also to find out their views and perceptions on knowledge integration within life sciences. The choice of the Legitimacy Code Theory used in the study was based on how teachers should carry their curriculum and knowledge across different domains and reach out to every student by simplifying content knowledge in every lesson presentation. This theory has been explained and unpacked to allow the researcher to investigate how life sciences teachers plan and present their lesson presentations following Tyler's, Taba's, Wheeler's, and Brunner's spiral curriculum development models.

LCT explain how teachers can promote cumulative learning through knowledge building using semantic gravity, semantic density, and codes to simplify content knowledge during lesson presentations. The images and models in the teaching and learning explained in this chapter serve as basis for an argument to support the view that can be used by teachers to promote knowledge integration and cumulative learning in life sciences to encourage students to be lifelong learners. Taba and Tyler's curriculum development models illustrate how and what needs to be considered during high school curriculum development and explains how the curriculum should be structured and taught to promote knowledge integration in science education. Taba's model also suggests that teachers, as agent of curriculum implementation, should be empowered with skills and content knowledge in order to implement the curriculum successfully throughout the learning experience in life sciences through the principle of knowledge integration. Hence, teacher development and empowerment were discussed in the chapter.

CHAPTER 3: RESEARCH PARADIGM AND METHODOLOGY

3.1 Introduction

Research adds to the existing body of knowledge by using gathered information to amongst others answer research questions, accept or reject hypotheses, make discoveries and create new knowledge. In order for this kind of knowledge to be recognised or taken into consideration, the writer needs to prove that it is valid (Bouchrika, 2020). To determine the validity of the study, depends on the research methodology employed by the researcher. According to Bouchrika (2020), research methodology includes the data collection methods as well as the principles, theories, and values that support the research approach. Research methodology elucidates and clarifies aspects of the data collection process and demonstrates how data analysis was performed. Methodology does not necessarily provide a solution; therefore, it is not the same thing as a method. It offers a theoretical underpinning for understanding which method is the best to employ in a particular case study research.

3.2 Research Design

This research study employs a qualitative case study research approach because it provides the researcher with the means to unravel and understand intricate social phenomena (Baxter and Jack, 2008). According to Igwenagu (2016), the qualitative research method is based on the beliefs, views and perceptions that humankind possess as well as experiences which provide the most meaningful data from participants. Another advantage of the qualitative method is that a huge amount of data is harvested from a limited number of participants (Igwenagu, 2016).

The purpose of this case study research was to investigate teachers' perceptions and views and explore strategies of knowledge integration within the field of Life Sciences (Snyder, 2012) and to understand the world view of participants through the lens of their experiences (Igwenagu, 2016). To this end a qualitative case study endeavours to answer the research question using not only one lens but several lenses which allows for multiple phenomena to be uncovered and explained (Baxter and Jack, 2008). Furthermore, this research study is embedded in the constructivist paradigm as proposed by Baxter and Jack (2008) that views reality as being constructed by individual teachers interacting with their social world (Snyder, 2012). According to Baxter and Jack (2008) and Snyder (2012), a qualitative case study is suitable for exploring the meaning teachers have constructed based on their experiences.

3.2.1 Research Site

The sites of this research study were three secondary school situated in the Metro South District of in the city of Cape Town. These schools each has a capacity of more than one thousand learners and more than forty staff members with two deputy principals. They offer schooling only from grade ten to grade twelve.

Most of the South African schools are arranged in terms of quintiles from one to five, as determined by the location of the school and the wealth of the community (Blease and Condy, 2014). Schools categorised as quantile four to five are regarded as well-resourced and well performing schools while quintile one to three schools are regarded as under resourced schools that perform at an average of 40 per cent to 75 per cent. All the schools that formed part of this research are categorised from quintile one (no fee school) to quintile three and learners are provided with two meals, one in the morning and one at noon. The choice of these sites was also based on their performance in the Life Sciences learning area. Two of the three schools have demonstrated poor performance in Life Sciences over the past three years.

3.2.2 Sampling and Population

Convenience and purposive sampling were chosen for this study. Convenience sampling is a rigorous sampling strategy that is based on the availability and accessibility of the participants (Kielmann *et al.*, 2012). Purposive sampling allows the researcher to target the best candidates for data collection and which best suits the nature of the study (Kielmann *et al.*, 2012). The total of seven Life Sciences educators from three different schools was based on ease of access and the proximity of the schools they teach at and where the researcher could easily travel to at any given time. These Life Sciences teachers are qualified to teach Grade 8 and 9 Natural Sciences and Grade 10 to 12 Life Sciences and all of them are currently teaching Life Sciences in the Further Education and Training phase (from Grade 10 to Grade 12). For data collection purposes these Life Sciences teachers were interviewed and observed in order to obtain information about how they teach Life Sciences in the FET phase using knowledge integration.

Participant 1 from school A has a bachelor's degree in education and majored in life sciences, physics and mathematics. She has been teaching grade 8 to 12 natural and life sciences at this school from 2013 till today and she has more than nine years of teaching experience in life sciences. Although she is qualified to teach physical sciences and mathematics, she never got an opportunity to teach the two subjects. She is an experienced NSC marker for paper one and she is a post-level one educator.

Participant 2 has obtained a bachelor's degree in education and majored in Life Sciences and IsiXhosa. She has been teaching life sciences and natural science in her current school. At the time of this research participant 2 was teaching grade 11 and 12 life sciences and she has four years of experience in the field of education and in teaching and learning life sciences. She also has a background knowledge of geography and physical sciences at a middle-school level.

Participant 3 has 3 years of experience in the teaching of life sciences, and he is currently teaching only grade 10 life sciences. He graduated with a Bachelor of Education and majored in life sciences and IsiXhosa. He has no experience of teaching grade 11 to 12 life sciences. He has taught grade 8 and 9 natural sciences.

Participant 4 is a novice life sciences teacher with eight months teaching experience, straight from the college of education. He has obtained a Bachelor of Education and majored in life sciences and language. He is teaching only grade 10 life sciences and natural sciences in grade 8 and 9.

Participant 5 is the headmaster of a school with 15 years of experience in the teaching and learning of life sciences in this school. He is only teaching two classes, both grade 12s, and he studied genetics and majored in (biology) life sciences and agriculture. He has an NSC marking experience in life sciences.

Participant 6 obtained a senior diploma and advance diploma in natural sciences and (Biology) life sciences. She has four years of teaching experience at this school in grade 12 life sciences and GET natural sciences, but she started teaching in 1992. She also has an NSC marking experience. Through her professional development she obtained an advanced development certificate in natural sciences at the University of Stellenbosch.

Participant 7 has five years of teaching experience in teaching 10 and 11 life sciences and grade 8 and 9 natural sciences. He never taught grade 12 Life sciences. He graduated with a Bachelor of Education, majoring in life sciences and mathematical literacy.

Table 1: participants' credentials

No	Participants	Gender	Years of experience In L. S	Grades	School
1	Teachers 1	F	9	12	School A
2	Teacher 2	F	4	11-12	School A
3	Teacher 3	M	3	10	School A
4	Teacher 4	M	8 months	10	School B
5	Teacher 5	M	15	12	School B
6	Teacher 6	F	4	11 & 12	School B
7	Teacher 7	M	4	11	School C

3.3 Data Collection and Research Instruments

This research study has selected two methods of data collection namely, semi-structured interviews and classroom observation. The main purpose for these two methods was to investigate the perceptions and views of Life Sciences educators about teaching Life Sciences as an integrated learning subject using the principles of knowledge integration through face-to-face interviews.

The use of interviews and observation as preferred methods was driven by the fact that the nature of this research problem was to understand social science phenomena in teaching integrated Life Sciences in the FET phase (Noor, 2008). Social science phenomena in the context of this study is the social reality constructed by Life Sciences teachers about knowledge integration in the teaching and learning of Life Sciences (Booi, 2018). Studying social science phenomena is not about seeking and gathering the facts but measuring how often certain patterns occur (Noor, 2008). According to Noor (2008), when studying social science phenomena one seeks to understand the reality and views/perceptions of teachers and this method is called post-positivism.

In order to understand the teachers' perceptions about knowledge integration in the teaching and learning of Life Sciences in the FET phase the choice of semi-structured interviews and observation were employed to investigate and answer the research question: How can the principle of knowledge integration be taught in Life Sciences in the Further Education and Training phase? Semi-structured interviews were selected because they provide the researcher with the fluidity and open-endedness in approaching different respondents in different ways while using the same set of questions (Noor, 2008).

3.3.1 Interviews

The interviews were audio recorded to secure an accurate account of the conversations and to avoid losing data since not all information can be written down. The participants were asked 12 questions, of which three of the questions were about teacher information and nine questions were about knowledge integration. Interviews were chosen because they saved time and could be completed within 20 to 30 minutes. Semi-structured interviews are personalised, it permits the in-depth information gathering, free response and flexibility that cannot be obtained by other procedures, hence the choice of semi-structured interview was opted (Gadula 2017).

3.3.2 Observation

The second method selected was observation. Observation was one of the primary data collection methods that was chosen by the researcher to allowed the investigator to be involved in the process of discovering the human behaviour of the teachers during the process of teaching and learning.

During the data observation process the researcher was able to observe how teachers teach life sciences as an integrated subject learning area and through the process observation the researcher was able to get the data that was not covered during the interview method. In the process observing the life sciences teachers teaching integrated life sciences, the research was able to understand the teaching approaches and models and images used in the planning and presentation of life sciences. The use of LCT and semantic gravity and density to simplify knowledge transferred to learners during the course of teaching and learning was assessed (Noor, 2008). Observation was chosen to get a direct access to research phenomena because the researcher immerse himself in the setting where the participants presenting their lesson.

3.3.3 Data analysis

An inductive approach was employed to analysing research data in order to answer the research questions, aims, and objectives during the research process. Coding and themes were used to extract the key concepts that emerged from the interviews and the observation. The aim and purpose of coding and themes was to make it easy to find the common aspect and concepts from respondents and to enable the researcher to effectively analyse the findings. During the data analysis personal identification was not used, instead participants are given pseudonyms to protect their identity (Douglas *et al.*, 2009).

This study has employed an inductive approach to analysing the collected data in order to answer the following research question: how can the principal of knowledge integration in life sciences be taught in the further education and training phase? This study is grounded in Beinstein's Theory of discourse and structured knowledge that is explained as Legitimacy Code Theory. Inductive analytic methods entail the continuous comparison of data collected through interviews and observation throughout the research process. An analytical inductive method is closely related and associated with studies that seek to solve social science problems. After interviews were done, the researcher transcribed data in order to extract codes and themes using an inductive analytic approach.

Coding and themes were extracted and transcribed as notes to represent the key steps in the process of handling and summarising data. According to MacQueen and Namey (2019) coding and theming have been described simply as the process of categorising and sorting out data and codes which serve as a drive to summarise, synthesise, and sort data collected through classroom observation. Coding provides a link between data and conceptualisation and breaks down, examines, and compares data. All the themes and codes generated from transcribed interviews and classroom observations are discussed in chapter 4 when results and findings are discussed in detail.

3.3.4 Trustworthiness

Reliability and validation are a point of discussion and debate, but qualitative research can be trusted based on how it is conducted and analysed (Blease and Condy, 2014). Reliability is generally understood to concern the validity and credibility of the research study and its ability to obtain similar findings if another study is undertaken using the same research method approach (Kielmann *et al.,* 2012). Triangulating research ensures the credibility and the validity of the data obtained during data collection (Kielmann *et al.,* 2012). In this study, methodological triangulation was ensured by using more than one data source (interviews and observations) to increase confidence in the results (Bowen, 2009; Kielmann *et al.,* 2012). According to Bowen (2009), by triangulating data, the researcher provides evidence that breeds the credibility of the study and helps the researcher to guard against the accusation that the findings are simply an artefact of a single method and bias. The results from the interviews and observations provided the necessary triangulation for this study (Bowen, 2009). Triangulation is the evident that two or more data collection tool were used to support each other and to ensure that if another similar study conducted same results will merge.

The participating teachers will receive a copy of the transcribed data to allow them to check if the information gathered from them is accurately and truthfully described (Blease and Condy, 2014). The names of teachers that participated in this research were not mentioned throughout the research, teachers were given fake names to protect their identity and their confidentiality was prioritised. Teachers were named given numbers from one to seven to identify them.

3.3.5 Ethical Issues

The researcher ensured that the rights and safety of the participants of this research study were protected. Clearance was being obtained from the Cape Peninsula University of Technology ethics committee and a letter of permission was requested and granted by the Western Cape Department of Education. Informed consent from the participants was also obtained from the school principal and the participating teachers. The confidentiality and anonymity of the participants were respected, and participants were made aware that they could withdraw or refrain from participating if they did not feel comfortable. As indicated, the data transcripts will be made available to the participants for the reason of transparency. Data collection was conducted in an environment where the participants felt comfortable. The information will remain confidential and will be used for the research purposes only (Blease and Condy, 2014).

CHAPTER 4: PRESENTATION OF THE FINDINGS, DISCUSSION, AND CONCLUSIONS

4.1 Introduction

This research aimed to establish how the principle of knowledge integration in the life sciences curriculum could be taught in the further education and training phase to enhance the teaching and learning of life sciences. In this chapter the researcher presents the findings from the semi-structured interviews. The data collected from interviews were recorded and transcribed to extract themes and codes to answer the research question and sub-questions of this research study. The data were collected from three secondary schools and all participants were life sciences teachers teaching life sciences during the study period. In the final discussion of this section the researcher summarises findings to substantiate the points made during the presentation. The data presented in this chapter addresses and answers the main research question of this study: How can the principles of knowledge integration in life sciences be taught in the further education and training phase?

The purpose of this study was to understand scientific phenomena and how life sciences teachers perceive and understand the concept of knowledge integration in the teaching of life sciences as an integrated subject discipline.

The following sub-questions were addressed to answer the main research question of this study:

- #SQ 1: What are teachers' perceptions regarding teaching knowledge integration in life sciences?
- #SQ 2: How can teachers be trained to teach knowledge integration in the life sciences curriculum?

Themes emerged from the observation and interview data are as follows:

1. The use of curriculum models to bridge the content and knowledge integration in life sciences teachers.
2. Teaching approach and material used in teaching and learning of life sciences.
3. Professional development for teachers of life sciences teaching FET phase content.

4.2. Presentation of Data from both Interviews and Observations

4.2.1. SQ1: What Are Teachers' Perceptions Regarding Teaching Knowledge Integration in Life Sciences?

This sub-question examines the perception of life sciences teachers on teaching life sciences as an integrated science subject discipline. To teach knowledge integration in life sciences and other science disciplines requires a better understanding of what is meant by knowledge integration and knowledge integration by life sciences educators so as to increase the chances of teaching life sciences as an integrated learning area that is composed of different subject disciplines.

4.2.1.1 Theme #1: Use of Curriculum Models to Bridge the Content Knowledge and Knowledge Integration in Life Science.

Curriculum images and models are the driving forces of knowledge integration in the teaching and learning of science. The understanding of teaching models guides teacher educators to consider knowledge integration in teaching life sciences as an integrated science subject discipline. Models serve as a bridge between the theory taught in the classroom and the world of experience in science education (Girlbert, 2004).

To address the above research question #SQ1 interviews and observations from three different schools will be presented.

a) **Interviews:** seven participants took part in responding to interviews question, few of them have shown an acceptable understanding of what is meant by the term knowledge integration. The analysis of the data collected through interviews has shown that out of seven teachers interviewed only two experienced teachers had a decent understanding that life sciences is an integrated subject learning area that requires those who teach it to consider knowledge integration when they are teaching life sciences. Is was not only novice life sciences teachers who did not understand what knowledge integration was and how life sciences can be taught as an integrated subject discipline. Although Life Sciences contains sub-topics from other subjects' learning areas, such as geography, history, agriculture, etc., other teachers have content knowledge gaps and they have no intention to go the extra mile to learn more about other disciplines that are within life sciences. Teaching images/models play a key role in the planning and presentation of lesson plans only when a teacher holds a good understanding of how curriculum images and models work. A lack of understanding when it comes to the principles of knowledge integration in life sciences teachers has resulted in teaching life sciences as a single isolated subject area which makes learning difficult and puts learners at a disadvantage.

Here is what the teachers had to say during the interviews:

Participant 4 from school B stated: *"When I am planning my lesson, I do not take into consideration the integration aspects of Life Sciences. I look at the textbook and I try as much as possible to simplify the content that is provided in the textbook and deliver it to the learners in the simplest way I can, I never really take into consideration that the subject I am teaching is an integrated subject that consists of other subjects."*

Participant 1 from school A stated that: " *For teachers to successfully teach Life Sciences using the principle of knowledge integration each learner has to have a textbook because it happens that the teachers have a gap and do not master certain topic. Teachers are not honest and should ask others who understand and master certain topics to deliver or teach it on their behalf."*

Yet participant 7 said, "*For instance in this question paper (referring to test) there was a question where learners have to calculate a percentage, now we do not teach maths in Life Sciences, they must get those skills from Maths. For example, graphs, we do not teach graphs but in Maths they are doing graphs from grade 8. We do not have time to teach them this pie chart, line graphs."*

Participant 6 reported that: "*It is not difficult because we got Annual Teaching Plan (ATP), first we must consult ATP then from there you do your lesson plan according to your learners. You know the level of your learners; you know how they respond."*

b) **Observations:** data collected through observations allowed the researcher to verify what teachers said during the interviews (Noor, 2008). All the participants were aware of the presence of the researcher in their classroom. The field notes gathered throughout the class observations have shown that some teachers do not consider knowledge integration when they are planning their lessons, or they do not even plan their lessons. The use of textbooks as the only source of information was used more often in different classes by different teachers. The textbook is designed to assist learners with extra notes, not to be used as the sole tool to teach learners with.

Four out of seven participants (P2, P3, P1, and P7) were observed to be reliant on textbooks in their form of teaching and in presenting their lesson to learners. The textbooks were used as the only source of information and there was no additional information other than the textbook. The use of textbooks as the only source of information for teaching and learning is a sign of a content knowledge gap in a teacher or a sign of unpreparedness. This means that some teachers cannot teach without textbooks as a source of information, and they do not go the extra mile to enhance their lessons by adding and infusing other knowledge from different subject disciplines to fulfil learners' needs.

c) **Findings:** theme 1 was aligned to answer research sub-question 1 (SQ1). Based on the information collected during interviews and observations, the presentation of data shows that some life sciences teachers have gaps in subject content knowledge that hinder them in teaching life sciences as an integrated subject. Curriculum knowledge and knowledge integration requires and demands teachers to teach different subjects within life sciences to create integrated learning opportunities for learners. Most teachers are unwilling to tap into other subjects disciplines due to their areas of speciality. Although teachers claim that their workload is too much, teachers are not aware and do not consider knowledge integration in life sciences.

4.2.1.2. Theme #2: Teaching Approach and Material Used in the Teaching and Learning of Life Sciences

Teaching methods and approach are key components of the teaching and lesson presentation. Teachers are the curriculum drivers which determine the success of the implementation of knowledge integration in life sciences and science education to enhance and stimulate learners' interests and academic performance in life sciences as a learning area. According to Jansen and Christie (1999) a teacher is a key resource amongst the available teaching and learning resources for learners as they hold skills that make it easy to transfer the knowledge to learners by involving them throughout the teaching and learning process. The use of technology in the teaching and learning of life sciences does not necessarily qualify knowledge integration, but rather the integration of technology in the teaching and learning of the subject (Jansen and Christie, 1999).

a) **Interviews:** data collected through interviews stressed that teachers think that using any form of technology during the lesson presentation addresses the issue of knowledge integration.

   Participants 2 argued that "*Since my learners do not have a background of other science subjects, I design PowerPoint slides so that I can attract their attention into my lesson. Most of the time I use a laptop to prepare my slides."*

   Participant 3 said: "*There are two apps on the mobile so there were two apps that I like the most. The one we use from Vodacom is a free app then you can get in there download videos free."*

   Teachers rely on the use of technology as a tool of teaching and learning to enhance the teaching of life sciences but forget to present integrated knowledge to learners to prepare them for the real world.

b) **Observation**: During the observation, only two out of seven teachers used integration of technology in their lesson presentation, although six teachers attested that they were using technology during the interviews. During observation, five out of seven teachers did not use any form of technology in their lesson or simply did not state so during the interviews. Most teachers were standing in front of the class reading and explaining what is in the textbook. Then learners must take keynotes and look at their textbook as well. This form of teaching method is a very old teaching approach that was used during the olden days of teaching biology as a single subject. The biology teaching approach had to only focus on what the textbook had to say and only the content of the syllabus was more important than any other aspect of the lesson (Jansen and Christie, 1999). According to Jansen and Christie (1999), rote learning, which is more of a teacher-centred approach, focuses on the memorising and regurgitation of facts that were taught by the teacher instead of applying an understanding of knowledge learned through the teaching and learning process.

c) **Findings:** theme 2 was also aligned to answer sub-research question 2 (SQ#1).

Teaching methods and strategies and resources used by teachers during lesson presentations showed that most of the teachers are not honest and do not understand the impact of their teaching methods and the resources they used in assessing learner performance. Most teachers are still comfortable in using the old teacher-centred approach, although, it seems to not work for science subjects such as life sciences. Most teachers do not distinguish between knowledge integration and the integration of technology in the teaching and learning of life sciences. This notion reveals confusion in teachers when they use technology to enhance their lesson presentation, they believe that automatically qualifies as knowledge integration.

4.2.2. SQ 2: How Can Teachers be Trained to Teach Knowledge Integration in the Life Sciences Curriculum?

4.2.2.1 Theme 3: Teacher Professional Development in Life Sciences FET Phase Content

Professional development for teachers is one of the driving forces to delivering curriculum content to the learners in every aspect of education (Lizer, 2013). Teachers are the key resource to convey information to a learner. The change in the science education curriculum was more in its educational infrastructure and it forgot about developing teachers over time. Science is not a static subject, it keeps changing with time and as a result teachers need to be equipped with the necessary skills to address the current generation's needs (Lizer, 2013).

a) **Interviews:** data collected through interviews have shown that the lack of professional development for teachers in life sciences has opened a gap in content knowledge required from teachers. Teachers who lack subject content knowledge tend to teach topics they are comfortable with and skip/brush off certain topics. This issue leads to a lack of content knowledge transfer to learners which limits the learners' abilities to learn on their own. The lack of mentorship and planning amongst teachers was pointed out to attest that most life sciences teachers are not well developed or trained to teach life sciences as an integrated subject discipline due to a lack of understanding of content and knowledge integration. One of the participants *(P6)* has highlighted that:

"*The issue of mentoring has gone out of the window and people, when they are mentored, they are seeing it as a sign of weakness and mentoring it is not for novice teachers could be for me as an adult teacher as well we are in a space where we need to integrated technology into teaching and learning and many of the experienced teachers' technology is no go area but the young teachers might not have the content experience but they have* *got the technology, I have got the knowledge experience then how do we begin to integrate the two, I will give the content experience I have but use your technology to put it in a way that learners can better receive it."*

Participant 6 added that: *"As a staff member I got a duty to engage my other colleagues in other departments and say I am teaching this topic how is it related to own topics? And to me, that is what team-teaching means. I am not forced to go and teach that topic myself if I am not comfortable with the knowledge, I have on it but that is when somebody else can do it.''*

Yet participant one stated that: *"Teachers do not seek help and assistance and they* are not *honest."*

b) **Observation:** During the observation, the researcher pointed out the lack of skills in life sciences teachers to transfer content knowledge to learners in a simplified manner to make it easy for learners. Most life sciences teachers teach life sciences content without using the relevant context through which learners will be able to link the content to the relevant context of real-world experience. Life sciences is a subject of terminologies that helps a learner to understand the meaning of each terminology they come across during the lesson. In school B the researcher observed participant two who was teaching/introducing human reproduction. During the lesson presentation, the teacher was using Xhosa terms and concepts to name and explain the content, which led to different meanings constructed by learners based on their previous knowledge and understanding. The link between high Semantic Gravity (SG+) and low Semantic Density (SD-) is seen to be a big challenge faced by life sciences teachers when teaching life sciences.

Failing to teach terms and concepts in any lesson presentation deprives learners of understanding the content within the context where the content is applicable.

Although teachers are taught pedagogical knowledge and skills in teacher training institutions, it seems it is not sufficient because they struggle to teach life sciences as an integrated subject discipline. According to Niemela and Tirri (2018), Shulman's theory emphasises the importance of pedagogical content, i.e. the teaching of the subject content as crucial in teacher development and empowerment. Niemela and Tirri (*ibid*) also pointed out that although pedagogical knowledge is an area of concern, pedagogical skills are necessary for teaching science subject content.

c) **Findings:** theme 3 was aligned to address the sub-research question (SQ#2).

The researcher detected that the lack of teacher centred professional development in life sciences is a factor that affects the way teachers plan and teach life sciences. Limited workshops provided attended by life sciences teachers show that the gaps in curriculum content knowledge and teaching approaches and methods applied during lesson presentations are the result of a lack of support provided to teachers.

4.3 Discussion of Findings

The findings of the study were reported for three different schools and seven participants according to each research sub-question. The findings were presented based on the themes emanated from data collected from both interviews and observation. The researcher interviewed and observed three teachers in school A, three teachers in school B, and one teacher in school C Teachers' perceptions and views were observed and obtained in terms of their understanding and interpretation of teaching FET life sciences as an integrated subject learning area. Each theme had to focus on a different aspect to answer the following research sub-questions:

1) What are teachers' perceptions regarding teaching knowledge integration in life sciences?
2) How can teachers be trained to teach knowledge integration in the life sciences curriculum?

The first and second theme looked at the perceptions and understanding teachers had on knowledge integration to bridge the gap in teacher content knowledge. The first theme was more on understanding how teachers perceive knowledge integration in life sciences and the lack of curriculum content knowledge in other life science teachers. The second theme was more on the teaching approaches/models and teaching material used by teachers to accommodate knowledge integration in FET life sciences. The third theme looked at teacher-centred professional development to detect the impact it has in the teaching and learning of Life Sciences in the FET phase.

4.3.1 Major Findings of the Study

When teachers get into classes their purpose is to teach and transfer the subject content knowledge to learners and learners should learn what is provided/taught to them. Teachers must promote the teaching and learning of life sciences as an integrated subject to help the learner to understand the subject content. Learners are the product of what teachers produce during teaching and learning in secondary education (Baska and Brown, 2007).

The study found that:

1. Most Life Sciences teachers lack and or hold a poor understanding of what knowledge

integration is. According to Booi (2018), the lack of understanding of knowledge integration from teachers proved to be a barrier to Life Sciences teachers teaching the principles of knowledge integration. The principles of knowledge integration have been a strong focus in the education curriculum reform (Booi, 2007), moving from Outcome Based Education, which was a subject based discipline, to a multi-disciplinary knowledge design that was meant to challenge teachers who taught Biology. Teachers were encouraged to adopt an interdisciplinary approach when designing their teaching and learning programmes. Education that involves an interdisciplinary, a multi-disciplinary, an integration, or an active learning approach have been suggested to be vital to all educational levels when life sciences disciplines are taught (Nsubuga, 2008).

2. A lack of subject content knowledge from some of the teachers was outlined during classroom observations and that creates content knowledge gaps in knowledge transferred to learners. The limited knowledge transferred to learners limits them from becoming lifelong learners and deprives them of studying Life Sciences at a university level. The curriculum reform in South African education has resulted in many problems in the quality of the content knowledge received/transferred from teachers to learners. Jansen (2002) pointed out that during the OBE curriculum teachers were using rote learning and learners had to remember what was being taught by teachers instead of learning on their own. Changing from Biology to Life Sciences, teachers struggled with key philosophical foundations of the curriculum reform and spent most of their teaching time making an attempt to make sense of life sciences and its concepts (Jansen, 2002). Studies show that for science teachers, the teaching and learning of Life Sciences requires a better

understanding of life sciences issues, such as the concepts, terminology, and processes that shape and change the nature of teaching high school science subject disciplines (Baska and Brown, 2007). Baska and Brown (2007) and Drescher (2007), argue that science teachers should be aware of the crucial role that the development of scientific knowledge plays in assisting learners to understand scientific concepts and terminology. Knowledge integration requires teachers who specialised in one or two subjects yet to create integrated learning opportunities for learners (Tirri, 2017). The knowledge transfer received by learners is regarded as horizontal knowledge. Maton (2017) explains how Bernstein regards and distinguishes the kind of knowledge students receive during their teaching and learning. He states that horizontal knowledge refers to everyday knowledge (SG+; SD-) that learners receive when a teacher lacks content knowledge. Vertical/hierarchical knowledge is, therefore, regarded as a no-go area for teachers who lack the specialisation of content knowledge as they struggle to teach integrated life sciences. This knowledge is referred to as science technical language (SG-; SD+) and, hence, in such a situation, the meaning of content is less dependent on its context.

3. Teachers were found struggling to teach Life Sciences concepts and terminology in a way that helped learners to understand the subject content within the context. Understanding concepts and terms are key in teaching any science subject or learning area. When teachers fail to explain life sciences concepts and terms during their lesson presentation it becomes a barrier for learners to learn life sciences with understanding instead of memorising facts and textbook notes. The complexity of the meaning of concepts and terminology in life sciences content can be condensed within symbols and concepts (Maton, 2014; Maton and Doran, 2017). The teaching and learning of life sciences is more dependent on its concepts,

terms, and processes. Teachers are required to teach and explain each term/concept within its context to assist student to learn more easily. Waite *et al.* (2019) argue that teaching and learning should follow a semantic wave where teachers move from abstract and complex knowledge to simpler content knowledge to help learners to understand easier and then go back to abstract meanings again. Good teaching and learning is about unpacking complex science knowledge into smaller pieces for learners.

4. Teachers are not willing to learn other subject learning areas that are related to life sciences to limit the challenge of teaching what is available in the textbook. Unwillingness from teachers affects the ability of learners to integrate life sciences in that it requires teachers to infuse other subjects when they plan and teach the subject. Literature has proven that biology was more focussed on what was in the syllabus and what teachers, or textbook, had to offer as important information for learners. Learners were to get information from the teacher and memorise the facts taught for the preparation of an assessment (Jansen, 2002).
5. The teaching approach and teaching material used by teachers were not supporting the implementation of knowledge integration. During observation, teachers were using a teacher-centred approach that only favoured the comfortability of a teacher in their role to fulfil their teaching needs. Secondly, teachers were reading from the textbook to teach and transfer content knowledge to learners. A teacher-centred approach was found to be an old teaching method that limits learners from exploring different learning styles that promote the culture of learning. The study shows that in this teaching approach the understanding of knowledge is not at "the centre of teaching and learning" and, therefore, it deprives learners of using what they learned in different ways (Jansen and Christie, 1999:21).

6. Teacher-centred professional development was found to be an area of concern where teachers lacked the expertise to teach and understand the role of teaching models and images in teaching life sciences as an integrated subject area. During the changes to the biology/life sciences curriculum, teacher-centred professional development was not enough to assist teachers to teach integrated science. According to Lunenburg (2011), Taba's instructional curriculum model put emphasis on the importance of teacher involvement during the process of curriculum development. Taba iterates that those teachers are at the centre of curriculum development and its implementation. Tirri (2017) argues that the success of knowledge and curriculum integration and its implementation need special knowledge and skills which should be held by science teachers. Teachers are the key players to driving the successful implementation of knowledge and curriculum that embrace knowledge integration in science subject disciplines Tirri (2017).

4.4 Implications of the Study

This study has pointed out that Life Sciences teachers are not aware of knowledge integration in the Life Sciences curriculum content and therefore has sought to provide Life Sciences teachers, teacher educators, subject advisors and curriculum planners with an understanding of how Life Sciences should be taught in secondary schools to help learners to improve their academic performance.

Subject advisors and curriculum planners are to be at the centre of developing and running teacher development workshops to empower Life Sciences teachers to successfully implement knowledge integration in the teaching and learning of Life Sciences (Booi, 2018). Departmental heads (HOD) need to assist novice teachers to guide them as to what is expected. This will avoid the teaching of what is only available in the textbook. A teacher needs to go the extra mile to integrate content knowledge from various disciplines before they present their lessons to learners. All of the aforementioned has implications for the training of future Life Sciences teachers at higher education institutions and this information should be channelled to the relevant teacher educators for consideration and implementation.

4.5 Conclusions

This study investigated the perceptions of Life Sciences teachers on the teaching of the principles of knowledge integration in FET Life Sciences. The issue of knowledge integration is a worldwide issue which addresses the curriculum's need for learners to learn independently and study Life Sciences further. The study found that teachers have gaps in their knowledge of Life Sciences curriculum content, and that they are not willing to learn other subjected related to Life Sciences to bridge the content knowledge gap. Teachers tend to teach what is available in a textbook and continue with the topics they are comfortable with. This issue results in knowledge gaps in learners when they proceed to the next grade, which has an impact on their academic results.

Teachers, HODs, subject advisors, and curriculum planners need to work together to overcome these issues and teach life sciences as an integrated subject discipline to strengthen the knowledge transfer to learners. Life Sciences is a subject that is learned through the understanding of terms, concepts, and processes. If learners do not understand the concepts and terms, it will be difficult for them to understand the content without context or terms/concepts. Teacher professional development as a key to empowering educators is one of the key solutions to minimising the issue of the lack of content knowledge in teachers. More workshops should be provided to teachers from General Education and Training (GET), Natural Sciences, and FET Life Sciences. The teaching and learning of Life Sciences should focus on how it should be taught as an integrated subject to simplify the content from strong semantic gravity (SD+) to weaker semantic gravity (SG-)

4.6 Recommendations

This research study was limited to three schools and seven educators. It is therefore recommended that further studies should be considered to include all the schools offering Life Sciences in the Metro East district of Cape Town and further afield, as well as in the different provincial departments within the Basic Education sector. Future studies could also look at the quality and approaches used to empower novice teachers with content knowledge of related disciplines that will enable them to teach life sciences as an integrated, multidisciplinary subject. The co-relation of Life Sciences and the quality of knowledge integration employed by Life Sciences teachers should be the starting point of investigation to determine the factors affecting Life Sciences results from grades 10 to 12.

4.7 Limitations of the Study

This case study focused on three schools and seven Life Sciences educators. The findings of this research study apply to the schools and educators selected and cannot be generalised to all schools that offer Life Sciences and the responsible teachers. The sample of teachers was limited to seven teachers from which conclusions cannot be made on behalf of all Life Sciences teachers. Data collection was done during the COVID-19 pandemic which caused delays and two other teachers were not available. This reduced the number of participants to seven participants instead of nine participants as per target. The school rotation timetable had an impact on the observation schedule because some of the teachers were teaching grades 10 and 11, in which they rotate days of attendance.

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APPENDIX A1 : CPUT CLEARENCE

Cape Peninsula University of Technology

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FACULTY OF EDUCATION

On the **11 October 2020** the Chairperson of the Education Ethics Committee of the Cape Peninsula University of Technology granted ethics approval **EFEC 14-09/2020** to **Mfundo Nyunguza** for research activities related to the **M.Ed** degree at the Cape Peninsula University of Technology.

Title of thesis:	Using the principle of knowledge integration in the teaching of Life Sciences in the Further Education and Training phase

Comments:

Permission is granted to conduct research within the Faculty of Education only. Research activities are restricted to those details in the research project.

____

Date: 11-10-2020

Dr O Koopman

Acting Chair of the Education Faculty Ethics committee

Faculty of Education

APPENDIX A2 : WCED CLEARENCE FORM

Western Cape Government
Education

Directorate: Research

Audrey.wyngaard@westerncape.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20201120-9708
ENQUIRIES: Dr A T Wyngaard

Mr Mfundo Nyunguza
6090 Sobukwe Street
Llingelethu
Malmesbury
7300

Dear Mr Mfundo Nyunguza

RESEARCH PROPOSAL: USING THE PRINCIPLE OF KNOWLEDGE INTEGRATION IN THE TEACHING OF LIFE SCIENCES IN THE FURTHER EDUATION TRAINING PHASE

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **01 February 2021 till 25 June 2021.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards,
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 23 November 2020

APPENDIX B3 : INTERVIEW QUESTIONS

Section A -: Teacher Information (TI)

<u>School name -: K1</u> **<u>Teacher's name -:</u> K11**

1. How long you have been teaching Life Sciences at this school?
2. What is your highest academic qualification? and your majors?
3. In what grade(s) do you teach Life Sciences?

<u>Section B -: Knowledge integration (KI)</u>

4. How do you design your lesson planning to accommodate integration of other subject areas into Life Sciences lessons?
5. What are your teaching technique/strategy(s) that you are using to allow a successful knowledge integration in your Life Sciences lessons?
6. Do you design your lesson planning as individual or as collective (group of teachers) in order to expand your content knowledge and knowledge about other subject areas? Why?
7. Life Sciences requires an understanding of chemistry, geology, etc., How do you apply knowledge integration to deal with these sub-topics within Life Sciences lessons?
8. What do you think about combining/infusing /sharing/connecting other Life Sciences sub-topics together with other subject areas, to help learners understand the lesson more easily?
9. What teaching materials do you use to advance content, knowledge integration and enhance the learners' understanding of Life Sciences?
10. What learning materials do the learners use to advance their understanding of content and knowledge integration in Life Sciences?
11. What is your general views/perceptions about the teaching of Life Sciences as an integrated subject discipline in all grades?

12. When you design your lesson plans, what aspects do you consider as important parts of knowledge integration? Why?

APPENDIX B4 : OBSERVATION SCHEDULE

Classroom Lesson observation

School name -: K1 Grade: Teacher's name -: K11 Date:

	Knowledge integration	**Excellent**	**Good**	**Fair**	**Comments**
1	Teaching method & strategy are relevant to semantic waves (SG and SD).				
2	Introduction: arouse learners interest and link with previous knowledge and experience. The link will allow the connection between high semantic gravity (SG+) and low semantic density (SD-).				
3	Reinforces: key concepts explained, content knowledge is integrated with other learning areas.				
	Content knowledge (CK) of Life Sciences in FET	**Excellent**	**Good**	**Fair**	**Comments**
4	Teacher display sound knowledge of the subject and able to link subject theory with learner's experience and enforce thinking and create low gravity and strong density to help learners to learn				

	independently.				
5	Explanation of terms, diagrams, graphs, chart and other concepts are defined and explained correctly and easily understood by learners.				
	Teaching and Learning Material Support (TLMS) to support knowledge integration	**Excellent**	**Good**	**Fair**	**Comments**
6	Teaching Media used functional and facilitate effective learning and enhance students understanding.				
7	Media used encourage learners to participate in the lesson and relate the lesson to their world experience.				

APPENDIX C5 : LETTER OF PERMISSION {SCHOOL A}

From : Mr Mfundo Nyunguza

To : Principal,SMT & Staff at large

Date : 10-03-2021

Dear principal

I hope this letter finds you very well.

I write this letter to request your permission to conduct my masters' research (M.Ed.) at your school (**School A**). I am a full-time registered M.Ed. candidate at Cape Peninsula University of Technology (Mowbray Campus) from 2020-2021. I am in the second phase of my research thesis where I need to collect data from three Life Sciences educators through interviews and class observation. Therefore, by granting me permission to interview and observe three Life Sciences educators at your school will help me to complete my thesis. The collected data will not be used for publicity or evaluating the level of teachers' knowledge, it will be used for completion of the thesis only. All educator taking part in this project will remain anonymous and the school name will not be featured in the research, therefore there is no need to worry about confidentiality of the teachers and the school name. The aims of this study is to look at images and models of knowledge integration used in the teaching and learning of Life Sciences. This research will benefit Life Sciences educators who are interested in learning about images and models of knowledge and curriculum integration in Life Sciences. I thank you for your support.

Please see the attached clearance from CPUT & WCED.

Kindly regard

Mr Mfundo Nyunguza

Cell: 064 909 4480

Whatsapp: 078 829 2842

APPENDIX C6 : LETTER OF PERMISSION {SCHOOL B}

From : Mr Mfundo Nyunguza

To : Principal,SMT & Staff at large

Date : 10-03-2021

Dear principal

I hope this letter finds you very well.

I write this letter to request your permission to conduct my masters' research (M.Ed.) at your school (**School B**). I am a full-time registered M.Ed. candidate at Cape Peninsula University of Technology (Mowbray Campus) from 2020-2021. I am in the second phase of my research thesis where I need to collect data from three Life Sciences educators through interviews and class observation. Therefore, by granting me permission to interview and observe three Life Sciences educators at your school will help me to complete my thesis. The collected data will not be used for publicity or evaluating the level of teachers' knowledge, it will be used for completion of the thesis only. All educator taking part in this project will remain anonymous and the school name will not be featured in the research, therefore there is no need to worry about confidentiality of the teachers and the school name. The aims of this study is to look at images and models of knowledge integration used in the teaching and learning of Life Sciences. This research will benefit Life Sciences educators who are interested in learning about images and models of knowledge and curriculum integration in Life Sciences. I thank you for your support.

Please see the attached clearance from CPUT & WCED.

Kindly regard

Mr Mfundo Nyunguza

Cell: 064 909 4480 Whatsapp: 078 829 2842

APPENDIX C7 : LETTER OF PERMISSION {SCHOOL C}

From : Mr Mfundo Nyunguza

To : Principal,SMT & Staff at large

Date : 10-03-2021

Dear principal

I hope this letter finds you very well.

I write this letter to request your permission to conduct my masters' research (M.Ed.) at your school (**school C**). I am a full-time registered M.Ed. candidate at Cape Peninsula University of Technology (Mowbray Campus) from 2020-2021. I am in the second phase of my research thesis where I need to collect data from three Life Sciences educators through interviews and class observation. Therefore, by granting me permission to interview and observe three Life Sciences educators at your school will help me to complete my thesis. The collected data will not be used for publicity or evaluating the level of teachers' knowledge, it will be used for completion of the thesis only. All educator taking part in this project will remain anonymous and the school name will not be featured in the research, therefore there is no need to worry about confidentiality of the teachers and the school name. The aims of this study is to look at images and models of knowledge integration used in the teaching and learning of Life Sciences. This research will benefit Life Sciences educators who are interested in learning about images and models of knowledge and curriculum integration in Life Sciences. I thank you for your support.

Please see the attached clearance from CPUT & WCED.

Kindly regard

Mr Mfundo Nyunguza

Cell: 064 909 4480 Whatsapp: 078 829 2842

APPENDIX D: Proof Language Editing

Edit Report Mfundo Nyunguza

- Please remember that your page numbers may change as corrections are made to your document. Once you have finished making all of your corrections, you need to go and re-check all of the page numbers in your indices.
- Errors in syntax, spacing and punctuation have been corrected.
- I have used the Track Changes facility in Word, so that you can see where I have corrected your document. You may need to turn this facility on, on your computer before making the corrections. Changes will be indicated in red or purple text. When you accept the changes, (by clicking on the blue tick in the task bar) the text will automatically change to black. Accept each change as it appears, if you are in agreement but you would be wise to avoid the 'accept all' option.
- A vertical line will appear in the left-hand margin opposite where I have made any corrections.
- Comments will appear in red or blue in the right-hand margin of the document. Once you have dealt with a comment, right click on it, and select the option to delete the comment. Alternatively, overline the comment and select reject (red cross) in the task bar.
- Remember to turn the Track Changes facility off before printing your document.
- Please check where I have reworded your text that I have not inadvertently changed the meaning of what you are trying to say.
- Write out acronyms in full when they are used at the start of sentences.
- In future papers, the oxford comma should be used throughout.
- Make sure when you reference online sources that you include the date you accessed the source in your reference list.
- Some author names in your reference list are incomplete.
- I have corrected most of your reference list but due to the formatting I cannot leave comments on specific errors. You need to go through your reference list and make sure all information is included.

- Please ensure that the numbering of your headings is consistent as well as the formatting the formatting
- Remember that we edit for language. I have, however, corrected minor formatting errors where applicable.
- There are general formatting inconsistencies which you will need to correct in line with your module guidelines.

APPENDIX E: PROOF OF PAYMENT/INVOICE

Barbara Dupont Editing Services

Cell No: 0846668351
Email: barbs1@skytec.co.za

ABSA Bank - Galleria Branch
Cheque Acc 4084962935

Bill To: Dr Kwanele Booi
Address: Cape Peninsula University of Technology
Faculty of Education

Phone:
Email: BooiK@cput.ac.za

Invoice No: KB/02.21
Invoice Date: 05/10/2021

Invoice For: Language Editing of Dissertation

	Description	Qty	Unit Price	Price
23/09/2021	Language editing of dissertation titled:			
	2) Teaching the Principle of Knowledge Integration in	82	R 35.00	R 2,870.00
	Life Sciences in the Further Education and Training Phase			
	BY: Mfundo Nyunguza			
07/10/2021	**EFT Payment**			R -2,870.00
	This can be paid directly into the following bank account:			
	Barbara Dupont			
	ABSA Bank			
	Galleria Branch			
	Cheque Acc No: 4084962935			
			TOTAL	R -