Learner perceptions of Life Sciences as a daily life and scientific human challenge

by

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Declaration

I, Ali Yemisi Deborah, declare that the thesis, which I hereby submit for the degree Philosophiae Doctor in the Department of Humanities Education, Faculty of Education at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Ali Yemisi Deborah

29 August 2019

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ETHICS STATEMENT

I, Ali Yemisi Deborah, hereby declare that all ethics approval needed for this work were obtained and were observed as required in terms of the University of Pretoria's code of ethics for researchers and the policy guidelines for responsible research.

DEDICATION

I dedicate this research to the Almighty God for strength and wisdom throughout the time of this research work.

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ABSTRACT

In the current knowledge era, learners, as the future of our world, require both knowledge and skills and a moral sense and values. The world is beset with diverse and evolving challenges fundamentally related to Life Sciences, which require certain skills and virtues that are not emphasised by current educational practice in schools. My quest to discover the ultimate consequences of learners' Life Science learning within the context of the existing prescribed Life Sciences Curriculum and Assessment Policy Statement (CAPS) was prompted by my personal experience as a high school learner and my desire to see learners have rewarding and relevant educational experiences.

Although the CAPS of the South African Department of Basic Education aims at providing a link between Life Sciences in the classroom and its everyday application in learners' lives, in practice it does not seem to achieve its purpose of equipping Life Science learners to be independent problem solvers of life challenges, as stated in its aims.

This qualitative case study explored learners' perceptions of Life Sciences as an essential factor for everyday life and scientific human challenge. The perceptions of 12 purposively selected learners from Grades 8–12 were explored by using semi-structured interviews, open-ended questionnaires, non-participant and quasi-participant observations, elicited materials, and field observation as data collecting instruments.

The transcripts of the semi-structured interviews and open-ended questionnaires were analysed using constant comparative analysis while data from the other instruments were used in corroborating or refuting the data from the semi-structured and open-ended questionnaire.

The findings indicate that learners perceive their life science learning as only for academic progress with just a few indicating a desire to pursue a science-based university degree. Furthermore, learners did not see Life Sciences as useful for application in their day-today life. However, with the learning of human anatomy, the participants assumed, somehow, that it would be necessary to understand how their body works, but not to the extent of applying the knowledge in their daily lives and decision making. In this regard the Life

Sciences curriculum fails to prepare learners to acquire the attributes required to successfully function in the 21st century.

Key terms

CAPS, citizenship, experiential learning, knowledge era, Life Science education, real life learning, science literacy, 21st century

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To whom it may concern

This is to certify that I, Alexa Kirsten Barnby, an English editor accredited by the South African Translators' Institute, have edited the doctoral thesis titled "Learner perceptions of Life Sciences as a daily life and scientific human challenge" by Yemisi Deborah Ali.

The onus is, however, on the author to make the changes and address the comments made.

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List of abbreviations

CAPS	Curriculum and Assessment Policy Statement
FET	Further Education and Training
GDE	Gauteng Department of Education
GET	General Education and Training
NCS	National Curriculum Statement
PCK	Pedagogical content knowledge
SCK	Subject content knowledge
SGB	School governing body
UNICEF	United Nations Children's Fund

CHAPTER ONE: GENERAL ORIENTATION

1.1 INTRODUCTION

In this century, unlike in any previous century, the learning of sciences must go beyond the mere assimilation of subject knowledge content. One peculiar trait of the knowledge age is active participation and application of scientific knowledge from the classroom to day-today life (Anilan, Atalay & Kiliç, 2018). However, achieving this could be a problem, especially when the curriculum fails to support such a shift in education. Although curriculum can be defined differently in different contexts, I adopt the definition of Abd-El-Khalick, Lederman and Schwartz (2015:510), which states that curriculum comprises the what, how and result of a learning programme:

> [The curriculum comprises] the domains of, and rationales for, subject matter and intended learning outcomes, nature and organization of instruction and learner experiences, and interactions among students and teachers within the immediate settings of classroom and school, as well as broader societal contexts (Abd-El-Khalick et al., 2015:510).

In this chapter, I discuss what precipitated my research in this area of study, and give an account of my learning process and educational experience during my secondary education. I reflect on the way I progressed towards academic achievement amid the difficulties and challenges I experienced in relation to learning. I also consider what the current education system offers today's learners by critically pondering the purpose of the South African Life Sciences curriculum, its structure and its possible consequences for the overall pursuit of education in the country. Since prevailing instructional practices are always considered critical in attaining academic success, I also consider current instructional practices and their implications for learners' learning processes.

1.2 BIOGRAPHICAL REFLECTION ON MY EDUCATION

My primary school years were exciting and enjoyable comprising elementary learning in an atmosphere of fun and play. I left primary school at a very young age, looking forward to the same experiences at high school. I was disappointed, however, because the high school operated very differently from my former primary school.

Before I entered high school, my parents told me that it was a place to work very hard. I assumed that this implied that I should be more serious about my schoolwork as I grew into a young adult and was determined to make my parents proud.

Unfortunately, high school turned out to be a very different experience. Ordinarily, I am a person who needs to understand concepts before applying them. However, now I was required to memorise concepts, even if I did not understand them, because they were presented as information without giving an opportunity to determine how they functioned. Years later, on reflecting on my personal educational experiences and those of my learners, I realised that I had concentrated on passing examinations, merely memorising concepts, rather than developing a deep understanding of how they worked.

Reflecting on my personal experience and my practice as a teacher propelled me to embark on this research.

1.3 PROBLEM STATEMENT

Human beings possess innate virtues that make them unique creatures. Again, reflecting on my educational experience, it seems to me that school practices today are no different from what I experienced as a learner. Accordingly, learners are rushed through the curriculum using various instructional means (direct teaching by the teacher and/or through electronic/internet mediums) to aid retention and reproduction of content as required in examinations. Emphasis on the reproduction of learnt concepts for examination purposes is known to generally encourage superficial learning.

Saidi and Sigauke (2017) concur with various studies that a deep understanding of science and creativity is often inspired by learners' authentic exposure to diverse experiences that enhance questioning, thinking and inquiry. The importance of deep thinking and creativity in this, the 21st century, cannot be overemphasised (Henriksen, Mishra & Fisser, 2016).

In view of the great advancements made in technology today and the improvement in artificial intelligence, it is evident that human beings are gradually becoming irrelevant in many routine and automated professions. Research indicate that technology is fast replacing most of the jobs that humans do in the workplace; however, to humans' credit, we possess the unique innate ability to think, which cannot be replaced by technology or artificial intelligences (Frey & Osborne, 2017). Frey and Osborne (2017:254) record that 47% of human work in the United States has been lost to robots. Jobs such as those occurring in the building and construction sector, as well as stacking and arranging positions, receptionists and voice-response services are carried out by machines and robots in many parts of the advanced world. In many organisations, computers and robots are built to carry out assignments that require direct instructions, and these are performed accurately and in a timely fashion by these machines. Therefore, in a world in which machines and humans compete, unique human abilities will have to be enhanced. However, this aim cannot be achieved by the superficial memorisation of knowledge. Moreover, if machines are capable of doing the work that was previously done by school leavers, the question of why we need to prepare learners for jobs that will not eventually be theirs arises (Brynjolfsson & McAfee, 2011:10-11). In my opinion, for learners to go through years of learning and then be unable to compete in the outside world after schooling constitutes a social injustice. Hence, it becomes imperative that school learners and university students should be exposed to learning that would enhance critical thinking and creative ability to innovate, among other things, as an advantage in our fast-growing and automated world.

Educational achievement is usually measured by written tests at both the national (matric) and the international (TIMSS) level. Harmon, Smith, Martin, Kelly, Beaton, Mullis et al. (1997:4) suggest that marks and test scores are regarded as a priority in our education system and this is still the case today. Since the main purpose of traditional assessment also seems to be high test marks in standardised tests (Marini & Genereux, 2013:1), usually used for academic progression, learners go through their educational programmes by memorising facts and content for once-off delivery in the exams.

Ringer, Volkov and Bridson (2014:504) report that in their view, learners are driven by what they perceive as the requirement for their progression to the next educational grade level. Although it has been documented that learners' achievement is greatly influenced by academic optimism, the three components of learners' achievement, namely, academic emphasis, collective efficacy and faculty trust, come into play in the process (Boonen, Pinxten, Van Damme & Onghena, 2014; Mitchell & Tarter, 2016). Besides, Sinay and Ryan (2016) allude to the fact that if these three are integrated into education practices, it could promote learners' positive behavioural attitude.

It is sometimes held that schools, along with society in general, both in South Africa and internationally, experience an increase in unethical behaviour, which may indicate a decline in fundamental human virtues. The discipline that is supposed to be one of the main consequences of education does not seem to be generally achieved. Mitchell and Tarter (2016) assert that academic achievement should include the promotion of citizenship and community engagement in holistic development. Citizenship in this context is defined as the expected behaviour of a responsible member of a particular society (Pancer, 2015:2). Together with much environmental degradation among other challenges facing humans, is the need to raise learners who will eventually take up the responsibility for caring for the earth and not to contribute to its destruction. However, owing to an emphasis on marks and tests rather than on the holistic development of learners, this may not be achievable (Slabbert, De Kock & Hattingh, 2009). Learners should develop mindsets such as those displayed by learners from Townsville in Australia. CNN reported that these learners took up initiative to save Nemo, that is, sea creatures on the verge of extinction by human exploiters. This indicates a profound sense of responsibility toward the harmonious coexistence of the creatures of the world (Watson, Wright & Booth, 2018).

Educational aims can be informed by various objectives (Mnguni, 2013:2). Undoubtedly, the CAPS for Life Sciences is packed with good intentions and goals to empower learners with knowledge and skills that will be meaningfully applied to meet their needs and, by extension, those of the globe (DBE, 2011:4), however, it would seem that these goals are not in the actual sense realised (Sethusha 2006; Sethusha & Lumadi, 2013). In practice, the enacted curriculum and its outcomes seem to lack the development of a sense of personal application of the knowledge to learners' lives and responsibility towards both the community and the global wellbeing of society (Sethusha, 2006), which stands as one of the core goals in the Life Sciences CAPS as mentioned in its general aim (DBE 2011:4) and specific aim, which is

> … to understand that school science can be relevant to their lives outside of the school and that it enriches their lives (DBE, 2011:17 section 2.5.3).

Ideally, the three types of curricula, namely, the intended, enacted and assessed curricula, should be aligned in order to achieve the outcome desired (Porter, 2002 in Kurz, Elliott, Wehby & Smithson, 2010:132). However, when the intended, enacted and assessed curricula are not aligned, it is a cause for concern and needs to be addressed. It is therefore important to ascertain whether CAPS falls into such a category where the intended, enacted and assessed curricula are not aligned.

Moreover, the question whether the intended curriculum (in this case Life Sciences CAPS) identifies, considers and presents what really counts as knowledge for the learner is worth considering. As Young (2010:4) emphasises, it is crucial that curricula should aim at equipping learners with "powerful knowledge" that enables them (learners) to harness their existing knowledge in the production of new knowledge. In so doing, learners would be exposed to deep and creative thinking.

The CAPS, being informed by four educational ideologies (Mnguni, 2013:9), may possibly not achieve all its aims. According to Schiro (2008), the four educational ideologies that guide the curriculum include a scholar academic ideology, an efficiency ideology, a student-centred ideology and a social reconstruction ideology. Mnguni (2013), in agreement with Schiro (2008), asserts that the effectiveness of the aims of a curriculum strongly relies on features like the subject content knowledge (SCK), instructional method, roles of the learners and teachers, and its assessment process (Mnguni, 2013:2). However, Lelliot (2014:122) and Mnguni (2013:7) report that although the curriculum itself is well structured, CAPS emphasises content knowledge.

Soudien (2016) argues that the purpose of education is to be viewed holistically and not from a self-centred viewpoint, since education should be the bedrock for the holistic development of learners' innate human attributes. Developing the innate fundamental human virtues places humans above computers and robots, thereby guaranteeing a platform for job acquisition and leadership positions (Soudien, 2016). Holistic development of learners rather than learning from a homo economicus point of view would enhance not only mental empowerment but also an all-round development which includes learners' physical, mental, emotional and spiritual states

(Slabbert et al., 2009). However, it is sometimes easy to overlook emotional intelligence (EI) and spiritual intelligence (SI) in traditional instructional teaching. Nevertheless, emotional and spiritual intelligences respectively encourage the ability to control oneself and foster every day problem solving. These traits fall into the class of social efficiency and social reconstruction ideologies (Schiro, 2008; Mnguni, 2013). These intelligences have been found to be crucial both in the world of work (Tabatabei & Zavareh, 2014) and in saving our planet.

An excellent intended aim of the curriculum does not automatically result in excellent learners' experience (Hume & Coll, 2010; Warren, 2017). The enacted curriculum experienced by learners is influenced by various factors which include those related to learners and those related to teachers (Taylor & Richards, 2018), as well as resource factors (Warren, 2017) among others. Current observations reveal that issues of citizenship and moral commitment cannot be attested to in our society, even at the lowest educational level (Yapandi, 2015:209). Could these observations thus be a result of learners' lack of understanding that learning, beyond the acquisition of knowledge, is aimed at everyday life and global prosperity?

1.4 RATIONALE/MOTIVATION

Aikenhead (2006:1) identifies two alternatives in instructional delivery: one is to train learners as recipients of scientific knowledge passed down from the "science expert" and the second is to be able to adapt scientific knowledge to everyday life. Aikenhead (2006:14) records that at the beginning of western science, the first alternative was favoured. Thus, the structure of school sciences and its curriculum is informed by 19th century educational intention, presenting learners as recipients of knowledge. This educational standpoint has created a huge challenge for the adaptation of the traditional science curriculum into one that is humanistic in intent (Aikenhead, 2006:14), even when scientists like Dewey and others proposed a link between school science and everyday activities.

The 21st century presents unique demands, both in everyday-life and scientifically, for securing a safe, sustainable, prosperous and habitable planet for us all. Hence, it is vitally important that learners become aware of their impact as human beings in determining what happens to the planet (Hawken, 2009). Currently, planet Earth is battling the anthropogenic effects of human actions which ultimately has negative consequences. These have led to global warming, overpopulation problems, polar ice melt, droughts, environmental pollution and global unrest, among others. Good decision-making and right choices are indispensable in this regard (Sormunen & Köksal, 2014:167) and have consequences for the environmental and social problems mentioned. Therefore, making choices that will benefit the community and the future generation is more critical now than ever before. For instance, CNN reported that Midway Island is currently experiencing problems with discarded plastic which has been deposited in the ocean by many countries in the coastal region, having damaging effects on the birds inhabiting the island (Paton, Formanek, Loo & Phillips, 2016).

Accordingly, it is important that we prioritise the development of learners as science-literate citizens. Norris and Phillips (2003:224) describe science literate citizens as those who are able to apply scientific principles to everyday situations even though they may not be science experts. In addition, Hellmuth (2014:1) stresses that the importance of science literate citizens cannot be overemphasised. Therefore, it is important that learners, especially those studying Life Sciences, become aware that being part of the solution to the world's problems is a human challenge and that all persons must take full responsibility for the way in which they contribute to the future of the planet. Since scientific knowledge has a close association with taking informed decision (Sormunen & Köksal, 2014:167), it is in my opinion important to ascertain the learners' perception on what they are learning in the Life Science classroom and their understanding of the importance of Life Sciences in their everyday lives.

Researchers like Mnguni (2013) and Lelliot (2014) have studied the effectiveness of CAPS in the delivery of its objectives. They report that although the CAPS aims are good, there are challenges with the achievement of these aims in the curriculum. Mnguni (2013) reports that the aim of the Biology CAPS curriculum is heavily premised on a scholar and student-centred ideology, which emphasises SCK and skills development. The prevailing educational ideology guiding the curriculum stands to heavily influence the enacted curriculum and, as such, may inform the perceptions of teachers and learners alike.

Various researchers have studied teachers' perception of their teaching in various subjects such as history (Warnich, Meyer & Van Eeden, 2014), natural sciences

(Ogunniyi, 2006); technology (Singh-Pillay & Ohemeng-Appiah, 2016), mathematics (Stols, Ono & Rogan, 2015) and teachers' perceptions of the CAPS curriculum (Du Plessis & Marais, 2015; Mather & Land, 2014). In addition, research has addressed learners' perception of their subjects such as mathematics literacy (Venkat & Graven, 2008) and physical education (Surujlal, Shaw & Shaw, 2007). However, at the time of writing this thesis, no known literature has been written on learners' perception of their Life Science learning experience, especially within the CAPS context. Therefore, it became important for me to explore the way in which learners perceive their learning in the Life Science classroom and whether it creates an understanding of how essential the subject is for human beings in everyday life as well as in the world of the scientist.

1.5 PURPOSE STATEMENT

The purpose of this research was to explore learners' perceptions of learning in Life Sciences as essential to everyday-life and scientific human challenges. According to Lavonen, Byman, Uitto, Juuti and Meisalo (2008), learners are intrinsically motivated to learn and apply knowledge constructed from classroom learning experiences when they become aware of the importance and relevance of a subject in their everyday lives. Such interest created by this kind of understanding is fundamental to achieving quality learning experience (Lohbeck, Nitkowski & Petermann, 2016:290) and as such, an increased desire for learning (American Psychological Association, 2015).

1.6 RESEARCH QUESTION

Derived from the research problem statement and rationale presented in sections 1.3 and 1.4 above, the primary research question for this study was formulated as follows:

Does learners' Life Science learning experience influence their understanding of Life Sciences as an essential daily life and scientific challenge?

In order to answer the primary research question, the following secondary research questions were considered:

- What are the current curriculum demands of the Life Sciences?

- What are the challenges confronting school Life Sciences as fundamental to a daily life and scientific challenge?

1.7 LITERATURE REVIEW

Since this research is aimed at exploring learners' perceptions of their Life Science learning experiences as an essential daily life and scientific challenge, it is essential for me to explore Life Sciences as a subject as presented in the South African CAPS (Department of Basic Education, 2011).

1.7.1 Life Sciences as a School Subject

Life Sciences is a recognised scientific academic discipline. The following paragraphs reflect the goals and the structure of the CAPS for Life Sciences (DBE, 2011) and also indicate the recognition of Life Sciences as a school subject by the South African Department of Basic Education (DBE, 2011).

It is a usual practice to develop curriculum content in a way that addresses the needs of the time (Balzer, Hautz, Spies, Bietenbeck, Dittmar, Sugiharto, et al., 2016:369; Olvera, Reyes & Ochoa, 2015:25–26). Following this principle, the CAPS was developed from a review of the curriculum content contained in the South African National Curriculum Statement (NCS) (Du Plessis & Marais, 2015). The latter curriculum did not address the instructional strategies that teachers should use (Du Plessis & Marais, 2015:1).

The revised NCS (CAPS) was developed in order to consider new knowledge and skills required for the developing adult (DBE, 2011). The CAPS proposes effective aims that are clearly stated; for example to

- "identify and solve problems and make decisions using critical and creative thinking";
- "collect, analyse, organise and critically evaluate information"; and
- "demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation" (DBE, 2011: 11).

However, a major challenge for the implementation of this curriculum is the emphasis placed on the student-centred and scholar academic ideologies and probably the inability of teachers to use effective teaching strategies to meet the demands of the curriculum (Mnguni, 2013). Furthermore, many teachers are yet to appreciate the essence of the CAPS and, as such, prefer the unmodified curriculum statement (NCS) (Du Plessis & Marais, 2015:1).

The CAPS Life Sciences curriculum (DBE, 2011) is divided into components, including the organisation of the subject knowledge content and time allocation. In addition, the programme details the assessment for each term of the academic year. In the organisation of Life Sciences section, the subject content is divided into categories that are identified as strands (cf. addendum A). These strands represent the broad knowledge areas which are in turn further divided into topics.

Since purpose is central to any curriculum development practice (Wong, 2018:2), a vital purpose of CAPS is to prepare learners to be relevant to local and global society by equipping them with the skills and knowledge that will be meaningful in their own lives (DBE, 2011:4). This suggests that learning content and practices should enable learners to see themselves through the lenses of what they are learning. In essence, they should be able to acknowledge the importance of Life Sciences' knowledge in their personal lives and that every topic has great consequential value.

Assessment is a crucial element of any curriculum (Lyndon, Henning, Alyami, Krishna, Zing, Yu et al., 2017:2). It involves gathering proof of a learner's academic competence, which stands as a means for determining the promotion of the learner from one grade level to the next (DBE, 2011:7). The assessment may be internally conducted (which often happen), or it may be an external assessment, which occurs yearly (DBE, 2011:7). For the higher levels such as Grades 10–12, the percentage of school-based assessment is usually higher than that of end of year examinations. However, both the school-based assessment and the end of the year assessments must total 100%. Assessment is based on four cognitive domains: (1) the ability of the learner to recall Life Science knowledge; (2) the ability of the learner to demonstrate understanding; (3) the ability of the learner to apply the knowledge, and (4) the ability of the learner to evaluate scientific knowledge critically. However, Mnguni (2013) reports that even though CAPS has all elements of the four curriculum ideologies, the scholar and student-centred ideologies are more pronounced. It is therefore possible that both instructional and assessment practices are guided by these two dominant ideologies which may have a strong impact on the outcome of the curriculum.

Table 1.1 shows the cognitive elements of an assessment that culminates in the promotion of learners.

Table 1.1: Cognitive elements of assessment (DBE, 2011:67)

Recalling science	**Understanding science**	**Applying scientific knowledge**	**Evaluating, analysing and interpreting scientific knowledge**
Percentage of use of cognitive elements			
40	**25**	**20**	**15**
Verbs useful during assessment			
State Name Label List Define Describe Other	Explain Compare Rearrange Give an example Illustrate Calculate Generalise Other	Predict Apply Use knowledge Demonstrate Solve Implement Judge Other	Select Differentiate Analyse Infer Suggest Reason Discuss Categorise Other

1.7.2 Reflecting on the Life Sciences Curriculum

Life Sciences involves the study of life (Noureddine & Zouhaire, 2017:475). In section 1.7.1 above, I mentioned that Life Science content in CAPS is divided into strands and that, because each strand is taught separately and independently, it would appear that the complexities and the interrelatedness of concepts may not be clear. Life Science content is generated by studying phenomena in reality through the application of specific methodologies such as observation, experimentation, and the verification of hypothesis with reality (Lederman, 2009). Knowledge comprises constructs or meaning gathered from experience(s), be it from scientific content transferred by means of pedagogies or from the study of reality (Louw, 1983:14; Lederman, Lederman, Bartels, Pavez, Lavonen, Blanquet et al., 2017). Therefore, knowledge in the Life Sciences can be acquired by studying the living components and transforming the understanding of these into constructs. Life Science constructs of various phenomena crystallise into the constellation of scientific content taught in classrooms, as represented in figure 1.1.

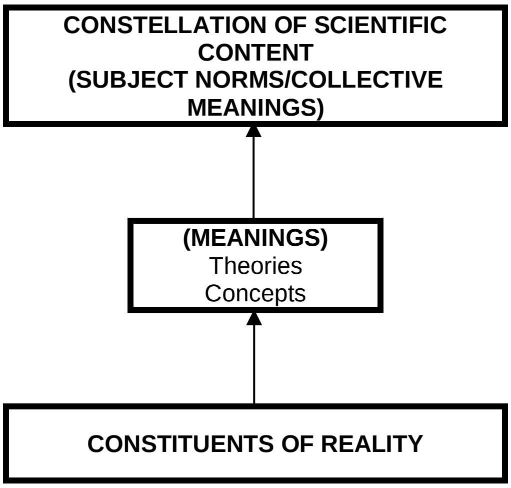

Figure 1.1: Constellation of scientific content

Fragmented knowledge, that is, compartmentalised knowledge, which is learnt without context, is detrimental to a holistic understanding of a system. The world is a complex entity, and the complexities and the challenges they present every day can only be addressed by multidisciplinary actions (Harlen, Derek, Rosa, Hubert, Guillermo, Pierre, Robin, Michael, Patricia & Wei, 2010:4). Understanding chaotic processes (for instance, the world) is radically non-permutable, and fragmented knowledge therefore would be inadequate for understanding them (Bohm 1980:63). Trevors and Saier (2010:49) assert that summation of disjointed knowledge often leaves knowledge gaps owing to the absence of context. Slattery (2006:xii) concurs, stating that phenomena or concepts are best learnt when knowledge is not compartmentalised into discrete units. Rather, he posits that holistic knowledge is better constructed within the context of reality. For example, in reality it took us a while to understand that the use of paper is unwise, as it poses the threat of desertification. This is because we partially understand that the world is integrated and that any human action has either negative or positive consequences for the world that sustains us (Bohm, 2005:23).

Unfortunately, such consequences sometimes only become apparent after the damage has been done. For instance, population growth is one of the world's challenges. The increased birth rate, especially in African countries, which led to problems such as poverty, food insecurity, inadequate education, population congestion and insufficient infrastructure, was not considered a problem until recently, simply because we failed to acknowledge the interlaced structure of nature. It follows that mismanagement of any aspect of the living system always results in significant consequences for other aspects of nature. Despite the fact that the negative consequences of human actions are not usually evident at the time of the action, the ripple effects of these actions may later be considered serious world problems. One example is the invention of biosoaps, which were introduced as a remedy for chemical environmental pollution but were later linked with the destruction of the orangutan's natural habitat (Gunter, 2018). This kind of action emanates from a lack of appropriate understanding of how systemically the world operates and is sometimes evidence of a careless attitude (Gunter, 2018). Thus, partial or fragmented knowledge which poses the danger of the "destruction of meaning" (Slattery, 2006:xii) has a negative effect on an understanding of an interconnected world.

In addition, the curriculum emphasises that it is essential for learners to gain deep knowledge of scientific process skills in terms of carrying out investigations and improving human lives (DBE, 2011:13). This is intended to be addressed by the investigative-practical skills which are demonstrated when studying Life Sciences in school.

The application of the understanding gained in the Life Sciences classroom goes beyond the classroom space (Saidi & Sigauke, 2017). Although an understanding of the SCK is fundamental, it is equally important that learners should appreciate its application beyond mental knowledge acquisition. They should be able to acknowledge its application in their everyday living and decision-making. Schmokers (2018:54) asserts that the effectiveness of the learning process, which in most cases culminates in a holistic understanding of concepts or areas of study, could be directly linked to teachers' adeptness. However, Khoza (2015:104) believes that understanding of the educational vision of curriculum is a force to be reckoned with when addressing the effectiveness of teaching. Unfortunately, he records that many teachers lack a vision for the subject and therefore do not know how to interpret the curriculum (Khoza, 2016:104–105). As a result, they lack the capability to facilitate learners' understanding of the subject beyond its content, which could be detrimental to their learning processes.

1.8 THEORETICAL FRAMEWORK

The theoretical framework for this research is placed primarily within the constructivist epistemology domain. In constructivist epistemology, knowledge is not considered to be information that is passively received through the senses or by way of communication; rather, it is known to be actively constructed by individuals either through personal constructs (radical constructivism) or through interactions with the environment (social constructivism) (Gottlieb, 2000:1; Atherton, 2013:1). Hence, constructivism assumes that knowledge cannot be transferred or transmitted either through teaching or instruction; only when learners interact with the learning opportunity and consequently attempt to make sense of it can it be considered that knowledge construction is taking place (Heyligen, 1997:2).

According to Powell and Kalina (2009:241), there are two types of constructivist epistemology: cognitive constructivist, which is personal knowledge construction by an individual, and social constructivist, which is knowledge constructed through interaction with other people.

Cognitive constructivism is based on the work of Piaget, which informs Von Glasersfeld's (1995) proposition of radical constructivism. Von Glasersfeld asserts that knowledge construction depends heavily on the experiences of the one constructing the knowledge at a particular time. He strongly believes that knowledge is subjective, hence, knowledge may be improved on as one experiences changes (Von Glasersfeld, 2008).

While Von Glasersfeld proposed radical constructivism, Lev Vytgosky was a proponent of social constructivist theory (Lantolf, Poehner & Swain, 2018:28). Social constructivism is premised on individuals' social constructs, which result from social interactions with other individuals.

Furthermore, this study draws on perception theory, as described by Démuth (2013). Perception theory is based on two premises: bottom-up theory and the top-down perception. It is important that we know what perception is and why we need to understand learners' perception of their Life Sciences education. Perceptions are ideas or views that an individual construct in order to "understand oneself and the world in which one lives" (Démuth, 2013:78). The bottom-up theory of direct perception considers the experience of the integral characteristics of all the stimuli that are received and their interrelatedness, through which the idea (perception) takes shape. A perception is, in itself, neither right nor wrong; its significance is found in a perpetually increasing qualitative adjustment (Démuth, 2013:30) that takes place through experiential learning (Kolb, 1984), allowing reality (internal and external) to be represented as accurately as possible. From this, qualitative improvement (of the individual's internal world and subsequently the external world) becomes possible. Kolb (1984:79) identified the following characteristics of experiential learning:

- Learning is best conceived as a process, rather than in terms of outcome.
- Learning is a continuous process grounded in experience.
- The process of learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world – learning by its nature generates tension.
- Learning involves transactions between the person and the environment.
- Learning is a holistic process of adaptation to the world.
- Learning is the process of creating knowledge – the result of the transaction of personal and social knowledge (Kolb, 1984:79).

However, essential to his learning theory, Kolb (1984) postulates that learning takes place in a cycle that consists essentially of four phases. These he called concrete experience, reflective observation, abstract conceptualisation and active experimentation. Figure 1.2 presents a schematic representation of Kolb's (1984) experiential learning cycle.

In the preceding paragraphs, I explained my leanings in constructivist theory, and, for the purpose of this study, I will focus on Kolb's experiential learning theory as guided by the constructivist's view where participants construct their own knowledge based on their experiences.

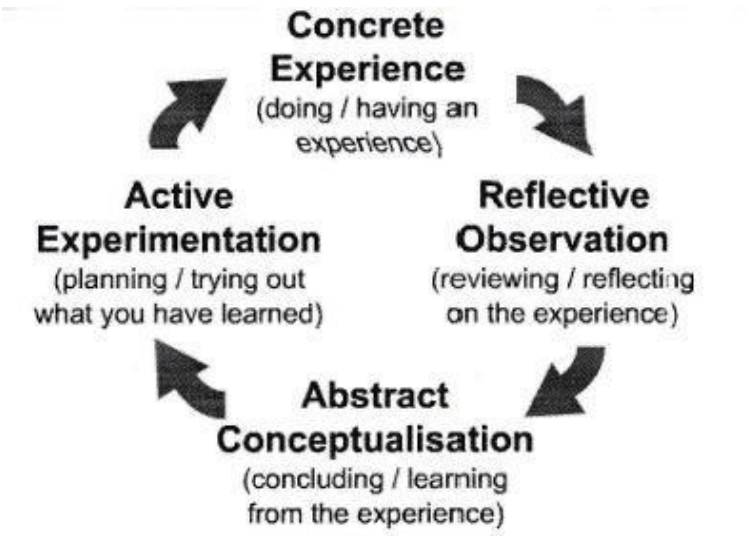

Figure 1.2: Kolb's experiential learning cycle (ELC)

1.9 RESEARCH DESIGN AND METHODOLOGY

The success and completion of research depends on proper research design (Blanche, Blanche, Durrheim & Painter, 2006:57; Di Fabio & Maree, 2012). Therefore, one of the first tasks in discussing the research design is to state my research premises.

1.9.1 Paradigmatic Perspectives

The paradigmatic premises for this research are stated by delineating my assumptions and perspectives, as suggested by Creswell (2008), Maree and Van der Westhuizen (2009), Goduka (2012) and Babbie (2013), among others. My ontological assumption within the context of this research is that reality is not independent of the perceiver. In this study I assume that reality is a process of concept construction and meaning-making through a continued relationship with reality. Hence, my paradigmatic assumption is a nominalist assumption. My epistemological assumption is that knowing reality should be seen as a relationship with the environment and not in an anti-positivist or interpretive way. Therefore, my epistemological assumption is socio-constructivist in nature. In addition, my methodological assumption follows an ideographic approach, where the emphasis is on individual and individuals' experiences, perceptions and behaviour. I assume that human nature is not determined. This mean that humans are not completely dependent on "outside" forces to determine their destinies, nor are they completely in control of their own destiny (voluntarism). Rather, humans are positioned between these two extremes of the continuum.

1.9.2 Delineating my Mode of Inquiry

This study is positioned within an exploratory qualitative research mode of inquiry. This mode of inquiry was chosen in order to enhance the researcher's understanding of how learners' exposure to Life Sciences influences their perception of the importance of the subject in their everyday life as humans. In addition, it allowed for an investigation of the meaning learners construct from their Life Sciences classroom experiences.

A qualitative research mode of inquiry can be placed within a number of domains, which are categorised by De Vos, Delport, Fouché and Strydom (2011), Creswell (2012) and Maree (2007). This research took the form of a case study.

1.9.2.1 Case study

This study comprised case study research. Science is both a science and a human activity, therefore, the construction and value of Life Sciences in learners' everyday lives is important to me. A case study, as defined by Bromley (1990, in Zucker, 2009), is a systemic inquiry into an event or set of related events which aims at describing and explaining a phenomenon of interest. Case study promotes understanding of the researched perceptions and their relationship with events. In other words, case study gives voice to the researched experiences so that they can be heard (Yin, 2014).

This study researched Grades 8–12 Life Sciences learners in the usual context of their classroom settings, exploring their experience of Life Sciences and their perception of Life Sciences as essential for addressing everyday-life and scientific human challenges. Cohen, Manion and Morrison (2007:253) state that it is important that events speak for themselves instead of outsiders' judgements and opinions.

Although a case study may not be generalisable, in this case it gives an overview of what learners' views of Life Sciences are and could also be a pointer towards what lies ahead for our education in this instance. Case study uses multiple data collection techniques and a variety of sources, which adds credibility to this type of study.

Learners in Grades 8 and 9 are categorised as being in the General Education Training (GET) phase of the high school in the South African education system, while Grades 10 to 12 form the Further Education Training (FET) phase. Both phases were included in this study in order to involve all the high school phases. This research was started in the second term, after the learners had presumably settled into their new grade, and data collection continued into the third term.

1.9.3 Data Collection and Sampling

The research was conducted in the natural setting of a school environment. The research site was purposively selected to ensure that the research focused closely on the diversity in the South African learner context. The researcher ensured that the school chosen was a public school that engaged in mainstream teaching. The school had all the essential facilities such as well-equipped classrooms, laboratories and laboratory equipments, access to internet and projectors, all which are considered necessary to facilitate learning, such that the data represent a true South African learning context. The site was conveniently selected because I was not teaching at the time of the research and needed to find a school that would accommodate the research work for the duration of the project. The primary data collection tools were the semi structured interview and the open-ended questionnaire. Other qualitative data tools like informal observation, and participants' drawings, which were meant to either corroborate or refute findings from the primary data, were also included to enrich the data. Data collection techniques are expounded in the following paragraphs.

Non-participant and quasi-participant observation

The classes were observed in natural classroom settings while the subject teacher was teaching, and the learners were deemed to be subconsciously constructing their meaning of Life Sciences and what it is about. This observation is informal and was intended in confirm or refute findings from the primary data gathering tools which were the semi-structured interview and the open-ended questionnaire. At times, participants were asked clarifying questions in a non-invasive manner. This was aimed at ascertaining what happened during their meaning-making process.

Audio-visual recordings

Audio-visual recordings were used during educational events in the classroom, especially those that signified critical experiences for participants' perceptions (like the practicals) without revealing the identities of participants and also subject to all the other ethical rules and regulations. The audio-visual recording was not used as a separate protocol, but as a technique to manage the data and for verification of the findings from the primary data gathering sources.

Field notes

During the observation sessions, field notes were made, recording certain significant events that could enhance the richness of the data. Field notes allow the researcher to have a record of events as they happen. The researcher also engaged in memo writing, in order to ensure the tracking of events, as well as my personal thoughts and reflections (Charmaz, 2006).

Semi-structured interview

Semi-structured interviews were conducted with 12 purposively selected participants in each class from each grade level (Grades 8–12). The semi-structured interview allowed participants to describe their perceptions of Life Sciences. It also gave me an opportunity to probe participants' answers in order to gather rich data.

Open-ended questionnaire

An open-ended questionnaire was designed also bearing the aim of the research in mind. All the questions designed were targeted towards answering research questions. The validity was tested with my supervisor.

1.9.4 Data Analysis

Since this study comprised a qualitative case study, continued engagement in social interaction with participants in many formats, as well as with their responses to particular assignments, became pertinent. Data of verbal social interactions or their representations were recorded, transcribed and coded.

In analysing the data, I employed constant a comparative analytical procedure, considering various coding possibilities and phrases. Additionally, data were subsequently categorised in order to conceptualise and identify similarities and differences that emerged and to establish any emergent themes. Details of the data gathering and data analysis are addressed in greater detail in chapter three.

1.10 DATA VALIDITY AND RELIABILITY

Researcher's bias is a critical concern in this research, considering my teaching experience background and having battled with certain unpleasant learning conditions myself. In order to eliminate biases as much as possible, I maintained focus on what the data revealed only. With this in mind, data validity can be described as measures that are put in place to ensure the trustworthiness of the research as suggested by Yin, (2014). Data validity criteria include creditability, conformability, transferability, dependability and authenticity of the study.

Measurement of validity involves ascertaining the degree to which the findings of the study are able to convince the audience that the research is of high quality (Cohen et al., 2007). Hence, to ensure validity, participants were involved in data checking. Moreover, prolonged data collection and saturation of data ensured credible data gathering (Di Fabio & Maree, 2012; Guba & Lincoln, 1989). Denzin and Lincoln (2011:5) assert that qualitative researchers can employ various strategies such as the triangulation method to validate their data. Although triangulation is not a tool for validity, it crystallises data from all the instruments employed in the study (Denzin & Lincoln, 2011:5). While there is the possibility of the researcher reflecting mainly on the positive aspects of the study, thereby neglecting the negative components, as far as this research is concerned trustworthiness and credibility were prioritised. All emerging concepts and themes from the study were addressed accordingly. I constantly checked my data collection instruments and the questions used with my supervisor and against the research questions and purpose of the study to ensure validity. Table 1.2 summarises my research design, paradigmatic choices and reasons for these choices.

1.11 LIMITATIONS OF THE STUDY

The fact that the study was conducted at one site representing Gauteng public schools and was conducted at a girls' school may be a limitation to generalising the result. In addition, one class in each of Grades 8 to 12 was purposively considered owing to time and financial constraints. However, the distinctive situation where the same teacher taught all the classes across the five grades that were selected for the research has significance in this study and may be a countering factor to the limitations.

1.12 POSSIBLE CONTRIBUTION OF THE STUDY

This study is about understanding learners' perceptions of the implications of their Life Science learning. It contributes to the body of knowledge by assessing the impact of participants' learning experiences on their personal development, as well as its effectiveness and usefulness in their lives. Furthermore, it aims to determine how the impact of what learners learn can help them to meet the demands of the 21st century.

1.13 ETHICAL CONSIDERATIONS

This research was conducted strictly in accordance with the ethical considerations of the University of Pretoria. Ethical clearance was applied for and was obtained through the Ethics Committee of the University. Informed consent was also obtained from Gauteng Department of Education office, as well as from the administration of the school where the study was conducted. Mouton (2005:243–244) believes that "human subjects" must be enlightened about the aim of the study, and "signed consent" must be obtained. In the light of this, participants were informed in detail about objectives of the study and were told that their participation would be voluntary. Furthermore, confidentiality and anonymity were preserved throughout the research process (Mouton, 2005:243–244).

1.14 MAP OF THE THESIS

Chapter one: Background and research context

In chapter one, I presented the background to the study and what motivated my choice of topic. In addition, I discussed the biographical reflection on my education process and Life Sciences as a school subject, as well as critically examining the curriculum (CAPS). This chapter also discussed the rationale and presented the research questions and the methodology that guided the study.

Chapter two: Literature review

In chapter two, I discuss the relevant literature on the establishment of Life Sciences as a scientific discipline, the nature and the structure of Life Sciences and its implications for our current educational practices, thereby identifying the gaps in literature. I also discuss the theoretical framework that underpins this study.

Chapter three: Research design and methodology

Chapter three explains the philosophical perspectives that underpin the study, as well as the research design and the methodology adopted. It also provides information on the justification for the methods used. Further, I describe the sampling technique used in the study, the process of site selection and the participants. I also describe the sample size, justifying each choice that was made. In addition, the process of data collection is discussed. Measures taken to ensure the quality of the study are also discussed.

Chapter four: Analysis and interpretation

In chapter four, I discuss my findings in detail as well as interpreting the findings. Every theme that emerged from the study is discussed in the light of the literature that confirms or counters the findings.

Chapter five: Conclusion

The concluding chapter presents a summary of the whole thesis. In this chapter, I draw from the findings to answer the research questions. I also present the significance of this study and the contributions it makes to the body of knowledge. Recommendations based on the findings of the study for future research are also presented.

1.15 SUMMARY OF THE CHAPTER

In chapter one, I briefly discussed my background and how it informed and prompted me to carry out this research, that is, to explore what learners are learning in their classrooms. I also discussed the importance of this study in addressing concerns about the South African Life Sciences curriculum as it relates to its mother discipline which is the Natural Science. In addition, I investigated the effect of current educational practice on learners.

In the next chapter, I will proceed to review the literature on Life Sciences and its nature and structure and how the knowledge of both the nature and structure influences our learning of science. In addition, I explore the literature on science learning and its implications.

Table 1.2: Research design and choices

Research design considerations		Choice(s) and its justification
	Research premises (paradigms)	
Ontological assumptions	Nominalist (subjectivist)	This research studies the perceptions of learners and is thus subjective. It is therefore informed by a nominalist assumption. This assumption infers that reality is a concept created by the mind. Hence, the truth is subjective. The research takes advantage of multiple participants.
Epistemological assumptions	Interpretative (from a socio-constructivist perspective)	I chose an interpretive epistemological assumption because this study explores the subjective perceptions of learners studying Life Sciences and how they interpret their educational experiences.
Methodological preferences	Ideographic approach	An idiographic approach studies a singular phenomenon. This approach enabled me to explore the learning experiences of learners studying Life Sciences in an in-depth manner.
Assumptions about human nature	Voluntarism	Voluntarism assumes that humans are free agents who have free will and who can make choices that overcome the influences of the environment.
	Mode of inquiry	
Qualitative mode of inquiry	Case study	I chose to perform a case study because this ensured an in-depth exploration of a bounded system. The bounded system in this study is the school and the learning experiences of the learners in the Life Sciences class.
	Site	
	High school in Pretoria	This school served as a representative of Gauteng high schools.
	Sampling	
Purposive sampling	Purposive	The samples were selected intentionally to address the research question and to generate information that would enhance the understanding of the central case.
	Data collection (methods, instruments and techniques)	
Observation	Non-participant and quasi-participant observation	I continuously observed the class as the subject teacher in a natural classroom setting.
	Observation: schedule, direct observation	Audio-visual recordings were occasionally carried out during educational events in the classroom that signified critical experiences.
	Recordings: audio-visual, field notes, reflective journal	Regular and frequent contemplative reflections regarding all aspects relevant to the research were made in a journal.

Table 1.2: Research design and choices (cont,d)

Research design considerations		Choice(s) and its justification
Data collection (methods, instruments and techniques) (cont'd)		
Interview	Open-ended questionnaire	This acted as the research tool for participant selection and allowed participants to respond with subjective perceptions.
	Semi-structured interview	This gave participants the opportunity to express themselves in detail and revealed other perspectives that the researcher may not have considered.
Data verification		
Qualitative	Trustworthiness Triangulation Peer examination Researcher bias	Trustworthiness and credibility are non-negotiable and therefore all emerging concepts and themes from the study were addressed accordingly.
My role as researcher		
Role of the researcher	Be a participant who acts as an observer Compile and manage all the observations Prepare, structure and conduct interviews Analyse and clarify the data Combine all the information into a logical research report	
Possible limitations and challenges		
Population/ location	Due to time and financial constraints, the study was conducted with Grade 8–12 learners in a high school in Pretoria which acted as a representative of all the high schools in Gauteng.	
Subject area	The study was conducted with learners in the Life Sciences class only and did not include all science learners.	
Pedagogical activities	The study addressed the perceptions of learners of the Life Sciences only. It did not cover aspects relating to environmental factors (facilities), learners' cognitive abilities or learning styles.	

CHAPTER TWO: LITERATURE STUDY

2.1 INTRODUCTION

In chapter one, I discussed extensively the CAPS (Life Sciences), its aims and structures in terms of the SCK and its assessment practices. CAPS is a summary of the subject and learning area statements, learning programme guidelines and subject assessment guidelines (DBE, 2018). It indicates what learners in South African schools should be learning in the Life Sciences classrooms. However, this study is not directly concerned with the teaching of the subject of Life Sciences; rather it queries exactly what it is that learners are supposed to be learning.

To build on this, chapter two explores the construction of scientific knowledge, as well as considering the literature on Life Sciences education, thus explicating its nature and structure. In this chapter, I further discuss how the nature and structure of Life Sciences could inform the type of educational approach used in the classroom, consequently shaping the perceptions of learners of Life Sciences education in recognising the subject as a part of their day-to-day living and as a scientific challenge.

Experiential learning theoretical framework that guides this research is discussed as a vital aspect of the research and literature reviewed. Experiential learning theory which claims that learners need to construct their own knowledge as they are exposed to reality is fundamental to scientific knowledge construction.

2.2 NATURE AND STRUCTURE OF NATURAL SCIENCE DISCIPLINES

During their education, teachers are expected to attain at least two types of knowledge. According to Lee, Capraro and Capraro (2018:75) and Schulman (1987:8), these are subject-content knowledge (SCK), which is knowledge of the subject that teachers are to teach, and pedagogical content knowledge (PCK), which is necessary for teaching the learners effectively. While it is important to make a distinction between these two types of knowledge, what is more important in education is the relationship that exists between them. It should be noted that a fundamental understanding of the nature and structure of the subject within the context of the overall teaching practices is required to make education credible.

Consensus on what constitutes the main branches of the sciences is unclear; however, it may be valuable to recognise the overall standpoint of science. This study is positioned within at least two of the major branches of sciences. These major branches include the Natural or Physical Sciences of which Life Sciences forms part, the Human or Social Sciences of which Education forms part and a third branch that is recognised as Mathematics and Logic. The focus of this section is on the Physical/Natural Sciences and education.

Biological science has been studied informally for a long time (Gunawardena, 2014; Johri & Bhattacharyya, 2006:28), but the earliest formal knowledge search started with natural philosophy which is the mother of all the sciences. The breaking away of other disciplines from natural philosophy was gradual and the separation of biological knowledge as a discipline took place in 1859, when the book *On the origin of species* by Charles Drawing was published (Rosenberg, 2012:4). Life Sciences as an academic discipline studies complex living systems, including the mutual ecological interactions between these systems and the associated abiotic environment. Owing to the complexity of the living system, the study of life does not follow the simple linear principles of cause and effect. The scientific study of nature is epitomised by detailed, unorganised inquiry processes that require deep thinking and are carried out usually in a messy manner (Deboer, 2006:17; Padilla, 2010).

2.2.1 Natural Sciences

In seeking to understand the world, Science with its ubiquitous nature cuts across all human undertakings (Harman & Dietrich, 2013:8). As emphasised by Sarton (Sarton, 2012: 2), Science is the active engagement of scientific inquiry and reasoning (National Research Council, 2007), which may involve solving innumerable problems of life. Empiricists, for instance Hume (in Rosenberg (2012:13), viewed natural scientific endeavours as direct experiences with natural phenomena, which in current science education terms are referred to as the engagement of scientific enquiry (Abd-El-Khalick, Boujaoude, Duschl, Lederman, Mamlok-Naaman, Hofstein et al., 2004; Padilla, 2010:8).

Lederman et al. (2017) differentiate knowing what scientific inquiry is all about from the practice of inquiry. Recently, in order to improve science education, inquiry, that is conducting inquiry, is inculcated in most educational curricula, yet many learners lack an understanding of what they do during this inquiry (Lederman et al., 2017). In most instances, learners follow specific steps and sequences during their investigations, as dictated in their practical manual. This stands to hinder critical thinking and creativity (Ozdemir & Dikici, 2017).

Lederman (2009) described scientific inquiry as science process skills with traditional science content, creativity and critical thinking to develop scientific knowledge with the aim of understanding certain natural phenomena. Knowledge established by the practice of science may enhance learners' application of the knowledge gained from these experiences in everyday life and in personal and societal decisions (Lederman et al., 2017). The possibility and importance of applying knowledge from natural sciences has been addressed by Degenaar (1983:86) and Sund and Trowbrige (1973:14), who indicate that natural scientific research should ultimately be practised to make positive contributions to the lives of human beings as scientific knowledge increases.

2.2.2 Construction of scientific knowledge

The *practice* of the natural sciences exists in the establishment of knowledge about natural phenomena via the application of natural scientific methodologies and the possibility of the *application* of scientific practice. Apart from having inquiry as an instructional means, it is crucial to know that scientific inquiry should stand as an outcome of science education, where learners get first-hand experience of the application of natural scientific methodologies in constructing scientific knowledge as the scientists do (Abd-El-Khalick et al., 2004). The epistemology of science and the way scientific knowledge is being generated is embedded in what Lederman (1992:332) refers to as the nature of science (NOS).

The practice of natural science and its application possibilities are interdependent. This interdependency is a result of the fact that the logic of practising natural science is rooted in the very knowledge that flows from studying natural phenomena (Abd-El-Khalick et al., 2015:510), which can be applied to improve the quality of the world via well-informed decisions (Sormunen.& Köksal, 2014:167; Lederman et al., 2017). This improved quality of life is nevertheless only possible when learners can relate what is learnt in the science classroom to their real-life experiences in order to take well-informed decisions and actions (Sormunen & Köksal, 2014:167; Anilan, Atalay & Kiliç, 2018:734).

Owing to the interdependency of the understanding of science, its practices (NOS) and its application (Abd-El-Khalick et al., 2015:510), natural sciences can therefore be summarised as fields of study in which there is a heuristic and explorative interaction with natural phenomena in order to explain or predict these phenomena with the aim of improving the quality of life for humankind (Abd-El-Khalick et al., 2015:510; Sormunen & Köksal, 2014:167).

Based on the practices of the NOS – observation, inquiry, amongst others – theories which are scientific knowledge or outcomes are developed through which the constituents of study can be described, hypothesised, verified against reality (constituents of study) and explained (Çibik, 2016:454). Consequently, natural scientific knowledge is established by transforming the constituents of studied natural phenomena to scientific knowledge constructs (Schwab 1958:72; Schwartz & Lederman, 2008:728; Abd-El-Khalick et al., 2015:510). This should also be the science that learners experience within the educational context (Abd-El-Khalick et al., 2004:398; Padilla, 2010:8–9), where there is an interplay of scientific practices and the development of scientific knowledge.

Having understood that the practice of the sciences (NOS) could be an instructional end product or a means of instruction (Abd-El-Khalick et al., 2004:398; Schwartz & Lederman, 2008:728) outside or within the school, it could therefore be assumed that both the process (scientific practices) and the product (scientific content or outcomes) play important roles in the learning of sciences. Hence, the following paragraphs focus on the nature and structure of Life Sciences as a natural scientific discipline.

2.3 LIFE SCIENCES KNOWLEDGE

It is difficult to define Life Sciences, possibly due to its rapidly evolving nature and structure. Therefore, to aid our understanding of Life Sciences, it is necessary to attempt to understand the construction of Life Sciences knowledge. This is rooted in an understanding of the nature and structure of Life Sciences, as well as its relationship with the education of Life Sciences (Bell, 2010:39).

The establishment of science knowledge has not changed much through the years except that it may occur much faster and be unanticipated. Scientific knowledge emerges when a certain phenomenon demands attention for a reason that is identified as an object for study (Lederman et al., 2017). Determining the terrain of study is done by demarcating the aspects of reality that represent the field being studied. Since phenomena within reality are varied and nuanced (Louw 1983:12–14; Leonelli, 2018:743) and can, therefore, appear in different shapes and forms, it is essential that the forms representing the object of study are identified, so that the scientist can obtain clarity over the aspects of reality that should be studied, in order to understand the identified object of the study.

However, the practice of science needs a starting point, which is the point of departure. Point of departure is identified within the demarcated study terrain (Louw 1983:14; Trujillo, 2014). Sonnekus and Ferreira (1981:31) explain that the point of departure of a scientific field has to be anchored in reality. According to Louw (1983:14), the point of departure should encompass the totality of the evidence for a certain phenomenon so that by studying this point of departure, the essence of the object of study can be described and explained scientifically. Therefore, the point of departure includes those phenomena that represent the essence of the object of study.

From the terrain of science, methodology (which also the scientific process of inquiry) is employed to enable the understanding of the object of study (Abd-El-Khalick et al., 2004:398). Lederman et al. (2017) explain that the methodology of the scientific field is not fixed or static but is determined by the unique nature of the phenomenon. The phenomenon itself, therefore, can be known via varied but field-specific methodology and in this way can determine the human actions necessary to unlock the understanding of that phenomenon. Hence, knowledge that describes and explains certain phenomena is generated through the application of field-specific methodologies. Scientific disciplines display a distinctive nature and structure in terms of their unique terrain, points of departure, field-specific methodologies and field-specific knowledge – this includes Life Sciences.

2.3.1 Life Sciences as a natural scientific discipline

The exact origin of Life Sciences is not easy to establish. However, signs of its existence have been recorded since antiquity (Leonelli, 2018; Mayr, 1982). Chinese

Taoist alchemists were known for their studies on plants, their production of medicinal cures for different ailments and diseases and their acupuncture, which are still relevant today (Little & Eichman, 2000:14). In addition, the ancient Aryuvedic Indians performed operations (Magner, 2002:9) despite having received no education to accomplish these (Sarton, 2012:31–34). Life Sciences was epitomised by unorganised inquiry processes that were usually carried out in a messy manner (Johri & Bhattacharya, 2006:x, 1). In ancient Greece, Aristotle's impact on Life Sciences was also in this vein; his search to solve the riddle about the existence of animals marked the first organised documented breakthrough in this field. We can therefore deduce that Life Sciences and its practice rests heavily on observation and the systematic comparative study of the organisms involved (Magner, 2002:29; Martinez, 2018).

Since prehistory, the construction of Life Science knowledge has taken place through observation that is powered by the innate curiosity in human beings (Johri & Bhattacharryya, 2006). However, such curiosity needs to be transformed into certain methodology in order for it to be accepted as a science, as is the case with the Life Sciences (Du Preez & Van Wyk, 2007:24–26). The Biological Science Curriculum Studies (2003) and many others such as the study by Ryke (1979:3) define Life Sciences as the study of life in all its manifestations, which includes the analytical study of living matter and the study of the origin, growth, support and activities of the great diversity of living organisms. Life Sciences as a scientific discipline therefore has the phenomenon of life as its object of study. In other words, the phenomenon of life constitutes the aspect of reality that is studied by Life Sciences. Studying the concrete terrain of living organisms implies the use of an empirical, field-specific methodology. Hence, knowledge of the phenomenon of life can be established and verified or tested in regard to the living reality through empirical research based on observation and experimentation. The establishment of Life Science knowledge consequently occurs via the integration of verified scientific knowledge based on constituents of living reality (Abd-El-Khalick et al., 2004:398; Schwartz & Lederman, 2008:728). Therefore, the totality of Life Sciences as a scientific discipline is concerned with describing and explaining the essence of the phenomenon of life by studying living organisms empirically.

Scientific disciplines, including Life Sciences, have developed from scientific practices like observation and calculated speculation to descriptive or correlational sciences and, to some extent, have developed into scientific knowledge (Schwab, 1958: 374–375; Lederman, 2009). Since Life Sciences stems from the human desire to understand living organisms and implies the study of the phenomenon of life, the development of Life Sciences into Life Science knowledge becomes apparent as human attempts to understand living organisms are analysed.

While the Life Sciences is a natural scientific discipline, it is also autonomous because of its distinctive nature and structure in terms of both its correlational and theoretical aspects. The unique nature and structure of Life Sciences as a scientific discipline is addressed in the following section.

2.4 UNIQUE NATURE AND STRUCTURE OF LIFE SCIENCES

Having discussed Life Sciences as a unique scientific discipline, it follows that it possesses its own unique nature and structure as do other disciplines. However, since the context of this study is that of the school Life Science, my discussion will be limited within the scope of Life Sciences as a school subject.

Schwab (1962:205) identifies the dual nature of the Life Science disciplinary structure as substantive and syntactical structure, the naming of which has evolved over the years. Recently, the literature, for example Lederman (2009), has referred to the terms as the “body of knowledge” of science and the “science process”. These two are interconnected in the unique nature of Life Sciences. Accordingly, I chose to address the two disciplinary structures in line with Lederman (2009) for the sake of simplicity and because these are the most recent terms.

2.4.1 The body of Life Science knowledge

The investigative nature of Life Science knowledge forms the basis of its tentativeness. The results of the investigation of the reality are accumulated as scientific discoveries and knowledge (Lederman & Niess, 1997:1), which are debated by the scientific community before publication in printed or electronic media (Schwartz & Lederman 2008:728). These results form the basis of scientific facts, concepts and conceptual frameworks, the three of which form the components of the substantive structure of

Life Sciences (Slabbert, 1984:12–15). The following paragraphs provide a brief description of the components of the body of Life Science knowledge.

Facts

Facts are specific, independent fragments of information (Van Dijk, 2019:90). The importance of facts as components of the Life Science knowledge structure is rooted in their function as the building blocks for Life Science concepts. Since Life Sciences is directed at the theoretical understanding of objects or phenomena, facts are only meaningful in terms of their contribution to theoretical understanding. It is important to note that facts, as in the naming of concrete observations of Life Science objects and phenomena (Life Science constituents), not only shape concepts but also form links between concepts as abstract, theoretical constructs and real phenomena and objects (constituents) related to the concepts. Flannery (1982:372) describes this coherence between facts and concepts as follows: "Concepts and theories are based on facts and are meaningless without them … Facts must be related to concepts and principles if they are to be meaningful." However, it is clear that the structure of Life Science knowledge is not organised in terms of these facts as isolated fragments of information but rather reveals a conceptual nature.

Concepts

Slabbert (1988:120) defines concepts as the classification of facts into particular categories in order for the underlying coherence to lead to a generalisation. From this definition, it is apparent that facts about a specific Life Science object or phenomenon can be coherently integrated in terms of a concept as a general and abstract category. In this form, facts serve as components of an ordered network of related concepts, principles, hypotheses and theories that meaningfully describes and explains the reality of Life Sciences.

Conceptual framework

Imenda (2014:189) defines a conceptual framework as "an end result of bringing together a number of related concepts to explain or predict a given event or give a broader understanding of the phenomenon of interest". A conceptual framework enhances an integrated understanding of factual concepts within a particular field of study, and as such may serve as the basis on which the content of a discipline is organised (Imenda, 2014:189). Consequently, it is evident that the conceptual framework of Life Sciences is established from higher-order concepts, namely generalisations, through the assimilation of Life Science facts and concepts into a coherent structure.

These three constructs of the body of Life Science knowledge – facts, concepts and a conceptual framework – are built up through a scientific process that rests heavily on the nature of science (Lederman & Neiss, 1997). The nature of science is the process involved in scientific knowledge construction (Lederman, 1992:331). The identified nature of the body of Life Science knowledge is epitomised in its empirical, socio-cultural nature which lead to creativity and imagination (Lederman, 1992; Jain, Abdullah & Lim, 2018:37).

2.4.1.1 Tentative character of the body of Life Science knowledge

Life Science knowledge should not be viewed as absolute truths (Schwartz & Lederman, 2008:728) about natural phenomena but as a logical synopsis of those statements that are considered to be the most probable explanations of Life Science phenomena at a certain period of time. Since the body of Life Science knowledge is empirical, socio-culturally embedded, and a product of creativity and imagination, the body of Life Science knowledge is tentative by nature (Schwartz & Lederman, 2008:728). A scientific investigation is conducted according to a naïve framework of knowledge and, as the investigation progresses, more knowledge is gathered about the object of study, study techniques are improved, and the researcher becomes aware of gaps in the existing knowledge structure. Collette and Chiappetta (1984:8) expanded the dynamic nature of the body of Life Science knowledge to a body of global natural scientific knowledge that is valid for the entire natural scientific community and not limited to a few researchers or research projects. The body of Life Science knowledge cannot thus be viewed as consisting of inalterable, dogmatic statements.

2.4.2 The process structure of Life Sciences

Schwab (1964:14) defined the process structure of a discipline as "the route or pathway by which the discipline moves from its raw data through a longer or shorter process of interpretation to its conclusion". Importantly, the route mentioned above encompasses a wide understanding that includes the totality of activities conducted in the development of the body of Life Science knowledge (Lederman, Gnanakkan, Bartels & Lederman, 2015:58).

The process structure of Life Sciences consists of all the methods that biological scientists employ during the process of scientific discovery. Lederman and Abell (2014), Lederman (2007), Matthews (2014) and others have summarised the competencies and methods generally used in this process. In the following sections, these procedures in relation to the knowledge statements that they generate will be discussed in the Life Science context.

2.4.2.1 Observation

The important role of observation in Life Science investigations is clearly demonstrated by Hutchinson (1983:64), who states that humans can obtain information about the world in which they live through the use of their senses. Through the observation of a Life Science phenomenon, relevant facts are obtained that serve as a basis for formulating possible explanations (hypotheses) for the studied phenomenon. Communication of the discoveries made during observations becomes crucial. Therefore, such communication is enabled via the use of distinctive terminology (Papenfus, 1981:88).

2.4.2.2 Establishment of terminology

Life Science terminology stems from the naming (via language) of subjective observations of Life Science phenomena. This naming is subsequently compared with field-specific norms to supply unambiguous meaning to the language used for observation. Despite the subjectivity of the observations made, biologists can communicate with each other in terms of the terminology formulated for the specific observations. According to Gardner (1975:11), the terminology is established by biologists by defining terminology in a specific manner. The naming of the observation is the first step in the establishment of concepts (conceptualisation), which in terms of the relationships between these concepts can be ultimately integrated to establish laws and theories.

2.4.2.3 Establishment of laws

According to Gardner (1975:14), laws make claims of association between concepts that are either directly or indirectly linked to observable phenomena. In regard to laws, the proposed associations between concepts can be verified by available and clearly observable observations or laboratory procedures. Therefore, laws can be viewed as generalisations that indicate the relationship between operationally definable concepts (Gardner, 1975:21).

2.4.2.4 Establishment of theories

Mannoia (1980:12–23) maintains that the establishment of theories can be explained in terms of three activities: discovery (the "imaginative episode"); prediction, and confirmation (the "critical episode"). He defines discovery as the activity through which observations can lead to the formulation of a problem and then to a possible answer (Mannoia, 1980). Therefore, discovery is an activity through which a researcher moves from specific observations to a theory by seeking explanations not only for a single observation but also for an assemblage of similar findings in general.

From the description of the procedures relevant to the discovery and verification of theories, certain heuristic activities can be identified that biologists must be able to master in order to execute these procedures, namely, the identification and formulation of problems, the gathering of existing knowledge, the formulation of possible solutions to these problems, the design and execution of investigations, the interpretation of data and the formulation of conclusions based on this interpretation. The following paragraphs focus on these aspects.

Identification and formulation of a problem

A natural scientific investigation is initiated by curiosity to know more about a phenomenon of which insufficient knowledge is available (Falk, 1980:17; Lederman, et al., 2014). Aclufi, (2005:30) describes the identification of a problem in terms of a discrepancy between the researcher's observations of the phenomenon and the existing knowledge about this phenomenon. Such conflict forces the researcher to formulate the problem accurately, isolating the key question implied by the problem.

Gathering of available existing knowledge

Even though scientists are in possession of certain applicable information based on their experience, more specific knowledge regarding the problem must be collected by consulting information sources and experts in the field (Aclufi, 2005:31).

Formulation of possible solutions (hypotheses) for problems

A hypothesis can be defined as a proposed, possible answer (solution) to a problem. Collette and Chiappetta (1984:11) emphasise the tentativeness of hypotheses (i.e. hypotheses are *possible* answers, not laying claim to a higher status until they have been subjected to testing). The work of Robinson (1965:48) made it clear that the establishment of hypotheses occurs through an action in which creativity and existing knowledge play important parts. Creativity is important since solutions are not elucidated automatically from empirical data. However, it should be noted that this creativity is carried out in correlation with the knowledge that the researcher already possesses. Meaningful creative thoughts are, therefore, dependent on an adequate theoretical background to the particular field of study. Since hypotheses are only possible answers to problems, they have to be tested against reality. To satisfy this verification requirement, the researcher must proceed to the planning and the execution of the most applicable ways in which these possible solutions can be tested.

The design and execution of investigations

The design and execution of Life Science investigations concern the selection, planning and execution of applicable verification procedures. Verification can occur via additional observations, experimentation (Collette & Chiappetta, 1984:11–12) and prediction (Mannoia, 1980:18–23). These three procedures are aimed at determining whether the stated hypotheses are able to satisfy the requirements of reality. Verification through additional observations is aimed at the collection of observations that support the stated hypothesis, whereas experimental verification procedures are used to determine the accuracy of a hypothesis, indicating a cause-and-effect relationship. After experimental verification has been conducted, applicable, logical conclusions can then be established from a theory.

Interpretation of data and the formulation of conclusions

On the one hand, the interpretation of data consists of forming a decision based on the results of the research and, on the other hand, forming a decision based on the known data and the tested hypothesis concerning the problem statement (Lederman, Lederman, Bartos, Bartels, Meyer & Schwartz, 2014:70). In regard to Life Sciences, the following heuristic skills and techniques are considered field-specific skills and techniques: observation; recording and collection; techniques for handling apparatus, instruments and material; manufacturing processes; examination of organisms; microscopy; dissection; and experimentation.

Figure 2.1 below presents a graphical representation of Life Science nature and structure.

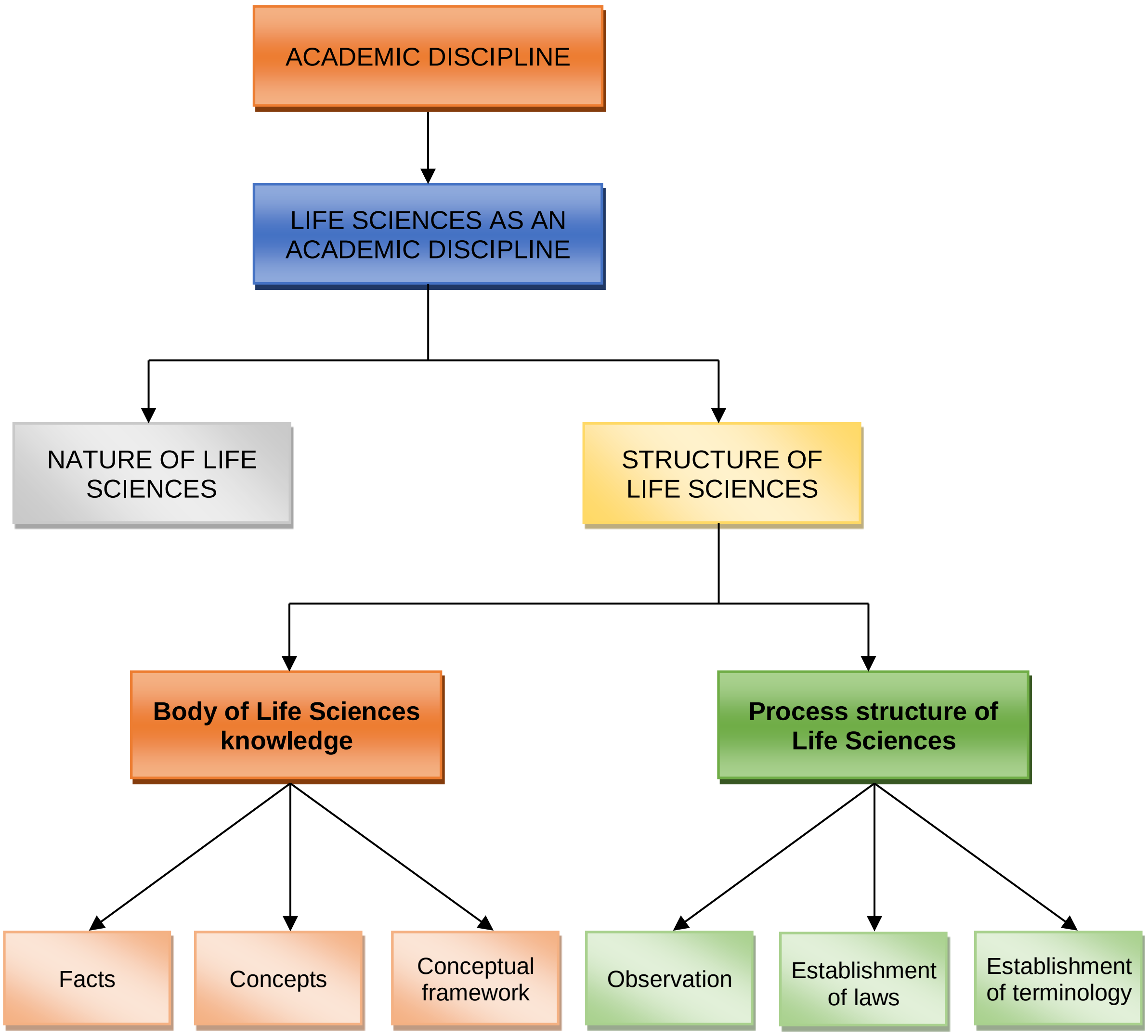

Figure 2.1: Graphical representations of Life Sciences' nature and structure

2.5 SYNTHESIS OF THE NATURE AND STRUCTURE OF LIFE SCIENCES

From the preceding paragraphs it is evident that Life Sciences is a natural scientific discipline in its own right in which attempts are made to describe and explain the essence of the phenomenon of life. Life Sciences reality is knowable in terms of facts, concepts and a conceptual framework (body of knowledge); these are constructed through the execution of the process skills (scientific process structure) of the Life Sciences. Through the observation of Life Science reality, gaps in its body of knowledge can be identified. Such gaps are formulated as problems for which empirically verifiable solutions are sought. Life Sciences, therefore, reveals a heuristic nature, which implies that investigative procedures are ultimately used to understand Life Science reality.

2.6 RELATIONSHIP BETWEEN THE NATURE AND STRUCTURE OF LIFE SCIENCES AND LIFE SCIENCE EDUCATION

From this paragraph forward, I turn my focus from the nature and structure of Life Sciences to identify the fundamental relationship between Life Sciences and Life Science education. To achieve this, I make reference to our current education as it manifests in practice.

2.6.1 How do our dominant education practices affect our perception of education?

Whether intended or not, our dominant education practices appear to revolve around the knowledge and skills that learners need to acquire (Mnguni, 2013:8). Teachers therefore employ various strategies and methods through which knowledge is transferred to their learners. Where there is a lack of knowledge acquisition by the learners, teachers may employ lecturing (Smith, Rayfield & McKim, 2015), explanations (Rittle-Johnson, Loehr & Durkin, 2017:599), demonstration (Chen, 2016:860), the use of video (Bétrancourt & Benetos, 2018:471) and film (Marcus, Metzger, Paxton & Stoddard, 2018) for more accurate learning and will expect a reciprocally accurate reproduction of the knowledge by learners as evidence of their learning. Rather than placing value on the understanding and promoting of reasoning skills and attitudes, value is placed upon the marks and outcomes of tests and examinations (Harlen, Derek, Rosa, Hubert, Guillermo, Pierre, Robin, Michael, Patricia & Wei 2010:3).

If a school subject has a ‘practical’ component such as executing an investigation or an experiment in the Life Sciences, this practical component is ‘taught’ by the teacher as steps to follow (cf. observatory note I in addendum O) and/or to satisfy the teacher’s conscience that the curriculum has been completed (Kibirige & Teffo, 2014). The curriculum and the value placed on marks therefore places demand upon the teachers to meet the specific knowledge area that fits the expected area of learning (Herlen et al., 2010:3). It thus seems as if learners are prepared for a certain set of knowledge rather than holistically empowering them for now and the future. Therefore, the value of education unknowingly becomes narrowed towards acquisition of knowledge as against what is relevant to learners' everyday lives (Herlen et al., 2010:2). High priority placed upon outcomes of tests and examinations consequently, most often, dictate what informs both teacher and learner actions (Herlen et al., 2010:2.

The issue of what counts as knowledge in schools and how best knowledge can be transmitted has been a concern for curriculum developers (Bruner, 1960:3; Bernstein, 1990: 116). The vague understanding of what the nature of knowledge is and how school knowledge can be presented to and acquired by learners is considered as a threat to the quality of education (Bernstein, 1990:176)

In all education, the aim is to ensure that learners gain knowledge (Barnett, 2007:164; Lundgren, 2015), and our current education is well tailored for this “learning-to-know” purpose (DBE, 2011:10; Mnguni, 2013:6–7). Even within this learning-to-know education paradigm, it cannot be disputed that the knowledge that needs to be acquired “should not be superficial but is supposed to have qualities of personal insight and understanding” (Barnett, 2007:164). This statement demonstrates that knowledge possesses certain ‘qualities’ that are attributed to it by learners.

According to the work of Harlen et al., (2010; 2015), the recognition and integration of the “big idea” of science is important in the quality of knowledge required for adequate preparation of learners for the future. In their work, they emphasize the multiple goals of science which are highlighted as:

- understanding of a set of ‘big ideas’ in science which include **ideas of science** and **ideas about science** and **its role in society**
- scientific capabilities concerned with gathering and using evidence
- scientific attitudes (Harlen et al., 2015:7)

They identified ideas of science as scientific knowledge that is known and can be passed on to learners such as “all materials…is made up of small particles” (Herlen et al., 2010:preface), “genetic information is passed down from one generation of organism to another” (Herlen et al., 2010:preface). While the ideas about science depicts the tentativeness of scientific knowledge and that science has impact on every facet of human living, the third big idea is that science has a place in the society, even in our everyday life. The last two of these ‘big ideas’, often seem to be neglected as concurred by Barnett, (2007).

Strong argument has been and is still ongoing in the literature about what fundamental knowledge is essential for learners (Bruner, 1960:2–3; Young, 2013; Beck 2013; Lundgren, 2015). Academic disciplines have to be recontextualised in the curriculum as school subjects (Young, 2013; Bernstein, 1990). Re-contextualising disciplinary knowledge, according to Bernstein (1996:47), demands the pedagogising of that knowledge from its point of production (universities or scientific institutes) to where it can be related to other forms of knowledge. However, Young (2013:101) found it important that, while re-contextualising academic discipline in the curriculum, “what learners are entitled to” should be fundamental. He makes the point that disciplinary knowledge is the entitlement of learners (Deng, 2015:773; Young, 2013:101).

In line with Young, Beck (2013) explains that disciplinary knowledge production emerges basically from two sources: knowledge emanating from the mundane and esoteric knowledge. Esoteric knowledge comprises facts, which are generated from the disciplinary body of knowledge and research. Addressing disciplinary knowledge as ‘esoteric’, Young distinguishes between everyday knowledge and disciplinary knowledge (Young, 2013). He argues that learning disciplinary knowledge passed down by the experts is not learning the curriculum of the past (Young, 2013).

However, Lundgren (2015) in his interesting counter argument, explains that education is radically different from teaching, though the two are interdependent. He claims that teaching is a day-to-day process of enacting the curriculum, while education is an overarching process of cultivating the human mind. From Herbert's (1806) point of view, he (Lundgren, 2015) argues that educating with disciplinary methods (that is, without re-contextualisation) is ineffective, and teaching without education will imply training learners to be passive receiver of knowledge (information).

Lundgren (2015) also emphasised that the curriculum is the means (responsible) to empower learners with knowledge and a frame of reference for *the demands of the future* (emphasis is mine). Therefore, he argues that Herbert's stance on teaching integrated with educational process is one that prepares learners for an unknown future.

Given that as we are currently experiencing rapid changes in our world and the system seems unpredictable, I would rather advocate for learning that prepares one for the unknowable future in which both every day and disciplinary knowledge is synergised for better future citizens.

Besides insight and understanding as human qualities, the elaborative, qualitative dimension of knowledge is emphasised by Davenport and Prusak (1998:5) in their most quoted definition: "Knowledge is a fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information." Halbwrigth and Toohey (2015:247) argue that knowledge transfer that it is not a single conveyance of information is a product of a complex knowledge generation process.

Within the context of Davenport and Prusak's (1998:5) knowledge definition, the statement of Von Glasersfeld (2008:48) that "knowledge is not a transferable commodity and communication not a conveyance" is profound because of the impossibility of transmitting the inherent personal, qualitative, experiential dimension of knowledge. Therefore, what is transmitted in education is not – and cannot be – knowledge but information. Information is, at best, only a tacit construction of a representation of an aspect of the subject together with the personal knowledge of the author/producer of the knowledge, devoid of all the qualities of personal experience in which its meaning (e.g. insight and understanding) is manifested.

2.6.2 What are the consequences of our information-based education?

Regarding education that is based on a compilation of fragmented bits of information, Slattery (2006:xii) declares: “When educational scientists divided knowledge into bite-sized chocolate morsels, meaning was destroyed.” Despite this fact, we persist in our ways: “Formal education on all levels focuses on the least valuable inputs, data and information” (Ackoff & Greenberg, 2008:7).

In this sense, there is the widespread fragmentation of knowledge, information divided into bits. Fragmentation has been considered as a concern not only in the education sector but also by society at large. School tests and examinations are often based upon questions which are disjointed from one another (Harlen et al., 2010:3). Fragmented knowledge hinders learners’ meaning making; it engenders a lack of connection in the concept of subject knowledge that is to be mastered (Sorgo & Siling, 2017). Apart from this, the memory can only accommodate a few bits of knowledge; hence, knowledge relayed in bits might lose its essence and could be easily forgotten.

2.6.3 What is education for?

In addition to the argument of Young (2013) and Lundgreen (2015) as mentioned previously, it is crucial that education influences our very being. Science learning should not be regarded as the assimilation of facts that has been established by scientists but should be regarded as an overarching process which comprises the understanding of concepts, their application in life as well as the attitudes that accompany it (Harlen et al., 2015:8). According to Barnett (2007:18), we have an ontological will to learn. Why do we possess such a relenting foundational disposition? Certainly, we need to make sense of the world around us since we are living in this world but much more importantly, we need to make sense of ourselves if we are to have a meaningful relationship with ourselves. Barnett (2007:40) maintains that authenticity is perhaps the key concept within the deep structure of education. Our ontological quest is to reclaim our authenticity, and this must be “fought for, won and sustained” (Ackoff & Greenberg, 2008:14). In this regard, Ackoff and Greenberg (2008:14) state: “Education, then, is a lifelong enterprise enhanced by an environment that supports or, more precisely, ‘nourishes’ to the greatest extent possible the attempts of all people to ‘find themselves’ throughout their lives.” Our authenticity defines who we really are and what we are capable of and establishes our ultimate purpose. Not only do we have the potential to become our authentic self, but we are also fashioned with the will to accomplish it. However, fulfilling our potential is not an option; it is an ethical imperative because failing to do so is too devastating to contemplate:

> According to some of the most distinguished and thoughtful students of the mind, one of the most devastating things that can happen to anyone is to fail to fulfil his potential. A kind of gnawing emptiness, longing, frustration and displaced anger takes over. When this occurs, whether the anger is turned inward on the self or outward towards others, dreadful destruction results (Hall, 1976:4).

Unfortunately, it seems that this description of Hall (1976) is evident in society in the consequences of people failing to fulfil their potential and/or abusing it for selfish gain; both of these result in the subsequent annihilation of society and the world at large. This is where the essence of educational intervention has an impact. Barnett (2007:7) emphatically states that "knowledge" and "skills" would not adequately offer us a sufficient set of ideas for education in the 21st century. At best, they only offer two pillars of an educational project: "By themselves, these two pillars, which we may label the epistemological and practical pillars, will topple over: they need (at least) a third pillar – the ontological pillar – to ensure any kind of stable structure" (Barnett, 2007:7). Banerjee (2016) found that graduates with excellent academic performance (knowledge and skills) lack the basic personal human attributes that have become key requirements for human flourishing and real-life employability for blue-collar workers and CEOs alike. Even though excellent knowledge and skills are available, human "dispositions and qualities are durable in their nature" (Barnett, 2007:102) and constitute the learner's pedagogical being. It is these human dispositions and qualities that have to be the focus of "teaching" (Barnett, 2007:102). If authenticity has to be the focus of education, how should knowledge be acquired?

2.6.4 How should knowledge be acquired?

The acquisition of knowledge has become a contentious issue, especially in view of the sociology of knowledge that differentiates between knowledge of the powerful and powerful knowledge and addresses the concept of differentiation of knowledge as in disciplinary knowledge, school (specialist) knowledge and everyday knowledge, as well as context-dependent and context-independent knowledge (Young, 2007; Young, Lambert, Roberts & Roberts, 2014; Young & Muller, 2015). The major argument is that all knowledge is not equally accessible to everyone and since this is the case, knowledge that is inaccessible (e.g. in disadvantaged communities) should be made accessible through pedagogies of transmission deemed to be socially just pedagogies. Unfortunately, although pedagogies of transmission may be socially justified for accessing knowledge, they cling to the vestige of knowledge for its own sake, thus excluding the cultivation of human qualities and dispositions as a central concern (Deng, 2009, 2017). In this sense, its resultant educational deficiencies are not only educationally unjustified but also professionally unethical (Bloch, 2009), as indicated in the previous paragraphs. Within the context of pedagogies of transmission, these deficiencies could possibly be best depicted by the following description of teaching:

> [T]eaching is an unnatural act, an incursion on another person's learning in progress … with a built-in demand that they stop thinking … that defines 'learning' as 'students memorizing my understandings' instead of constructing their own … teaching is, no doubt, an imposition, a sustained redirection of other curious creatures' voracious cogitation (Kersson-Grieb, 2006:6).

Conversely, Barnett (2007:164) states the following about the acquisition of knowledge through the process of learning: "'Learning, therefore, becomes a complex matter. It is to have *'depth*' [quality] and is certainly not to be a mere acquisition of knowledge". In fact, Von Glasersfeld (2008:38) states that "[k]nowledge is not a transferable commodity and communication not a conveyance". Heyligen (1997:1) confirms that "[k]nowledge can, therefore, not be transferred or transmitted through teaching or instruction". The constructivist view of learning is the construction of meaning by the learner through experience, with the learner subsequently being able to use it to do something creatively new (Von Glasersfeld, Ackermann, Kenny & Forman, 2011). Constructivism has surpassed the notion of being a convenient learning theory. Biological, physiological, neurological and neuroscientific evidence supports the constructivist view that

> … when children are exploring, experimenting, making their own discoveries, as they are innately impelled to do, their natural [neurological] structures are

> growing and connecting. These physical structures are the new higher-level knowledge and skills they are acquiring (Smilkstein, 2011:76).

2.6.5 What are the conditions for the construction of knowledge?

In order to answer this question, it is necessary to refer to our ontological being again. Even while a child is in the womb, it is bombarded with an unimaginable multitude of stimuli. When the child is eventually released from the relative security of the womb, the stimuli with which it must cope must be completely overwhelming. Yet, the child cannot be completely protected from the uncompromising super complexity it is born into. Instead of shying away from such a challenging environment, the child deliberately reaches out and explores its environment for no other reason than to make sense of it in order to live appropriately in it.

Without knowing how, without any necessity of knowing what it is called and without a teacher to teach this, children spontaneously explore, experiment, discover and engage with things around them in order to construct their meaning, the extent of which is completely underestimated. Children espouse these inherent qualities because their whole life is a unifying phenomenon in which no fragmental separation exists within their experience of the world as a holistic, interconnected unit. This is the reason for the following statement:

> Complex problem-solving is natural to children. From the moment of birth, nearly all their activity relates to a vast number of interrelated real-life problems. With each passing month, the number and complexity of the problems they face increase (Ackoff & Greenberg, 2008:29).

At the moment, our dominant education practices seem to represent a deficiency approach, that is, children are perceived to be deficient in their being. They need to acquire knowledge to conquer their deficiencies. We need to recognise the exceptional potential that children inherently possess and redefine our educational approach to an asset approach, in order to maximize their innate potential (Lipman, 2003:267–268). Therefore, the challenge to education is the following:

> [S]tudents [even on an elementary school level] should become ‘active learners’, capable of solving complex problems and constructing meaning

> that is grounded in real-world experience … It emphasizes that all instructional activities must be rooted in a primary concern for high standards of intellectual quality (Newmann, Mark & Gomoram, 1996:1).

As children grow older, the complexity of the stimuli exposed to from the external environment in the form of school subjects increases, as do the experiences of that environment. This is aptly described below:

> Infinite is the number of levels through which reality manifests – from the macro level of the whole universe to the micro level of a single quark. And all these levels project on human experience – not only because everything relates to everything else in the impossible-to-separate web of existential dynamics, but also it is because of our experience that we can grasp the meaning of the manifestations of these dynamics and ride on their inexhaustible power. We are endowed with a limitless potential to sense – recognise and understand – the meaning of the events of our experience. In every creative act of realization of this potential, a level of reality opens some of its secret to us (Dimitrov & Wilson, 2013:48).

Small children directly confront the challenges of their complex environment without inhibitions and succeed because they have access to their full authentic potential. As age increases, it becomes increasingly difficult to honour one's authenticity due to the escalating onslaught of conformation and the subsequent loss of authentic identity. Our inherent joy is replaced by discontentment in some form and at some level due to inauthentic beliefs of who we really are. It thus becomes imperative for each one of us to engage continually in the special type of work required to pursue our authenticity.

The keyword that indicates the relationship between our external and internal environment is experience. It is this concept in education that requires a more intentional exploration.

2.7 LEARNERS' PERCEPTIONS OF LIFE SCIENCES

Life Sciences is rich in its application to everyday usefulness, although this may not be acknowledged by many people (Sadler, Coyle, Smith, Miller, Mintzes, Tanner et al., 2013). Most of our daily activities, as related to the food we eat and the health-related choices we make like those pertaining to exercise and hygiene, draw heavily on basic knowledge of Life Sciences. Understanding Life Science knowledge can be described with respect to three areas of the learners' lives, namely, academic achievement, which is the mastery of Life Science content; engaging in Life Sciences beyond and outside the school level and application of Life Science concepts in issues of everyday life (Martin, Durksen, Williamson, Kiss & Ginns, 2016). The ability to apply Life Science concepts in daily life does not come automatically. Therefore, the extent to which learners can transfer knowledge to new terrain is a reflection of how deeply they understand the concepts.

Durmaz (2007) reports that biology (Life Sciences) concepts are perceived by learners as abstract in nature, consequently encouraging memorisation of the subject content instead of striving for a deep understanding of concepts. According to Orton, Anggoro and Jee (2012), it may be difficult to access the deep meaning and gain an understanding of some scientific concepts owing to their abstract nature. However, the quality of the constructed knowledge depends heavily on how deep the learners' understanding of concepts is and how such conceptualised knowledge can be transferred to everyday use (Martin et al., 2016:1365).

Since the reproduction of learnt knowledge, that is, the mastery of the Life Science content knowledge, is the most prevalent assessment practice, learners' factual understanding of the subject seems to be applauded at the expense of a conceptual understanding of Life Science principles. Sadler et al. (2013) found assessment based on factual understanding to be the easiest and cheapest assessment method, hence the possibility of its ubiquity. Prioritising content knowledge in assessment (Sadler et al, 2013) could lead to a superficial understanding of concepts.

Conceptual understanding of Life Sciences is required in novel situations (Martin et al., 2016:1365) because life is dynamic and issues pertaining to it are ever changing due to the complexity of real life. In most cases, it is difficult to recall memorised content knowledge in an unfamiliar situation if learnt for the purpose of content only. Contrary to the belief that the Life Sciences is an abstract subject in a traditional classroom setting (Orton et al., 2012), it is being appreciated that the subject has everyday life applicability (Martin et al., 2016:1365).

Knowledge is fundamentally rooted in experience; therefore, experience and knowledge are two inseparable crucial entities for learning. The pursuit of mental intelligence leaves some aspects of learners un-developed (Kersson-Grieb, 2006:6; Smilkstein, 2011:76). Knowledge is accessed when "we can grasp the meaning of the manifestations of these dynamics" (Dimitrov & Wilson, 2013:48) of the real-life experiences. It is easier to have memory recall of what is handled and experienced. Martin et al. (2016:1365) attest to improved content knowledge recall in regard to learners' motivations in situations where learning occurred by practically experiencing the reality of what is being learnt.

2.7.1 Role of perception in educational success

The quality of learners' learning experience depends on their perception of their studies and the subject in particular (Ekici, 2010; Etobro & Fabinu, 2017:140-141). Perception shapes and informs learners' motivation or de-motivation in learning (Bulut & Üğüten, 2003). Although many researchers assert that it is not uncommon that learners find science subjects difficult (Coe, Searle, Barmby, Jones & Higgins, 2008), Life Sciences included, it is important to note that learners' perceptions of how difficult the subject is and their confidence in achieving success is very much dependent on their learning experience and the learning process (curriculum, instructional strategies, environment and facilities). Martin et al. (2016:1366) state that the instructional strategy used by the teacher is vital for the way in which learners perceive the purpose of the subject. The paragraphs above explain the purpose of our education system as to the finding of our authentic selves as we directly engage in the learning process. Bulut and Üğüten (2003) argue that when perception of learners is not well aligned with the purpose of the subject, then learners' concerted effort in their learning process could be hindered. Halim, Abdullah and Meerah (2014:228) acknowledge that learners' perceptions to a large extent influence their learning processes.

2.8 EXPERIENCE AND EDUCATION

Knowledge and experience are inextricably linked. However, in order to clarify this relationship, I refer to Dewey (1929) who maintains that experience and nature are in a harmonious relationship

> … wherein experience presents itself as the method, and the only method, for getting at nature, penetrating its secrets, and wherein nature empirically disclosed (by the use of empirical method in natural science) deepens, enriches and directs the further development of experience (Dewey, 1929:5–6).

He continues:

> In the natural sciences, there is a union of experience and nature … the inquirer must use empirical method if his findings are to be treated as genuinely scientific. The investigator assumes as a matter of course that experience, controlled in specifiable ways, is the avenue that leads to the facts and laws of nature. He uses reason and calculation freely: he could not get along without them. But he sees to it that ventures of this theoretical sort start from and terminate in directly experienced subject-matter. Theory may intervene in a long course of reasoning, many portions of which are remote from what is directly experienced. But the vine of pendant theory is attached at both ends to the pillars of observed subject matter. And this experienced material is the same for the scientific man and the man in the street. The latter cannot follow the intervening reasoning without special preparation. But stars, rocks, trees and creeping things are the same material for both (Dewey, 1929:5–6).

Therefore, in studying the Natural Sciences and subsequently the Life Sciences as subject in school, what is important is that the reality we belong to, the reality that we long to know extends far beyond human beings who interact with each other. In Life Sciences, we interact with non-human, living and non-living beings that are as important and as powerful as we are – and sometimes much more so.

In view of the centrality of experience, it may be important to have a clear explication of experience as it was originally conceptualised by Dewey (1938) and later differentiated by Hohr (2013). To arrive at some form of consensus regarding this contentious concept, I have summarised its characteristics as follows:

- **Enliving.** This represents the aesthetic or perception dimension of an experience when an object or an event in the real world evokes an intentional perception thereof through a form of direct, concrete, ‘hands-on’, immediate contact with the object or through engagement with the event (unless inappropriate for some reason) that has at least initially, a pleasurable (or painful), ineffable, holistic, relational and transcendental sensation as a result.

- **Feeling.** Feeling refers to the basic mode of experience where action, emotion, cognition and communication constitute an original unity with a certain distance that emerges between action, emotion and cognition that allows for contemplation and choice to occur.

- **Conceiving.** The isolated and abstract understanding of the world with even greater distance between action, emotion and cognition.

This centrality of experience in education imposes the recognition of the dimensions that constitute us as humans. This is encapsulated by the words of Soren Kierkegaard who said: “Life is not a problem to be solved but reality to be experienced.” Dimitrov and Wilson (2002:48) indicate that our education systems are primarily directed to target the limited mental faculties of the learners’ *minds* in terms of knowledge acquisition and reproduction, of which the access is severely limited to a relatively passive seeing and hearing sense perception of the *body* to what is presented and transmitted. Even if the faculties of the body and mind operate at an optimal level, “[they] can only see a part of the holistic picture of reality” (Dimitrov & Wilson, 2002:48). The question is how do we attain the holistically integrated picture of reality, that is, the whole of reality? Dimitrov and Wilson (2002) claim that there is a solution:

> Unfortunately, our systems of education do not teach us how to listen to and understand the ‘voice’ of our experience. Often, this voice appears too subtle, to minds (Dimitrov & Wilson, 2002:48).

It is, therefore, critical to explore what is meant by “the ‘voice’ of our experience” (Dimitrov & Wilson, 2002:48). If our body and mind is capable of providing us with, at best, only a partial model of reality, what else is needed to make the model whole? Besides body and mind, what else constitutes human nature? This is a déjà vu experience in this study, since it reminds me of the quote from Barnett (2007:7) which states that knowledge, epistemology and skills cannot begin to offer us a set of ideas for education in the 21st century. We need at least a third pillar, the ontological pillar, to have any kind of stable structure, since without this the structure of human nature is non-existent. The overwhelming challenges of the uncompromising super complexity of the world that we are living in reflect our physical, mental, emotional and spiritual nature and demonstrate that we are capable of creating order on a higher level of consciousness, a higher level of being human that transcends the existential chaos. However, learning becomes possible if factors responsible for the integrity of all inseparable entities in human individuality (body, mind, soul and spirit) are simultaneously activated (Slabbert et al., 2009). This is the essence of human experience and the ‘voice’ that learners need to access. The unlocking of human (learners in this context) ability can only be achieved by education that addresses the four vital constituents of human nature.

2.9 THE THEORETICAL FRAMEWORK PERTAINING TO THIS STUDY

From the preceding paragraphs, a framework pertaining to this study has been slowly emerging. As the preceding paragraphs have revealed, experience seems to be pivotal to such a framework. Since this experience refers to that of the learners, the relationship with the learning of the learners is evident. However, the question as to how this educational learning experience relates to the nature and structure of Life Sciences has to be explicated. For this purpose, we need to refer back to Life Sciences as an academic discipline and realise that its nature in terms of observation, exploration, examination, investigation, experimentation and discovery must also define the nature of Life Sciences as a school subject. All of these actions are, no doubt, experiential in nature. Accordingly, the same should apply to the relationship with the *structure* of the academic discipline and the school subject. Most significantly, however, it is the relationship between the body of Life Science knowledge and the process structure of Life Sciences that is of decisive importance. For this, we need to recall this relationship from our exploration of this matter in section 2.4.1. This conclusion about the investigation of the relationship in question indicates that the body of Life Science knowledge comes into being through its process structure. Although the body of Life Science knowledge may ignite its process structure into action, it is the objective verdict of Dewey (1929:5–6) that affirms this relationship.

In the natural sciences, there is a union of experience and nature; the inquirer needs to use an empirical method to ensure that the findings are treated as genuinely scientific. The investigator assumes as a matter of course that experience controlled in specifiable ways is the avenue that leads to the facts and laws of nature. The investigator uses reason and calculation freely and cannot manage without them. But sees to it that ventures of this theoretical sort start from and terminate in directly experienced subject matter. Theory may intervene in a long course of reasoning, with many portions being remote from what is directly experienced. However, the validity of the theory is attached to the pillars of the observed subject matter.

There can, therefore, be no doubt that the process skills of Life Sciences that are derived from the process structure of its mother academic discipline provide the experience required for Life Sciences as a school subject to maintain its integrity as 'genuinely scientific'. In addition, there can be no denial that experience has to be pivotal in the construction of a theoretical framework for a study.

2.9.1 Experiential learning

It is the centrality of experience in education in general, the natural sciences in particular and in this study, the Life Sciences, that have brought experiential learning with Kolb's (1984) experiential learning theory (ELT) into sharp focus. Experiential learning is the pragmatic means of knowledge acquisition (Petkus 2000). Although influenced by the experiential work of Dewey (1938), as well as researchers such as Lewin (1951), Piaget (1950), Freire (1971), Vygotsky (1978), and James (1908), what is crucial about ELT is the way in which it started. Kolb began by asking key questions regarding the nature of the learning phenomenon as a process beyond the confines of an institution or type or level of learning and found that *experience* is the basis for learning. Experience may be described as *an individual's, personal, concrete, direct, hands-on (physical, mental, emotional, spiritual), active, participative interaction* with what is to be learnt. Kolb (1984) postulated his learning theory as follows:

> Learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience. This definition emphasises several critical aspects of learning as viewed from the experiential perspective. First is the emphasis on the process of adaptation and learning as opposed to

content or outcomes. Second is that knowledge is a transformation process, being continuously created and recreated, not an independent entity to be acquired or transmitted. Third, learning transforms experience in both its objective and subjective forms. Finally, to understand learning, we must understand the nature of knowledge, and vice versa (Kolb, 1984:41).

Central to this learning theory is the notion that learning takes place in four major stages which Kolb (1984) called concrete experience, reflective observation, abstract conceptualisation and active experimentation. Figure 2.2 is a schematic representation of Kolb's (1984) experiential learning cycle.

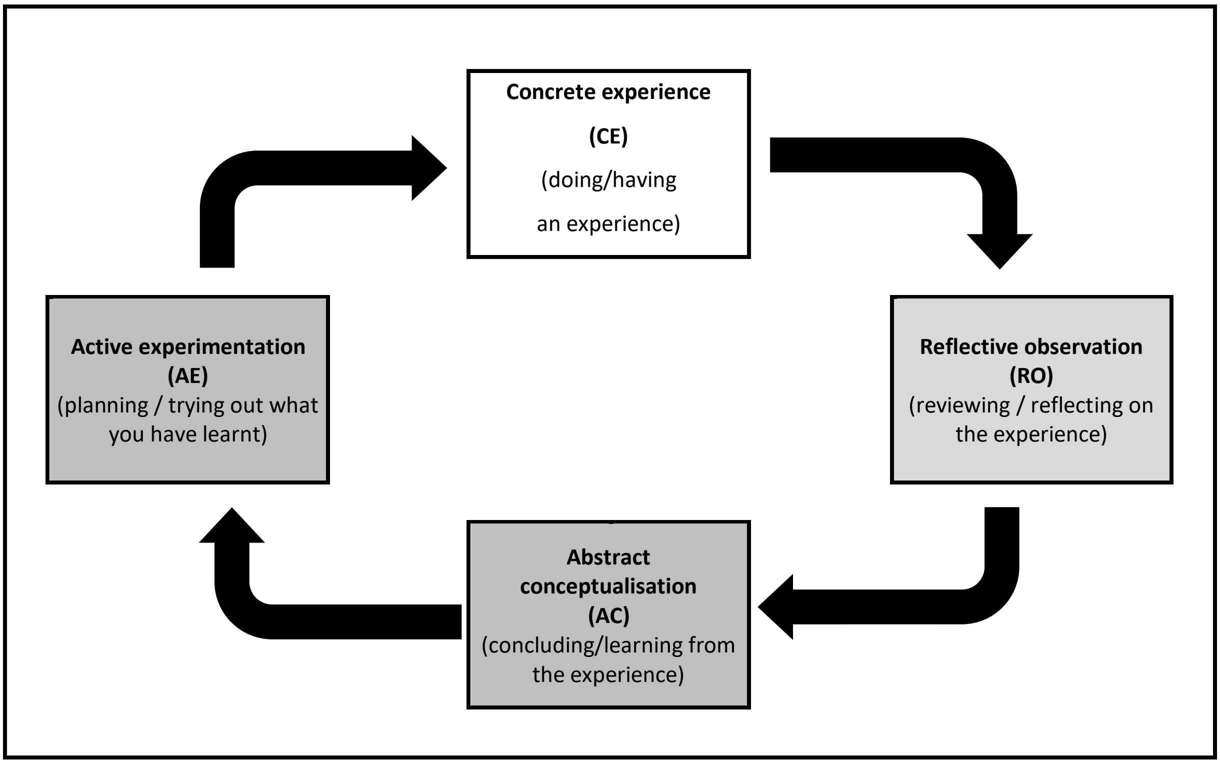

Figure 2.2: Kolb's (1984:76) experiential learning cycle

2.10 CONCLUSION

In this chapter, I discussed the emergence of Life Sciences as a branch discipline of its mother discipline, natural science. Life Sciences as a discipline developed its own unique, explorative, field-specific methodology through the years, and this was greatly defined by the discipline's nature and the consequent development of its structure. The structure of the Life Science discipline is rooted in the explorative experience of the phenomenon, which is life. Structure of Life Science demands different heuristic procedures such as the identification and formulation of a problem, the collection of available knowledge on the problem, the formulation of possible solutions, the design and execution of investigations that lead to conclusions and application of heuristic and field-specific skills to understand the living system.

I also explained the implications of the heuristic nature of Life Sciences in effectively achieving the aim of Life Science education as asserted by Slabbert (2015:132): empowering learners to maximise their potential to achieve “a safe, sustainable, and flourishing future for all” as opposed to the current traditional education.

This study is informed by Kolb’s experiential learning theory (Kolb & Kolb, 2005:207). Active learning is core to the heuristic practices of the Life Sciences and it demands that learners are actively engaged in tasks that encourage the practical operation of learning activity (Furman & Sibthorp, 2013:17). Life Sciences is basically the experiential acquisition of knowledge. Essentially, the construction of Life Sciences thrives on a practical search for knowledge and reflection on meaning(s) that is being constructed as learners engage in finding solutions to real-life problems observed in the living world.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

In Chapter 2, I provided an overview of the literature on the construction of Life Science knowledge, its nature and structure, and its implications for learning and doing science. I also went further to discuss in detail the theoretical framework that guides this study.

In this chapter, I discuss the methodology that was employed during this research. Methodology, as described by Babbie (2013:4), is the “science of finding out; procedures for scientific investigation". Birks and Mills (2011:4) explain methodology as a set of principles and ideas that inform the design of a study. With the view of Babbie (2013:4) and Birks and Mills (2011:4) in mind, methodology should therefore be able to lead the research to answering the research questions. This chapter describes my paradigmatic stance, as well as the mode of inquiry, site selection, selection of participants and rationale for these choices. It further discusses the data gathering and data analysis processes.

3.2 KEY CONCEPTS IN THE STUDY

The following paragraphs describe the concepts that are central to this chapter. The concepts are the prevailing terms represented in this chapter.

3.2.1 Experiential learning

This is an active knowledge acquisition process (Sharlanova, 2004). Experiential learning engages learners actively in activities that drive concepts and facilitates reflection on the activities in order to make meaning of their learning (Furman & Sibthrop, 2013:17). David Kolb, who is the proponent of this learning theory, describes experiential learning in a cycle of four stages:

First stage – concrete experience, which means that learners are immersed in a real authentic learning situation where they engage in doing some activities.

Second stage – reflective observation which emanates as a result of learners’ engagement in a concrete activity. The learner reflects on the activities in order to make meaning of learnt concepts.

Third stage – abstract conceptualisation which is the stage where learners make meaning out of their experience.

Fourth stage – active experimentation stage in which learners put into practice what has been learnt during the process of learning, from the concrete experience to the third stage of abstract conceptualisation.

3.2.2 CAPS Life Sciences

Life Sciences is regarded as a natural scientific discipline (cf. section 2.3.1). Life Sciences has been recognised by the South African Department of Basic Education (DBE) as a school subject (DBE, 2011). Hence, there is a need to develop the curriculum and set educational goals for Life Sciences as a subject. The Curriculum and Assessment Policy Statement (CAPS) "is a single, comprehensive, and concise policy document, which has replaced the Subject and Learning Area Statements, Learning Programme Guidelines and Subject Assessment Guidelines for all the subjects listed in the National Curriculum Statement Grades R – 12" (DBE, 2018).

3.2.3 Subject content learning

Subject content is a vital component that curriculum developers consider when developing curricula and SCK is essential for learning (Tammen, Faux, Meiri & Jacque, 2018:2). In the CAPS Life Sciences, content is divided into four strands (DOE, 2011:9).

- Knowledge Strand 1: Life at the Molecular, Cellular and Tissue Level
- Knowledge Strand 2: Life Processes in Plants and Animals
- Knowledge Strand 3: Environmental Studies
- Knowledge Strand 4: Diversity, Change and Continuity

3.2.4 Nature and structure of Life Sciences

Since Life Sciences is basically the study of life, understanding its characteristics and its essence is of paramount importance. The nature and structure of Life Sciences have been explained in the literature review (cf. section 2.4). Schwab (1962:205) identified Life Sciences disciplinary structure as dual in nature, namely, the body of Life Science knowledge and the process structure of Life Sciences. Accordingly, figure 3.1 represents the relationship between the key concepts of this study.

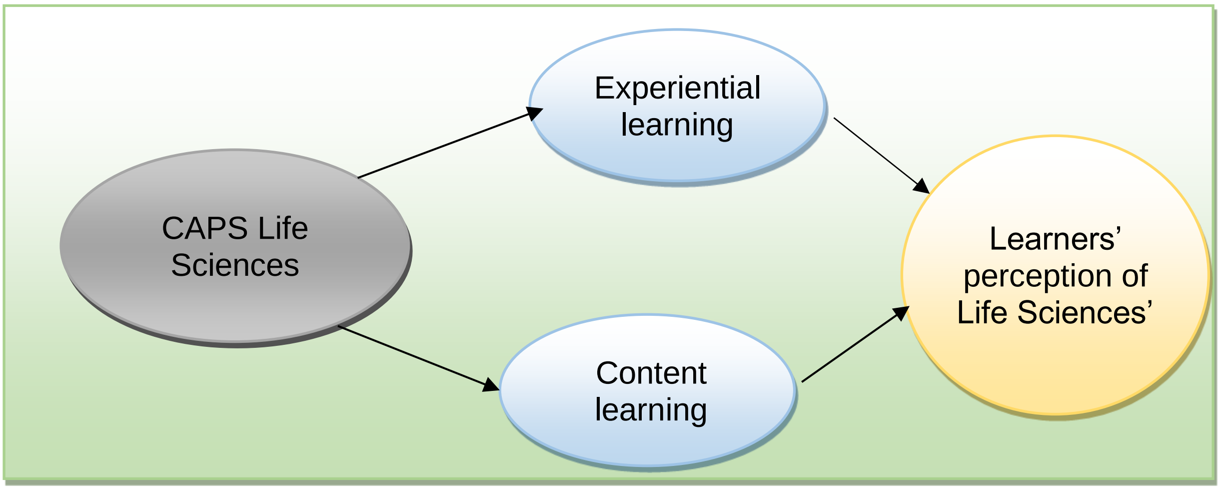

Figure 3.1: Representation of key concepts

As shown in figure 3.1, both experiential learning and learning of subject content should be integrated in CAPS Life Sciences. Learners' perceptions are the consequence of their experience of the Life Sciences curriculum.

3.3 RESEARCH DESIGN

It is agreed that the completion and success of any research relies heavily on planning (Durrheim, 2006:24; Kumar, 2014:226). A research design comprises "deliberately planned sets of actions targeted at answering the research question" (Durrheim, 2006:24). These planned sets of actions serve as a link between the purpose of the study and the methodology employed to answer the research questions (Durrheim, 2006:24).

A properly devised research plan is crucial in ensuring the completion of any research. This will ensure coherence between the research questions, the theoretical paradigm, the data collection process, data analysis and the context within which the research is carried out. In making decisions in this regard, I ensured that all these elements fitted logically within the research framework (Durrheim, 2006:26). According to Birks and Mills (2011:4) and many other authors, research design has three components – the philosophical stance or paradigmatic preference (Creswell, 2013:37), the methodology and the methods. These three components inform one another throughout the research process.

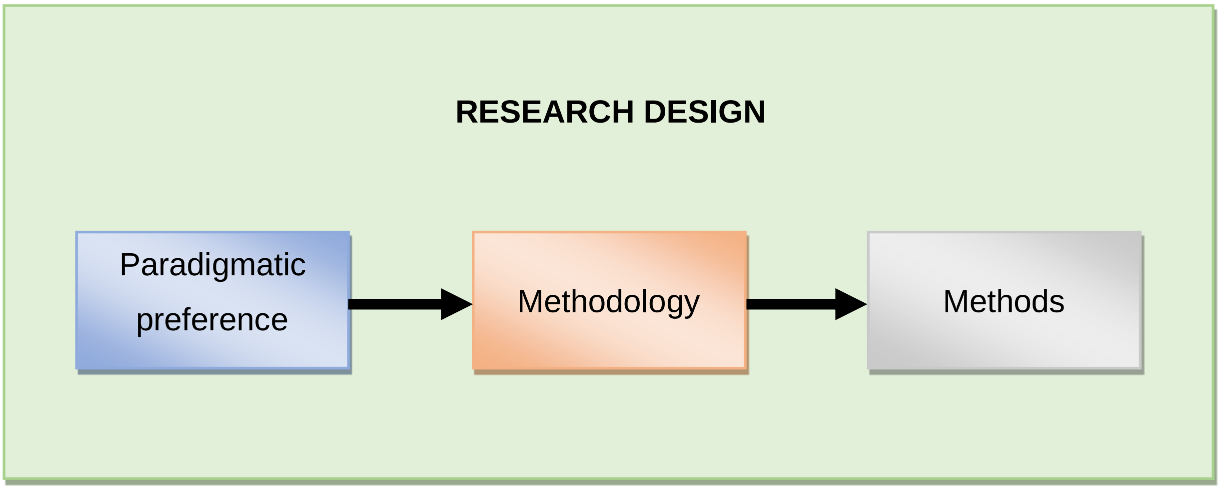

Figure 3.2: Research design

Figure 3.2 presents a schematic expression of the paradigmatic preference informing the methodology that was employed in the study. The choice of method and instruments used in the study was, in turn, informed by the methodology that was chosen.

3.4 PARADIGMATIC PERSPECTIVE

Understanding the positioning of research within the four paradigmatic orientations is critical to its success. These paradigmatic orientations are described by Denzin and Lincoln (2011:8) and Creswell (2012:40) and include a critical paradigm, positivism, postpositivism, and an interpretivist/constructivist paradigm. A paradigmatic worldview is the lens through which preferences and decisions are viewed; hence, my paradigmatic stance influenced my choice of approach in this research. Accordingly, this study is underpinned by an interpretivist/constructivist paradigm.

3.4.1 Interpretivist/constructivist paradigm

To address the weakness of a positivist worldview, a new paradigm was introduced, that is, an interpretivist paradigm, which stands in direct opposition to a positivist paradigm. Interpretivism, sometimes referred to as a constructivist paradigm, strives to “understand the participant’s world” (Guba & Lincoln, 1994:78) through the participant’s eyes. In this way, knowledge is constructed through dialogue between both the researcher and the participant (Mack, 2010).

Since this study is centred on participants' constructs of their educational experiences (Mack, 2010:8), the interpretivist/constructivist paradigm became my best choice. From the participants' reflections on their Life Science learning experiences and constructs, this study has been able to understand the outcomes that the Life Sciences curriculum is achieving in shaping the perceptions of learners of Life Sciences. Moreover, Lelliot (2014:311) emphasises the impact of the curriculum on educational outcome, stating that it is capable of informing learners' views on their learning. In essence, learners' realities in terms of their views of their Life Science learning experience have the capacity to reveal what CAPS is actually achieving as an outcome.

This study explores the participants' views on their learning experiences from multiple realities and points of view. A qualitative research approach is underpinned by this paradigm in which reality is seen as the construction of the mind by the individual (Creswell, 2012:38) and, as such, reality is subjective.

Guided by my assumptions of how reality is perceived and known and, as also suggested by Creswell (2013), Maree and Van der Westhuizen (2009), Goduka (2012), Babbie (2013), amongst others, I further explicate the axioms of this research, which are summarised in my epistemological views, ontological perspectives, the methodological approach and the methods employed in the study as suggested by Mertens (2014).

3.4.1.1 My ontological perspectives

My ontological assumption within the context of this research is not a realist assumption that proposes that an objective reality exists independently 'out there' and could become known 'from the outside' (Garrett, & Cutting, 2015). Realists assume that constructs are independent of the viewer (Garrett & Cutting, 2015). Rather, this study is underpinned by a nominalist assumption, where realities are addressed as subjective. The problem of universalism remains one of the nominalist arguments against the realists. Nominalist assume that an abstract object with no physical body exists somewhere within the mind of the viewer (Garrett & Cutting, 2015:97). Accordingly, this study believes that the participants' reality regarding their Life Science experience is locked in their minds and can only be accessed through their spoken words and meanings, in line with what Nieuwenhuis (2007) suggests about subjectivity. Hence, reality is discerned when the researcher constructs the concept of reality through a relationship with it (Mark, 2010).

3.4.1.2 Epistemological views

My epistemological assumption is one in which reality is known, not in an objective way as represented in the positivist paradigm, but through an anti-positivist or interpretive relationship that is socio-constructivist in nature, thus facilitating the understanding of learners' views of their learning as described by Nieuwenhuis, (2007) and Hickey (1997:175). Since this research adopts an interpretive worldview, the research is informed by a subjective process of data collection.

3.4.1.3 Methodological approach

Instead of the nomothetic method that aims at the discovery of general laws, my methodological assumption is underpinned by an ideographic approach in which emphasis is on the individual and the individual's experiences, perceptions and behaviours. In essence, my assumption of human nature is that we are not completely dependent on 'outside' forces to determine our destiny (determinism) nor are we completely in control of our own destiny (voluntarism). Rather, we are in a position that lies between determinism and voluntarism.

3.4.1.4 Assumption about human nature

My research is located between the two extremes of determinism and voluntarism. Determinism is the assumption that follows the principle of cause and effect, whereby human actions are determined by external circumstances and, thus, prediction of actions or reactions can easily be made. An assumption of voluntarism is the other extreme of the continuum, where individual experiences are controlled solely by the individual without any external influence.

3.4.1.5 Method preference

The methods I used to gather and analyse data were guided by my position in terms of my ontological, epistemological and methodological perspectives. Since my methodological approach appreciates flexibility and the emergence of findings from the participants (Creswell, 2007:15), qualitative research methods were employed, namely open-ended questions and interview data as primary sources of data collection. In addition, participants' diagrams were used and observations made during teaching were used as secondary data sources. Audio and video recordings were carried out, not as separate instruments for data gathering, but as a tool for organising and managing the data. These types of methods are contrary to the rigid well-structured research methods used in quantitative research (Kumar, 2014:344). Table 3.1 presents an overview of the philosophical underpinnings that guide this research.

Table 3.1: My philosophical underpinnings at a glance

Axioms	Description
Ontology	Reality is subjective and multiple as seen by the study participants.
Epistemology	I established a relationship with the participants to gain a better understanding of their experiences in their Life Science education using interviews, classroom observations and occasions of informal discussions.
Methodology	I used the inductive and abductive logical reasoning. I also employed a wide range of data-gathering and analysis techniques.
Methods	Open-ended interviews, observations, diagrams, video recordings

Source: Adapted from Creswell (2007); De Vos et al. (2011).

3.5 DELINEATING MY MODE OF INQUIRY

The choice of mode of inquiry was undoubtedly informed by my paradigmatic preference for a social view of knowledge construction. Depending on the paradigmatic view of the researcher, research can be informed by one of the two methodologies mentioned by Kumar (2014:305) or by a combination of the two. Creswell (2014:42) identifies these methodologies as quantitative and qualitative and the combined methodology as the mixed method, which is a combination of both qualitative and quantitative methodologies. However, as a researcher who holds the assumption that reality is subjective and there are multiple views on reality, my research was underpinned by an interpretivist paradigm which maintains that reality is subjective in knowledge construction.

Having positioned this study within an interpretivist paradigm, the consequent mode of inquiry is a qualitative research methodology. Since this mode of inquiry allows for multiple perspectives on reality and participants' subjective accounts of their personal experiences (Mertens, 2010:226), qualitative research methodology was appropriate for this research.

Qualitative research enhances the understanding of a process or situation regarding the researched. The emphasis is on understanding the reason(s) for the participants' behaviour in a context-defined setting. Therefore, choosing an exploratory qualitative research approach would enhance my personal understanding of how learners' exposure to Life Sciences influences their perception of Life Sciences as essential in everyday life. In addition, an exploratory qualitative research methodology allows for learners' constructs of their daily Life Science classroom experiences to be explored.

A qualitative research mode of inquiry can be placed within a number of domains, as categorised by De Vos et al. *(*2011), Maree (2007) and Creswell (2012). Owing to the exploratory nature of my research questions (Creswell, 2007:39–40), which were intended to 'explore' the perceptions of Life Science learners regarding their learning experiences, the study is regarded as exploratory qualitative research (Blanche, Durrheim & Painter, 2007). Since participants have expert knowledge of their experience(s), and their experiences are real to them, the onus lies with me as a researcher to understand their constructs as accurately as possible through the investigation of their experiences (Mertens, 2010:226).

This research comprised a case study. Case study research refers to the study of a particular case that is representative of other cases. Furthermore, in investigating the subjective experiences of participants and seeking to understand the socio-context of the learners' perceptions of the Life Sciences as essential in everyday life issues, data were inductively acquired.

3.6 CASE STUDY

Choice of a case study was informed by my research question, which sought to understand how Life Science learning experiences had influenced learners' perceptions of what Life Sciences is. The motivation for a case study was based upon the research question for this study which was intended to explore learners' understanding of Life Sciences as an essential everyday-life and scientific challenge with regard to their current Life Science classroom experience. A case study occurs as a unit bounded by set boundaries and, as such, encourages an in-depth exploration of the phenomenon. A case may include a unit or many units of analysis. However, this study is a multiple case study of Grade 8 to 12 learners and it considered the experiences of the learners as the singular unit of analysis.

The unit of analysis constitutes the learners in the grades whose learning experiences were to be explored. Although generalisation was not part of the aim of this study, it provided a baseline for other similar cases. Considering the learners in Grades 8 to 12, each case (as a grade) was unique and, as such, it was important that the researcher kept in mind the uniqueness of the learners in each grade, while working within and across the cases. However, this demands a strict consciousness of the process and the uncompromising importance of staying close to the data so that the uniqueness of each case is adequately represented in the study.

The strength of case study lies in its ability to utilise multiple evidences which might not be applicable in some other type of methodology. The inquiry draws on prior theoretical frameworks which is an added advantage for the methodology in the choice of methods to be used as suggested by Yin (2014:17).

3.7 SAMPLING PROCEDURE AND SELECTION OF PARTICIPANTS

In the subsequent paragraphs, I described the sampling procedures and the rationale for the choices that were made during the process.

3.7.1 Selection of research site

The selection of a research site was one of the earliest decisions that were made and a non-probability purposive sampling method was used. The context in which research is conducted is important for understanding of the study; in this study, the research site fell into the category of ordinary public schools, as categorised by the Department of Basic Education, as opposed to the special schools and independent (private) schools. The public schools in the South African education system are funded by the government quota given to the Department of Basic Education. In 2018, public schools in South Africa had the highest percentage enrolment (92.7%) of South African learners and ordinary public schools totalled 25 574 (DBE, 2018:3).

The research site was situated in an urban area in Pretoria in Gauteng province, South Africa. Gauteng has the third largest number of public schools, which cut across different socioeconomic groups, races and ethnicities. The school chosen adequately represents the Gauteng public schools in the execution of its programmes and curriculum.

Furthermore, the selected site is a girls-only school. In Gauteng, there is no disparity in the numbers of boys and girls enrolled. The pass rate percentage between the genders is also insignificant (Department of Basic Education, 2015:8–9). Every school is governed by a school governing body (SGB) composed of parents, teachers and, in the case of secondary schools, also learners.

The research was conducted in the natural setting of a school environment. The selection of the site was purposive since it was based on the fact that the school would be able to represent the diversity of learners which is typical of the South Africa context. Also, the school had to be a school that is running efficiently in all respects and had all the essential facilities so that it paralleled the South African educational standards. The selected site was also a convenient selection since I was not teaching at the time of the research and needed to secure a school that would accommodate my study for the duration of the research.

3.7.2 Selection of participants

The selection of participants was undertaken by carefully considering the purpose of the study (Creswell, 2008:216). Since the study centred on learners' perceptions of Life Sciences in terms of everyday life and scientific challenges, this criterion undoubtedly informed the choice of participants and the classes involved. Life Science learners and Science classes respectively became my choice. Further, I considered engaging the classes that had the same teacher, in order to minimise the limitation that can be imposed on the study from various teachers teaching the classes. However, selection is not based on whether learners were taking up science career in the future because this was not the aim of the study. Since the research participants played a large role in shaping the research and its findings, hence, the choice of participants was critical to the success of the study.

The participant samples were purposively chosen to meet the criteria required to answer the research question. It was important for me to choose learners who could communicate proficiently in English; hence the interviewed participants were also selected purposively. These participants include 12 learners from each class in each of the grades (n = 60).

Based on the division of learners by the Department of Basic Education in South Africa, the participants were categorised into two categories: The General Education and Training (GET) band which comprises Grades 8 and 9 and the Further Education Training (FET) band, constituting Grades 10 to 12. In Gauteng, the Gauteng Department of Basic Education (GDE) is the educational body that oversees both categories.

3.7.2.1 The Grade 8 and 9 participants

Learners in Grades 8 and 9 are in the GET phase of the South African education system. This phase is compulsory for every South African child. In this phase, science is integrated, and it is called Natural Science. Natural Science comprises Physical Sciences and Life Sciences. It is a compulsory subject at this stage and the curriculum comprises both life sciences and physical sciences, while in the FET phase Life sciences is taught as a separate subject. Participants were reminded to focus on life science aspects only in their responses. Since the subject is compulsory, findings in this study would possibly reflect how learners' experience of Life Sciences could be fundamental towards their motivation or demotivation, consequently influencing their choice of the subject in the higher grades.

3.7.2.2 The Grade 10 to 12 participants

Learners in Grades 10 to 12 form part of the second band of the Basic Education phase (FET). They are already being prepared to meet their future career goals. Learners in this group are given the opportunity to choose the subjects they want to study. In this band, Life Sciences is taught as a separate subject.

Figure 3.3 below represents the two-band structure of the Basic Education categories in the Gauteng Department of Education.

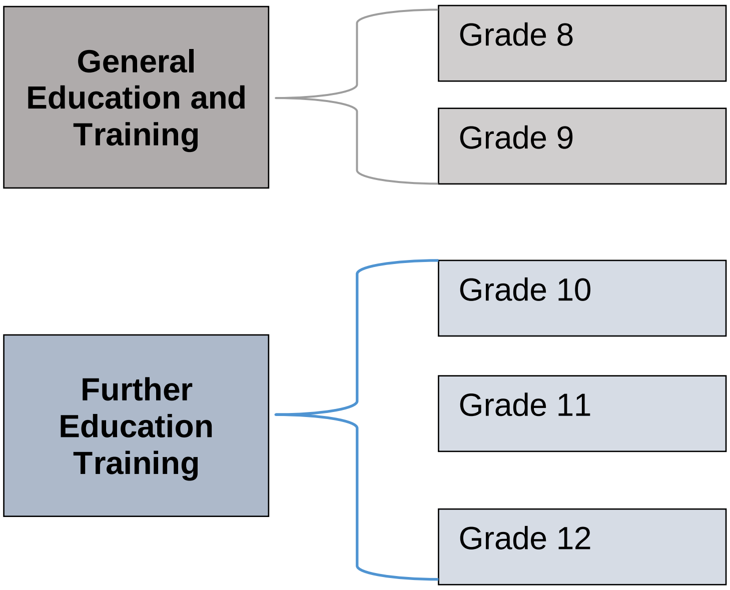

Figure 3.3: The two bands of the South African high school.

3.8 DATA COLLECTION

Since I am guided by a socio-constructivist perspective that believes that there are multiple realities and that participants are co-constructors of knowledge, I assumed a position of working together with the participants to construct both their knowledge and my knowledge. This approach is reflected in my data collection by using semi-structured interviews and open-ended questionnaire which were my primary data collection sources.

Data gathering procedure relevant to case study research was employed. In this study, data were collected from 12 participants in each grade, from Grades 8 to 12. Since case study engages multiple evidences, this study made use of multiple ways of data collection. Multiple evidences allow for the triangulation of findings (Yin, 2014:119), consequently improving the quality of the research. The following paragraphs (section 3.8.1–3.8.6) describe the instruments employed in the study.

3.8.1 Semi-structured interviews

Semi-structured interviews were used to explore experiences of the participants. My choice of these interviews instead of a highly structured interview was fundamentally guided by my research philosophy and the aim of the study which was "to explore". Semi-structured interviews allow researchers to probe participants further in order to gain understanding of the researched phenomenon (Galletta, 2013:24; Yin, 2014:106). The use of semi-structured interviews enables participants to describe their personal experiences within the context of the study (Seidman, 2013:19). As a researcher, I was aware that interviews might encourage biases, which possibly is a weakness of the tool (Yin, 2014:106)., however, with this is understanding, I engaged myself on focusing on the data and not my biases to ameliorate the limitation of this data gathering tool.

In the design of the semi-structured interviews, the purpose of the study was taken into account which was to explore the perception of Life Sciences learners. The aim of the interviews was to answer the research questions, therefore, within the semi-structured interview questions, I ensured that questions that would address this aim were taken into consideration in its design (see Addendum F, for the semi-structured interview questions). The semi- structured questions were also given to my supervisor to check for validity.

At the beginning of each interview, I followed a designed protocol which included the introduction of the researcher and a brief review of the purpose of the interview, as well as informing the participants that the interview would be audio-recorded. I then reiterated my ethical pledge. The interview took the form of a short case study interview (Yin, 2014:110). Thirty minutes was set aside for each participant's interview. Although the participants were young children, they were very clear and direct with their answers. The interviews were conducted during the break or sometimes after the school hours at the participants' convenience. Ethical issues such as anonymity, right of withdrawal at any time and the fact that no answers were right or wrong were addressed. A copy of the interview protocol and questions is attached at Addendum F.

During the interview sessions, the discussions were directed at exploring the participants' perspectives on their educational experiences. For data to reflect the participants' voices is important in case study research, hence questions were asked in an unbiased manner (Yin, 2014:110), engaging the participants in answering the semi-structured questions that I had carefully constructed to guide the interview. Although I had constructed the interview questions prior to my contact with the participants (cf. Addendum E), throughout the interviews, participants were asked other questions that were prompted by the answers given during the interview session.

This was also targeted at exploring the statements or narratives that were unclear. The participants were also allowed to raise issues that had not been addressed which they wanted to speak about and that were equally important for the study.

3.8.2 Elicited materials

Participants were requested to make a personal drawing of what Life Sciences meant to them with regard to their learning experiences in the classrooms directly after each interview. The time allotted for the drawing was in addition to the time fixed for the interview. This type of data is referred to as elicited material and has recently gained acceptance in social science research (Stiles, 2004). These elicited materials are often in the form of diagrams drawn by researcher or participants (Moagi, 2014:132). It differs from extant document such as articles, magazines newspaper and the like in that it represents the current state of the participants' notion or perception concerning the researched area (Charmaz, 2006:37). The purpose of the drawing is to capture all necessary data and to cater for diverse preferences in storytelling, though, it is assumed that its analysis can be subjective (Zang 2008:2089).

Diagram drawings are considered important in narrating experiences and perceptions (Copeland & Agosto, 2012), especially when the participants are young children, as in the case of this study. It is useful in the projection of the underlying intentions of the participants (Moagi, 2014:132), ensuring that context is covered (Khunyakari, Mehrotra, Chunawala & Natarajan, 2007). The way and manner children draw, in most cases, portray specific meaning since it is one of the communicative tools used in expressing their inner feelings like joy, fear, timidity, anxieties, among others.

Drawings can be analysed in diverse ways. Participants' drawings can be analysed through shared meaning making as described by Eggleton, Kearns & Neuwelt, (2017). It can also be analysed by the first impression principle (Farokhi & Hashemi, 2011), "pre-eminence of the whole" analytical method (Farokhi & Hashemi, 2011), thematic analysis (Farokhi & Hashemi, 2011).

In this study I adopted the content specific analysis method as described by Picchietti, Arbuckle, Abetz, Durmer, Ivanenko, Owens, Croenlien, Allen & Walters (2011). I looked for images and aspects in the drawings that would relate in some way to the data from the sem-structured interviews and open-ended questionnaires. The purpose was not an in-depth analysis of the drawings, but to gather more information to confirm or refute the findings from the primary data collection sources, namely the semi-structured interviews and the open-ended questionnaires.

3.8.3 Non-participant and quasi-participant observation

Throughout the data gathering periods, I conducted continuous observation of the class in the natural classroom setting, while the learners constructed their perceptions of Life Sciences as the subject teacher taught. Direct observation is one of the data gathering methods used in case study as it addresses an event as it is happening (Yin, 2014:12). Although the observation took place in the class setting, observation was casual and therefore I did not use a prepared protocol (Yin, 2014:113). The purpose of the observation was to verify the information provided by the participants in the semi structured interview. For example, where learners emphasized that the teacher did not explain concepts adequately in the classroom, my presence in the classroom would enable me to verify, if this was correct or an overstatement by the participants. This process further allowed me to be part of the participants' learning process. However, it is important to note that the purpose of the observations were merely to see the learners' workbooks and were meant for the purpose of verification and extension of data gathered from the main instrument, namely semi-structured interviews and the open-ended questionnaires.

3.8.4 Video recordings

Video recordings of the teaching sessions and practical sessions were taken with due permission as required by the ethics of the research. Video recordings captured the details that may have been overlooked during the observation process (Gibson, 2008:2) and also allowed for repeated viewing and analysis of the observed phenomenon. The video recordings were made to capture only the class work of the participants without revealing the identities of the participants and were strictly guided by the ethical rules and regulations and this process as I mentioned in section 3.4.1.2 was for the purpose of my observations.

3.8.5 Audio recordings

An audio recording of each interview was made. This was done to ensure that no detail was omitted. Transcription of the audio recorded interviews was also carried out.

Careful transcription is important in engendering rich data without loss of vital information (Cohen et al., 2007:365). Although the transcription was carried out by a transcriber, the manuscript was verified against the audio after the transcription had been made to ensure that no vital data was missing. While nonverbal reactions expressed through gestures and body languages may not be captured by audio recordings, they were noted in my field notes.

3.8.6 Observatory notes

Some of my field notes were made during classroom observation. Such notes included details of the classroom setting, interactions between the teacher and the learners, and questions asked by the teacher, learners or researcher during the classroom teaching. Other notes were taken during the interview sessions. All the field notes were handwritten. All observatory and field notes were intended for verification purposes, either to refute or corroborate the findings from the semi-structured interviews, and not as primary data collection instrument.

3.9 DATA ANALYSIS

Yin (2014:137-138) itemises the bases for analysis; among them is an inductive approach to the analysis of case study evidence, where analysis starts with an understanding of the pattern within the data. Accordingly, an inductive approach was adopted, since the research used constant comparative data analysis procedure (Flick, 2014). In this way, the analysis process involves engaging in the constant comparison of all data using different coding possibilities and the subsequent categorisation of data with continuous conceptualisation and assessment of similarities and differences.

3.9.1 Coding process

As emphasised by Charmaz (2006:3), coding is not a re-description of data; rather it involves naming a portion of the data for proper identification and description. Coding involves a process of opening up data for stringent and detailed analysis. Codes are usually inferred directly from data; hence, they are inductively generated. In general, codes can be represented by a phrase or a word that captures the meaning of a statement from the participant or may be a word extracted directly from the participant. Such code inferred directly from participants' words is called *in vivo* code (Birks & Mills, 2011:93). Coding also prompts analytical questioning from the data so as to make meaning out of them.

Initial coding

As initial coding provokes analytical probing into data after deep immersion and interaction with it (Charmaz, 2006:109), I engaged in reading and re-reading the transcripts (Glaser, 2007; Strauss & Corbin, 1998; Charmaz, 2005:16) in order to have a general idea of what the data were saying. Initial coding is also called ‘open coding’, where each code represents a concept or an abstraction from the data.

Focus coding

At this stage, initial codes were compared with other codes to establish codes with more analytical power (Thomberg & Charmaz, 2014:158). Such codes are more direct and conceptual in nature than the initial codes (Thomberg & Charmaz, 2014:158). During the focus coding, focused examination of data and possible explanations for such data were conceptualised (Bryant & Charmaz, 2007:608), This process continues until the most credible interpretation of the data emerges.

3.9.2 Categorisation

After the focus coding, categories start to emerge as patterns and explanations begin to become obvious and stand out from the data. These categories conceptually represent the patterns and explanations in the data. The categorisation process includes the entire interaction with the data by means of immersion in the data in order to evoke analytical discoveries and find hidden meanings (Charmaz, 2014).

3.9.3 Theoretical sampling

The categorisation process is followed by theoretical sampling which differs from the sampling at the beginning of the data gathering process. Theoretical sampling in seeks to ensure that there is data saturation (Glaser & Strauss, 1967), and to elevate the categories and codes with to a higher analytical stance (Charmaz, 2014). The theoretical samples undergo constant comparative data analysis, where the existing codes are constantly compared with the theoretical codes to allow for the emergence of theoretical categories which are used in theorisation (Charmaz, 2014).

3.9.4 Diagramming

As the analysis progresses, memos are kept to ensure that the substantive area of study is not lost because of the bulkiness of data. Diagramming ensures adequate data management, revealing the interrelationships between the codes, categories and subcategories (Charmaz, 2014). Although the diagram of the initial codes is usually chaotic owing to the presence of a multitude of codes, as the coding process progresses to an advanced stage it crystallises to form simple, neat diagrams. Diagramming ensures the quick identification of gaps in an emerging theory (Birks & Mills, 2011:105).

Table 3.2 to follow presents a summary of the research methodology.

3.10 DATA TRUSTWORTHINESS

Researcher's bias is a critical concern in all research and it is impossible to eliminate bias completely. To manage my biases, I ensured that my focus was on the data and not on my person or my experience. Also, knowing that researcher is part of the research instrument (Leedy & Ormrod, 2010:98) renders the validity of data imperative. Data validity is revealed in the trustworthiness of the research (Creswell & Poth, 2017:257) and is accomplished by satisfying the criteria identified by Guba and Lincoln (1985): creditability, conformability, transferability, dependability of the study and verification of the data by at least two of the three agents involved in the study.

3.10.1 Criteria for quality research

In the following paragraphs, I addressed the process undertaken to ensure that the quality of the research was not compromised.

3.10.1.1 Credibility

Credibility refers to confidence in the truthfulness of the findings of the research. It may also be described as the true value of the research and is accessed by the internal validity agent (the researcher); in other words, it is the genuineness of the research findings. In ensuring the credibility of this research, I consciously applied myself to the research process and the credibility of the findings ethically. The use of multiple evidences in research also known as triangulation (Merriam & Tisdell, 2015:244), which mitigates researcher biases and ensures the credibility of the research (Denzin & Lincoln, 2011:5; Lincoln & Guba, 1985; Yin, 2014:119).

Rather than disclosing just the positives of the study, I ensured that all negative cases discovered in the research were analysed and reported. Merriam and Tisdell (2015:257) and Guba and Lincoln (1989) also suggest member checks and prolonged engagement as a strategy for validating research findings, which were both used in this study. Also, to mitigate prejudice on my part, my personal biases were declared at the beginning of the chapters and were guarded against throughout the research. In this study, I ensured that both learners and teacher were involved in the data check, and engagement with the participants spanned three of the four terms of the academic year. During this period, I developed a relationship with the teacher and the learners as suggested by Merriam and Tisdell (2015:257).

3.10.1.2 Transferability

Transferability indicates that the research is applicable in other contexts or settings (Trochim & Donnelly, 2007:149). Merriam and Tisdell (2015) refer to transferability as external validity. In order to ensure transferability, thick, rich descriptions of research processes – site and site selection, participants' selection, data gathering and its analysis as well as the findings with the evidence – were performed (Maxwell, 2013:138; Merriam & Tisdell, 2015:257). Thick rich descriptions guide the reader in terms of decisions relating to the transferability of the findings of the research (Creswell & Poth, 2017:263; Kumar, 2014:390).

3.10.1.3 Dependability

The characteristic of dependability means that when the research is repeated in a similar situation and under the same conditions, the same results or findings should be obtained. Reproduction of findings in qualitative research may be challenging, since human factors can be very flexible. However, a thick and detailed description of the participants, site, process and findings can enhance replication (Kumar, 2014:390).

3.10.1.4 Confirmability

Confirmability is an indication that researcher bias did not influence the findings of the research. Confirmations are carried out by people external to the study who have nothing to gain or lose by the findings of the research. Hence, it is a verification of the study and its findings by other people (Trochim & Donnelly, 2007:149). The strategy employed to ensure this research characteristic was to engage in reflection and to ensure an audit trail (memos) as suggested by Guba and Lincoln (1985).

According to Creswell and Poth (2017), validation must be based on the judgement of three parties: the researchers, the participants and the reader. External audits involve people external to the study who are not connected with the research but who are held responsible for auditing the research process and the findings. These people can be either experts in the methodology or novices but must be able to give their comments. In this study, I made use of two external people (both university lecturers) with whom I consulted at the beginning of the study and during the research process, especially in times of uncertainty regarding decisions and progress. These external observers enhanced the mitigation of any bias that may have ensued from me as the researcher. In addition, my supervisor served as one of the parties that criticised and questioned the data as the research progressed. This was to ensure the rigour needed for the success of the research (Creswell & Poth, 2017:263).

3.11 ROLE OF THE RESEARCHER

Since the researcher is part of the research, his or her personality and experiences are involved in it. However, it is important that measures such as use of multiple data sources and member checking are put in place to ensure that these biases do not affect the findings of the research.

As the researcher, to minimise bias I ensured the following:

- I identified my biases and minimised their influence on the study.
- I conducted a rich and robust literature review.
- I obtained ethical clearance from the relevant organisations (the University of Pretoria, the Department of Education and the school where the research was conducted). Acceptance of the research proposal was granted by the University of Pretoria and consent to the research process was obtained from the teacher, the participants and their parents.

- I designed the open-ended questionnaire, conducted the interviews and made the audio recording of the data available.
- I analysed the data and organised the findings.
- I reported the findings in a well-structured manner.

3.12 ETHICAL ISSUES AND CONSENT LETTERS

For social research, ethical considerations and decisions span the entire research process (Edwards & Muathner, 2012:18). Hammersley and Traianou (2012:16) define ethics as "what social researchers ought and ought not to do and how this should be decided". In the context of this study, all ethical policies and requirements of the University of Pretoria and the Gauteng Department of Education regarding human science research were adhered to throughout the research process.

Since this study is in the Human Sciences research domain, ethical issues are critical and have serious implications. Application for ethical clearance was submitted to the University's Research Ethics Committee and the application was approved by the University on 18 April 2016.

The school at which the research was conducted is located in Gauteng province in South Africa and is under the control of the Gauteng Department of Education (GDE). Therefore, ethical approval was also sought from the Department. This was granted and a copy of the GDE ethical approval is attached as Addendum H.

3.12.1 Understanding of the research

As the researcher, I was ethically obliged to understand clearly the aims, process and importance of the research in order to explain it effectively to all the parties involved (Kumar, 2014:491).

3.12.2 Informed consent

Participants must be informed about the nature and purpose of the research and their role as participants. The participants were also informed that participation was voluntary and no one was obliged to participate (Kumar, 2014:491). I sent letters of invitation, which doubled up as consent letters, to the principal (cf. Addendum B), the teacher (cf. Addendum C) and the participants (cf. Addendum E) in order to seek their consent to be involved in the study.

Following the description of Creswell (1998:116), the letters of invitation and consent letters explained the purpose of the study, the procedure for data collection, right of withdrawal at any time and assurance of anonymity. I also drew up a comprehensive combined consent letter which was given to individual learners (cf. Addendum E) and their parents or guardians (cf. Addendum D). Parental consent was necessary because all the participants were assumed to be under the age of 18. The parents appended their signature to indicate that they understood the purpose of the research and their voluntary consent to participation in the study.

The participants took the parental consent forms home for signature. Both participants and their parents could ask questions about anything that was unclear concerning the research either via e-mail, by phone or in person, as my details were clearly written on the consent letters.

3.12.3 Confidentiality

In order to reinforce trust and confidentiality, I assured the participants that the information given was meant solely for the study (Kumar, 2014:494). This was reinforced throughout the research. This pledge of confidentiality enhanced participants' free interaction with me.

3.12.4 Anonymity

The respondents' identities were anonymised through the use of letters and numbers. This use of pseudonyms was necessitated to avoid the use of other names that might have coincided with those of their classmates (Mouton, 2005:243–244).

3.13 CONCLUSION

In this chapter, I discussed the rationale behind my choice of methodology. The process of research, methods and instruments used in the study were also explained.

The next chapter discusses the data analysis, the results and the interpretation of the results.

Table 3.2: Summary of the research methodology

RESEARCH METHODOLOGY	
Assumptions	
Ontology	Nominalist
Epistemology	Constructivist and socio- constructivist
Methodological	Ideographic approach
Research design	
Approach	Qualitative research
Methodology	Case study
Research site	
	A school in Pretoria
Selection of participant	
Purposive sampling	60 participants, 12 participants in each grade from Grades 8–12
Data collection	
	Semi-structured interviews, video recordings, audio recordings, non-participant and quasi-participant observation, open-ended questionnaire
Data analysis	
	Constant comparative analysis
Quality criteria	
Credibility	Multiple method, member checking
Transferability	thick rich description of the site, study and the findings with the evidence
Dependability	thick rich description
Research Bias	Multiple method, member checking
Ethics	
	Informed consent, confidentiality, anonymity

CHAPTER FOUR: DATA ANALYSIS, FINDINGS AND DISCUSSION

4.1 INTRODUCTION

In the previous chapter, I discussed the methodology and paradigmatic orientation that to a large extent informed this study. The paradigm assumed reflects one's belief about reality and the assumptions that are made, as we view the world in terms of these beliefs and assumptions. In chapter three I explained my epistemological (how knowledge is constructed) and ontological belief (the nature of knowledge). Accordingly, my ontological and epistemological assumptions informed the approach and methodology used in this research, and thus grounding the study in qualitative research. I also explained desire in this research to explore the participants' perceptions of Life Sciences within the context of CAPS. As a qualitative researcher, the answers to my research questions were pursued using a case study research design. In chapter three, I also discussed the rationale behind the use of a case study design.

To answer the research questions, which were constructed in line with qualitative research criteria as described by Nieuwenhuis, (2007), I had to employ qualitative data gathering methods, and therefore explained the data gathering methods, the selection of the site and the research participants, the data gathering process, the tools used and their purpose in chapter three. I also explained the data analysis method used and further established the way in which the quality of the research was assured.

In this chapter, I proceed to present in sequence the data gathered by the qualitative research tools and the integration of the findings in answering my research questions. For easy navigation the sequence of data presentation and the tools used are tabulated in table 4.1.

Table 4.1: Sequence of findings

Sequence of findings	
Interview data	Grades 8–12
Discussion	
Open-ended questionnaire	Grades 8–12
Discussion interpretation	
Other tools such as video recordings, diagrams and field notes or memos are incorporated in the discussions	

4.2 SEMI-STRUCTURED INTERVIEW

Participants were interviewed individually to prevent one opinion from influencing another. Interviews were scheduled for 30 minutes each but in effect lasted about five to six minutes per participant, because the participants were young children and were direct and brief in their answers. The time set aside for the interviews excluded the additional time allotted for drawing and the informal protocols. Even though the time was shorter than expected, I was able to get participants' opinion on their perception of their Life Science experience. In order to adhere to research ethics, participants were briefed about the purpose of the research and were informed that their participation would be voluntary. They were also informed that interviews would be audio taped but that anonymity would be ensured. The interview protocol was designed prior to the interviews and the protocol followed as a guide during interview sessions. Table 4.2 indicates the interview questions and the corresponding research question that it was aimed to address.

Table 4.2: Interview questions and the corresponding research questions to be addressed

Interview questions	Research question
Q1 Describe in a few good, full sentences what normally happens in your Life Science classes/lessons Q4 Could you tell me the most important things that you have learnt in your Life Science classes/lessons	Secondary RQ1 What are the current curriculum demands of the Life Sciences?

➡

Table 4.2: Interview questions and the corresponding research questions to be addressed (cont'd)

Interview questions	Research question
Q2 What do you like most about your Life Science classes/lessons? Q3 What do you like least about your Life Science classes/lessons	Secondary RQ2 What are the challenges confronting school Life Sciences as fundamental to a daily life and scientific challenge?
Q5 Use the blank A4 sheet of paper to draw your own unique picture of all the most important things you have learnt in your Life Science classes up to now and how all of them fit together.	Primary RQ Does learners' Life Science learning experience influence their understanding of Life Sciences as an essential daily life and scientific challenge?

4.3 PRESENTATION OF GRADE 8 INTERVIEW

Table 4.3 presents the codes and the emerged subthemes and themes for Grade 8. Thirty-four codes were generated from the interviews which were conducted with 12 Grade 8 learners. The codes were subsequently comparatively analysed into themes and subthemes. The first column contains the initial codes, the second the focus codes, the third the subthemes and the fourth the main themes.

Table 4.3: Grade 8 codes and emergence of the themes

Initial codes	Focus codes	Sub theme	Themes
Feeling compelled to learn Life Sciences Lacking interest in learning Life Sciences Learning nothing of personal interest	Feeling compelled to study Life Sciences as a subject	Experiencing difficulty in the learning process	Experiencing difficulty in learning process
Making no understanding for relevance of Life Sciences topics Seeing Life Sciences as unimportant Searching for reasons for learning Life Sciences	Finding no relevance of Life Sciences topics		
Having wandering mind during class Having prolonged lecture time	Disconnecting from learning process	Disconnecting from the learning process	

Table 4.3: Grade 8 codes and emergence of the themes (cont'd)

Initial codes	**Focus codes**	**Sub theme**	**Themes**
Associating lecturing method of instruction with boredom Having too much to learn Finding lesson boring	Finding lessons boring		
Excusing lack of understanding of Life Sciences as personal weakness Playing down self-potential	Playing down self-potential	Justifying poor academic performance for personal inability	Prioritising Life Sciences content
Excusing the dislike of the subject for lack of comprehension	Excusing a dislike of the subject for lack of understanding		
Presenting understanding as recalling Attributing interest to ability to recall knowledge Linking academic success to effective information recall Emphasising content knowledge	Prioritising Life Sciences content	Prioritising Life Sciences content	Prioritising Life Sciences content
Doing practicals to confirm theory learnt in classroom Advocating for more experiments Getting clarity on Life Sciences topics from experiments Finding understanding through experiments	Using practicals as 'add on' knowledge'	Using practical sessions as 'add on' knowledge	Using practical sessions as 'add on" knowledge
Teacher explaining the experiment manual Teacher's teaching Life Sciences content and concepts Watching the teacher while demonstrating practicals	Depending on teacher's knowledge for practical activities	Dependence on teacher's knowledge for practical activities	Dependence on teacher's knowledge for practical activities

Table 4.3: Grade 8 codes and emergence of the themes (cont'd)

Initial codes	Focus codes	Sub theme	Themes
Teacher explaining the practicals for understanding			
Putting off learning responsibility during practicals	Putting off learning responsibility during practical sessions		
Attributing high marks as academic success	Judging academic success with marks	Life Sciences as content laden	Life Sciences content laden
Judging academic success with marks			
Deriving motivation by information recall	Deriving motivation by information recall		
Emphasising Life Sciences content	Memorising Life Sciences contents		
Striving to remember Life Sciences content	Memorising Life Sciences contents	Life Sciences as content laden	Life Sciences content laden
Viewing Life Sciences from animal science perspective	Fragmented view of Life Science knowledge	Fragmented view of Life Science knowledge	Fragmented viewing of Life Science knowledge
Disliking plant science topics			

4.3.1 Emerging themes in Grade 8 interviews

In this section, I discuss the findings gleaned from the Grade 8 interviews. A comparative analysis of the codes from these interviews generated six themes, which are presented as the emerging themes in section 4.3 in table 4.3.

4.3.1.1 Theme I: Experiencing difficulty in the learning process

The Grade 8 learners seemed to experience difficulty in learning Life Sciences as a subject. The findings revealed that learners believe that Life Sciences should not be a compulsory subject and they should be given the option whether to study to study the subject or not. Therefore, most of them, with exception of those planning a career in the science field, felt they were compelled to study the subject. When Lau Gr. 8 was asked about how she experienced Life Sciences, her response was: **Oh, I don't really like it [Life Sciences], but I have to do it (Lau Gr. 8, Para 8.)**

Accordingly, it would seem that learners do not understand the concepts of the subject and consequently lost interest in it. For example, Lau Gr. 8 said while responding to the probing question of: What makes you not to like Life Sciences?

> *It is hard… [because] I don't understand the concepts* (Lau Gr. 8, Para 22).

And consequently, she also said:

> *Sometimes I just go with it and sometimes my mind just goes wandering … and I don't know what it is* (Lau Gr. 8, Para 28).

All Grade 8 learners are required to take Life Sciences as a subject to obtain wide background knowledge on every subject and to be adequately informed to make a choice of career. However, lack of understanding of Life Science concepts at times would appear to be a barrier to their interest in the subject beyond the lower grades (Grades 8 and 9).

The findings indicated that learners appeared not to understand the link between what they learn in the classroom and its significance in their own lives and the community at large.

For example, participant Lar, Gr. 8 said:

> *I don't understand when we're going to need it. It is all these elements. It doesn't really make sense to me and then we're just writing tests about something that doesn't really like …* (Lar Gr. 8 para 14).

She also mentioned:

> *I don't know, I don't think she's explained to us what they're used for or what you need them for. So, it is basically just numbers and symbols and words. It doesn't make any sense* (Lar Gr. 8 Para 16).

Another participant had this to say:

> *Well, some things are hard and some things are easy. It is just sometimes I just go with it and sometimes my mind just goes [wanders off] … and I don't know what it is* (Lau Gr. 8, Para 28).

Moreover, learners' interest in Life Sciences dampened because they cannot link the subject to what they do every day nor could they relate to it.

4.3.1.2 Theme II: Prioritising Life Science content

The Life Science curriculum is divided into strands (cf. Addendum A). The topics for Grade 8 include elements, matter, energy, light and the solar system, which are fundamentals for the sciences (including Life Sciences). I discovered that the Life Science topics studied by these learners did not rouse any interest in the subject in the learners [cf. section 4.3.1.1]. Hence, they felt dissatisfied with the learning process. Furthermore, learners expected the teacher to explain why they had to learn what they were learning and its significance. For instance, Lar Gr. 8.

> *I don't know, I don't think she's explained to us what they're used for, or what you need them for. So, it is basically just numbers and symbols and words. It doesn't make any sense* (Lar Gr. 8 Para 16).

Also, learners find the subject abstract. They appeared not to have an opportunity to understand the link between what they are learning as it relates to their lives or the context. For example, Lar Gr. 8 stated:

> *I don't understand when we're going to need it. It is all these elements. It doesn't really make sense to me and then we're just writing tests about something that doesn't really … and drawing atoms, also, [this is] not nice* (Lar Gr. 8 Para 14).

It would seem that the learners' unhappiness, as mentioned in section 4.3.1.1, Theme I, is compounded by lack of real-life application of learnt concepts, as Khu Gr. 8 says in her statement:

> *Well, what I like the least is that we have test and have to write ... I would like, if we would like do experiments, and have projects every single day when it comes to Natural Science [Life Sciences] … when you do experiments, it gives you feedback. So, you know what feedback you want from life. It shows what goes on with life.*

Hence, her response to my question in the interview: “Make a list of the most important things that you’ve learnt in Life Sciences classes. She said:

> *Well, I’ve learnt let’s say, I’ve learnt nothing, it is just fine ...* (Khu Gr. 8 Para 29).

Learners continue to attend classes, listen to the teacher, perhaps for necessity’s sake, having no real enthusiasm to learn or any particular interest in the subject.

4.3.1.3 Theme III: Depending on teacher’s knowledge for practical activities

Learners in this grade acknowledged that they enjoy the practical sessions that they had. Dan Gr. 8, when asked what was the most important thing in her Life Sciences educational experience, said: “*That would be practicals, then, you have an idea of how it works and what to do with it*” (Dan Gr. 8 Para 8). Also, Khu Gr. 8 in responding to the same question said: “*We do experiments. That’s what I love a lot*” (Khu Gr. 8 Para 15). However, some learners not only enjoyed the practical session but were also happy with the way the teacher taught them how to do the experiments (Clo Gr. 8; Field note I, addendum O). For example, Clo Gr. 8 said: “*I like doing experiments or like watching teacher doing experiments using apparatus and stuff*” (Clo Gr. 8 Para 8).

Lar. Gr. 8 also said

> *She [teacher] doesn’t waste any time [with practicals] … just tells it how it is* (Lar Gr. 8 Para 5).

Learners’ views regarding the practical sessions do not seem to indicate an investigation and scientific inquiry process. They assumed that the teacher had to teach the experiment and tell them what to do, even when the laboratory manuals, which contain a step-by-step procedure for experiments, had been given to them beforehand.

4.3.1.4 Theme IV: Life Sciences as content laden

The Grade 8 learners main motivation appeared to be to score high marks in their tests and exams in order to progress to the next grade. Nad Gr. 8, one of the participants, mentioned that Life Sciences was not her good subject but she emphasises that it was important for her to get good mark in it.

> *It is not my favourite, because I don't really like science. It is not my strong point, but I like the periodic table test because it is something [the topic] you can actually do well [in], if you study* (Nad Gr. 8 Para. 12).

> *It's [tests] got to be so technical. And then when it's technical and you lose marks for not underlining a date or something* (Nad Gr. 8, Para. 15).

Lar, a Grade 8 participant, in telling the story of what the most important thing to her, said:

> *The most important thing … I've learnt how to make a list, how to do a graph, how to do tables. All the rules that you need [to get the graphs and tables right]* (Lar Gr. 8, Para 18).

And Mik Gr. 8 said:

> *I think the most important things that we've learnt in Life Sciences is how to set up diagrams and the human body* (Mik. Gr. 8, para 23).

Dev Gr. 8 said that the most important thing for her is

> *… draw diagrams and things like that. I like drawing the graphs and tables. It is easy for me. So, I know how to draw them properly. I know how to do that properly* (Dev Gr. 8, Para 8).

All the participants cited above mentioned that content knowledge in Life Sciences is most important and Dev Gr. 8, in her statement, emphasised that her love for this topic is based on the fact that she 'understood' the topic. Participants that do not 'understand' therefore have the option of memorising the content so as to obtain good marks and grades in examinations.

The CAPS assessment criteria in this grade required that learners to explain and distinguish concepts (Department of Basic Education, 2011:39). Seeing that the assessment in CAPS in this grade is theoretically based, participants resolve to focus on the content of the subject, forcing them to memorise the content.

4.3.1.5 Theme V: Fragmented viewing of Life Science knowledge

Most participants in this grade had a dislike for plant study. According to the Grade 8 curriculum, the topics that relate to plant study are ecology and ecosystem, which deal with living organisms and their relationship with their environment. Some of the topics that were addressed include photosynthesis and plant respiration (CAPS 2011:35). However, participants seemed to prefer one aspect of Life Sciences over another. They seemingly did not understand the necessity of all aspects of Life Sciences for life and their own wellbeing. For example:

> *I don't like the work on plants and, also, when we have to write long essays on what we've done … I find it very boring, all the photosynthesis and all that… It is just plants; [they] stand so still, they're so stagnant. There's nothing that you can really be seen happening. Of course, there's something happening. But it's just something that I'm not really interested in (*Mik. Gr. 8, Para 19-21).

This participant found plant studies 'boring' and had definitely lost interest because of the discrepancies she perceived between plants and human, stating that plants unlike humans do not move around.

4.3.1.6 Theme VI: Using practical session as 'add on' to knowledge

The findings showed that participants assumed that practical sessions are a way to consolidate the content knowledge they acquired in the classroom. For example: Khu Gr. 8 said:

> *It [theory] shows like, you know, [but] when you do experiments it gives you feedback. So you know what feedback you want from life* (Khu Gr. 8, Para 22).

Participants assumed that the purpose of practical sessions was to consolidate what was learnt in the class, where the content knowledge is still unclear; participants assumed that the teacher is obliged to explain to them. Participants did not regard the practical session as an investigative process targeted at honing their skills such as critical thinking, creativity and problem-solving ability.

4.4 PRESENTATION OF GRADE 9 INTERVIEWS

Table 4.4 represents codes and the emergence of the themes for Grade 9, from which 23 codes were generated. The codes were comparatively analysed to derive the themes and subthemes, as indicated in table 4.4.

Table 4.4: Grade 9 codes and emergence of the themes

Initial codes	Focus codes	Sub theme	Themes
Enjoying how teacher explains topic Understanding Life Sciences content as a result of teacher's explanation	Depending on teacher for knowledge supply	Dependence on experts knowledge for practical activities	Dependence on experts knowledge for practical activities
Getting explanation of topics from teacher Receiving notes from teacher	Depending on teacher for knowledge supply	Dependence on experts knowledge for practical activities	Dependence on experts knowledge for practical activities
Writing notes from textbooks Reading text books for knowledge acquisition Learning Life Sciences contents from textbooks	Consulting the experts' view		
Seeing Life Sciences as a way to appreciating the world Experiencing motivation by being able to explain what happens around the world	Finding a way to satisfy curiosity	Finding a way to satisfy curiosity	Centralising Life Sciences content knowledge as Life Sciences essence
Rating the interest in Life Sciences by the level of understanding of its contents and topics Learners being frustrated by lack of understanding	Desiring to understand Life Sciences content knowledge	Seeking understanding of Life Sciences content	
Seeing practical sessions as application aspect of Life Sciences	Seeing practical session as a means to understanding Life Sciences content	Using practical session as 'add on knowledge'	using practical session as 'add on knowledge'

Table 4.4: Grade 9 codes and emergence of the themes (cont'd)

Initial codes	Focus codes	Sub theme	Themes
Seeing practical sessions as a way to experience Life Sciences			
Seeing Life Sciences as a means to achieving aspired career	Deriving motivation to study Life Sciences from career point of view	Career-driven Life Science education	Career-driven Life Science education
Finding interest in Life Sciences because of aspired career			
Disliking homework and tests	Feeling overwhelmed with academic demands	Feeling overwhelm with Life Science content demands	Feeling overwhelm with Life Science content demands
Having constant and continuous tests			
Finding Life Sciences as a voluminous subject	Tussling with limited time to complete Life Science topics		
Having undetailed learning because of limited time			
Compromising the quality of learning because of time constraint			
Taking Life Sciences learning as casual	Underplaying significance of Life Sciences to life	Underplaying significance of Life Sciences for life	Underplaying significance of Life Sciences for life
Attaching no importance to Life Sciences in future use			
Finding no reason for learning plant science			

4.4.1 Emerging themes in Grade 9 interviews

The themes that emerged from the Grade 9 after the comparative analysis and the coding from their interviews are as follows.

4.4.1.1 Theme I: Dependence on experts knowledge for practical activities

In this study, Grade 9 participants depended more on what the teacher taught in the classroom, their notes and textbooks for academic success and did not consider the application of what was being taught, as reflected in Rei Gr. 9's statement.

> *… my teacher taught us that, we should stand on one leg every day, to maintain our balance … for just hip and bone strengthening all of that* (Rei Gr. 9, Para 7).

In this statement, Rei Gr. 9 mentions that in class the teacher taught about the importance and maintenance of strong healthy bones. This was meant to be a practical application of the knowledge of the skeletal system as part of the curriculum introduced by the teacher. However, it is interesting to note what she (Rei Gr. 9) further said:

> *It is just a waste of time. We can go to the lesson and finish fast* (Rei Gr. 9 Para 7).

Participants prefer just to go through class without engaging in deep thinking of in applying the information.

4.4.1.2 Theme II: Centralising Life Science content knowledge as its essence

In the study, the Grade 9 goal is to understand Life Science topics, concepts and facts, and where there is no understanding of a topic, participants express uneasiness similar to that discerned among the Grade 8s (4.4.1.1 Theme I). For instance:

> *… I didn't like the beginning of the term when we had to do the scales, because I don't really understand variables and all of those things* (Rei Gr. 9 Para 15).

Furthermore, study participants indicated that they saw practicals as an 'add-on' to the knowledge acquired in the classroom. They also assumed that practical sessions were meant to help them understand the content knowledge of the subject better. However, few practicals sessions were conducted by participants in this grade.

4.4.1.3 Theme III: Career-driven learning

As for participants in this grade, findings showed that few participants that were motivated are participants with anticipation to take up science profession. In this grade, Sciences is a compulsory subject; therefore, only participants who have a reason to study Life Sciences as a subject may eventually go further with it at the higher levels, especially when they are required to choose the subjects that they are to do. For example, the participant below was interested in Life Sciences because she wanted to become a doctor.

> *Well, I like it because I want to be a doctor. I know it will be very helpful for me to know anatomy of human. It also gives me knowledge of what is happening inside human body, only to know about the processes that happen within the body* (Lets Gr. 9, Para 10).

Another participant (Les Gr. 9) mentioned that learning Life Sciences would contribute to her achieving her dream of becoming a dentist.

> *Yes, it does as I want to take Life Sciences as my subject. So it will help me to know all about it in life. And I want to be a dentist in future* (Les Gr. 9 Para 17).

Participants were motivated to study Life Sciences, not because they needed to know or were curiosity to know about it, but for career purposes. Consequently, participants who were planning a career in another profession like law or business might not be enthusiastic about taking Life Sciences as subject.

4.4.1.4 Theme IV: Feeling overwhelmed with Life Science content demands

The Grade 9 participants mentioned feeling overwhelmed by the volume of work they have to cover in Life Science topics. This feeling was exacerbated because they had lost interest in most of the topics taught, especially plant studies which seemed not to appeal to most participants. Cooper (2014) asserts that interest is most often played down when participants nurse feelings about being compelled to study a topic or subject which is of no significance to them.

As Nal Gr. 9 said:

> *Also, the work is too much, when you kind of have a lot of things to study and you don't know the topic that will be covered in the exam. I really feel that, it is too much work* (Nal Gr. 9 Para 12).

Parkinson, Gilling, and Suddaby (2006:253) report that learners lose interest and motivation when a subject is encumbered by a heavy workload. However, they also report that the relevance of the subject or topic could engender interest. In the current study, both heavy workload and lack of relevance of topics (plant topics) were evident. Figure 4.1 depicts one participants boredom in the classroom as the teacher teaches the lesson.

Figure 4.1: Learner displaying boredom in classroom.

4.4.1.5 Theme VI: Underplaying the significance of Life Science learning for life

The Life Sciences participants in this grade see Life Science learning as a common phenomenon (Pfa Gr. 9), which happens to every child when they go to school. They assumed that this is the way it and how it will always be. They are compelled to take Life Sciences as a subject like every other child in school before them. For example, Pfa Gr. 9 said: "*It is all the things that we are to learn. They are just the work, nothing much*" (Pfa Gr. 9 Para 13).

The comment "*nothing much*" by Pfa, Gr. 9 is an indication of a nonchalant attitude toward the study of the subject.

4.5 PRESENTATION OF GRADE 10 INTERVIEW DATA

Grade 10 codes and themes are presented in table 4.5. Twenty-eight codes were drawn from 12 individual interviews from which themes and subthemes emerged the data were comparatively analysed.

Table 4.5: Grade 10 codes and emergence of themes

Initial codes	Focus codes	Sub themes	Themes
Requesting teacher to explain Life Sciences content	Requesting teacher to explain Life Sciences content	Requesting teacher to explain Life Sciences content	Dependence on teacher’s knowledge
Having teacher to explain Life Sciences content	Having teacher to explain Life Sciences content	Depending on teacher for supply of knowledge	
Loving teacher’s explanation of topics	Enjoying receiving knowledge from teacher		
Loving teacher’s teaching method			
Teacher teaching through notes			
Finding practical class as a way of gaining understanding	Finding practical class as a new approach to gaining understanding	Finding the few practical sessions useful	Finding the few practical sessions useful
Learning skills through practical sessions	Learning skills through practical sessions		
Doing few practical sessions	Enjoying few available practical sessions		
Liking practical sessions			
Getting to know one’s body through human studies	Personalising human studies aspect of Life Sciences	Developing interest to animal and human studies aspect of Life Sciences	Fragmented viewing of Life Science knowledge
Seeing Life Sciences as personal life and the nature			
Finding the study of human processes most relevant			
Eager to learn human anatomy topic	Deriving joy in studying animal and human anatomy		
Finding joy in learning topics related to human body			
Attaching significance to animal and human studies			
Finding plants studies insignificant	Disliking plant studies aspect of Life Sciences	Developing disinterest to plant studies aspect of Life Sciences	
Disliking plant study			

Table 4.5: Grade 10 codes and emergence of themes (cont'd)

Initial codes	Focus codes	Sub themes	Themes
Struggling with understanding of Life Sciences content knowledge Disliking homework	Struggling with understanding Life Sciences content	Struggling with understanding Life Sciences content	Struggling with understanding Life Sciences content
Feeling pressed for time Prioritising time Struggling with limited time	Prioritising time as necessary for academic achievement	Prioritising academic progression as central to Life Sciences education	Prioritising academic progress as central to Life Sciences education
Recounting Life Sciences subject content as knowledge Emphasising Life Sciences content as most important part of learning	Prioritising retention of Life Sciences contents as knowledge for academic progress		
Prioritising test Applying Life Science knowledge in test	Prioritising tests as a way to academic progress		
Having classroom discussion Looking for one to one instruction	Enjoying interactive learning	Enjoying interactive learning	Enjoying interactive learning
Choosing Life Sciences for career purpose	Choosing Life Sciences for career purpose	Choosing Life Sciences for career purpose	Choosing Life Sciences for career purpose

4.5.1 Emerging themes in Grade 10 interview

The following themes emerged from a comparative analysis of Grade 10 data. These themes are presented as the emerging themes in table 4.5 in section 4.5.

4.5.1.1 Theme I: Depending on teacher's knowledge

In this theme, the teacher is seen as the custodian of knowledge (Bon, Gr. 10 Para 10). Like the Grade 9s, participants in this grade prefer that the teacher tells them what content they need to know.

For example, Bon Gr. 10 said:

> *Then she'd [teacher] take time to summarise the work for us, if we don't understand. And she explains everything in detail* (Bon Gr. 10 Para 8).

Similarly:

> *I like the teacher, how she explains the work to us, and she doesn't just rush through the work. She takes time to go through everything. If you don't understand, she'll explain it again. That's what I like about [Life Sciences class]* (Bon grade 10 Para 10).

Another participant also commented "*and I like the way the teacher explains things*" (Ber Gr. 10 Para 8) and Maz Gr. 10 said, "*I think my teacher is a great teacher, she explains things*" (Maz Gr. 10 para 10).

In addition, participants were happy for their teacher to be the knowledge giver with them remaining the recipients of knowledge (Ber Gr. 10 Para 8). Not only do they depend on the teacher, but they also request that, at times, the teacher should tell them what they need to know and the content that has to be mastered in the subject (Kel Gr. 10 Para 14).

> *I don't like the work, when the work gets much, it is unclear. Or like, when she [teacher] us, you know … it is on the projector as well, and it is kind of like a summary of what is in our notes, which is fine. But … it is kind of cumbersome to use your notes, and the textbook and her notes and try to compile all and figure out what is most relevant. That, I really don't like that* (Kel Gr. 10 Para 14).

Accordingly, Kel Gr. 10 would like the teacher to tell them, once and for all, what they are required to learn without them having to search for or consult any textbook or go through the rigour of reasoning and knowledge construction, which could be brain tasking.

4.5.1.2 Theme II: Finding the few practical sessions done useful

Most participants in the Grade 10 regard practical sessions as another way of learning Life Science content. For example, Ber Gr. 10 said: "*I like experiments … They're just* *very cool. You see different things*" (Ber Gr. 10, Para 8-10)**.** However, for some participants this represented another way of acquiring a better understanding of and consolidating the knowledge, and not, perhaps, a way of applying the knowledge.

Bon Gr. 10 implies this in her statement below:

> *Not necessarily … We only come to … apply it [knowledge from practicals], when we have to write a test or exam or something like that* (Bon Gr. 10 Para 16).

For participants, writing tests and passing then was the ultimate aim of the practical sessions. The sessions were neither investigative nor targeted at developing intrapersonal skills. However, some interpersonal skills, like working in groups, were exhibited.

4.5.1.3 Theme III: Fragmented view of Life Science knowledge

Participants perceived Life Science content knowledge as fragmented. The findings revealed that participants' perceptions of topics and concepts entailed that the subject is an accumulation of disjointed bits of information, which lacks coherence and renders the understanding of the concepts and topics incomplete.

Participants could not perceive the interconnectedness between the topics or concepts, hence preferring to learn the topics as discrete topics. This process consequently places participants in a position where they find some topics far more important than others.

For example, Kel Gr. 10 said:

> *I think the most important … I'd say, is the reproduction [topics]… because I'd say that is interesting. And, like the lungs, that's also really, really interesting… I think it is most interesting, because of the way that it will affect my life. I don't know cells dividing; [it] doesn't really affect me because they just do it by themselves* (Kel Gr. 10 Para 22).

The same participant also had this to say:

> *I prefer learning about the human like system than cells and things. Because, it, kind of, tells you how things work, and you figure it out what causes it and that is very interesting* (Kel Gr. 10 Para 12).

Maz Gr. 10 said:

> *What I'm excited the most about Life Sciences is when we start learning about the human body. We haven't done that yet. We're still doing plants. And I don't really like plants, because, they just don't make sense to me that much* (Maz Gr. 10 Para 20)

Participants in this grade prefer topics that address human anatomy and the body and excite their joy and interest, over the topics relating to plants. This is because they find the former to be personal and separate from plant study which is assumed to have no personal significance.

4.5.1.4 Theme IV: Struggling with understanding Life Science content

In this grade, participants struggled to do homework and understand Life Science content. Maz Gr. 10 (Para 12) had this to say.

> *Like any other child – homework. I don't like the homework … you will need to write all the work in the way the teacher wanted it* (Maz Gr. 10 Para 12).

Homework appeared in a way to be a test for the participants, who were expected to reproduce the content as it had been taught or as the teacher would want it. The thought of what to write in order to gain acceptance and marks from the teacher prevailed over the construction of knowledge and understanding of topics.

Val Gr. 10 said in this regard:

> *Sometimes, homework is difficult, because you need to do the assignments in the book. So, many times, you need to study a lot of pages in the textbook to get the answers for the homework* (Val Gr. 10 Para 12).

Homework is usually content based, which becomes additional work to the volume of pages that are required to be taught by the curriculum. The purpose of homework is usually to ensure that the topics required by the curriculum are completed.

4.5.1.5 Theme V: Prioritising academic progress as of central importance

Academic promotion and progress were prioritised by participants and Grade 10 participants were no exception. Therefore, in order to ensure that they (participants) passed their tests and moved on to the next grade, participants prioritised the retention of content knowledge. One of the participants' responses to the question of what the least important thing in the experience of Life Sciences is, was as follows:

> *Sometimes, the class tests that we have [though], it does help you [to pass], but sometimes, it is just in the middle of all the other tests. So, it is kind of like hard to make time to study for* it (Ale Gr. 10 Para 10).

Maz Gr. 10 preferred that the teacher should go straight into teaching Life Science concepts, rather than engaging the class in the practical use of the concept (bones and skeleton) in daily exercise. Maz Gr. 10 therefore suggested that instead of the bone/skeleton exercise, the teacher should continue teaching SCK.

> *I don't like the homework. And usually, when we do the skeletal exercise, I don't really like that. I find that, it takes too much time, and I'd rather that we get on to the work straight away* (Maz Gr. 10 para 12).

What frustrates participants the most is tests, even though they agreed that they help them to achieve better marks in exams (Ale Gr. 10 Para 10., Val. Gr. 10):

> *It is the class tests that we have. Even when you write everything you know in the work, you still kind of get low marks. Sometimes homework is difficult, because we need to do the assignments in the book so, many times you need to study a lot of pages in the text book to get the answers for the homework* (Val Gr. 10, para 10)

Kel Gr. 10 also had the following to say:

> *So, it is kind of cumbersome, to use your notes, and the textbook and her notes and try and compile all and figure out what is most relevant [in exams]. That I really don't like* (Kel Gr. 10 Para 15).

However, passing tests and exams was a big issue for participants because they want to pass and consequently go on to the next grade.

4.5.1.6 Theme VI: Preferring interactive class sessions

One of the Life Science participants in Grade 10 mentioned that she preferred a one-on-one instructional method, which seems quite impossible in public schools (Ale Gr. 10 Para 7). In addition, due to the volume of topics and the limited time, interaction and much discussion on topics cannot take place in the classroom. Some of the participants like Bon Gr. 10 and Ber Gr. 10 indicated that content was covered very quickly:

> *… if the work is rushed and you don't understand properly, you can't really go home and try to explain it to yourself, because, then, you need someone who knows it to explain it. So, I don't like it, when things are going too fast and then you're just left then, you don't understand* (Bon Gr. 10 Para 13).

Ber Gr. 10 had the following to say in this regard:

> *Sometimes when the teacher gives us notes like, she gives it too fast and you don't have time to write it down* (Ber Gr. 10 Para 14).

Further, Val Gr. 10 stated:

> *I don't know, it's like, I will prefer that the teacher take the work slowly and allow us to ask questions. I prefer that the teacher allow us to interact and ask any question, it is then, I can, kind of, learn more* (Val Gr. 10, Para 12).

In the process of trying to complete the topics required by the curriculum within the timeframe, participants' understanding of concepts is compromised.

4.5.1.7 Theme VII: Career-driven education

Researchers have found that many learners take up Science subjects at high school because they have already been decided on the kind of career they envisage for themselves. This was evident in this study, as Ale Gr. 10 said:

> *Well, I [study Life Sciences] because I want to use it in my career and stuff. And because it is very like helpful, … you have far more knowledge about what goes on in your body than the people who don't take Life Sciences … I want to go into medicine. I want to be a doctor* (Ale Gr. 10 Para 18).

It was revealed that the way in which the Sciences are being taught in the classroom does not provide sufficient motivation for learners, especially those who are not planning a science-based career.

4.6 PRESENTATION OF ANALYSIS GRADE 11 INTERVIEW

Table 4.6 presents the codes and themes for Grade 11. Twelve individual interviews were held which generated 38 codes. Themes emerged from the codes as they were comparatively analysed.

Table 4.6: Grade 11 initial codes and emergence of the themes

Initial codes	Focus codes	Sub themes	Themes
Listening to teachers teaching for content knowledge	Struggling with understanding Life Sciences content	Placing importance on recalling of Life Sciences content for high marks	Placing importance on recalling of Life Sciences content for high marks
Finding test as a way to commit Life Sciences content into memory			
Using tests as a means of getting understanding of Life Sciences content knowledge			
Struggling with recalling of content during tests			
finding studying for test boring			
Placing importance on recalling Life Sciences content knowledge	Placing importance on recalling of Life Sciences content for high marks		
Setting high test scores as academic goal			
Having frequent test s as a way to assimilate content			
Revising repeatedly as a way of retaining knowledge			
Revising as a way to remember Life Sciences content knowledge			

Table 4.6: Grade 11 initial codes and emergence of the themes (cont'd)

Initial codes	Focus codes	Sub themes	Themes
Learning Life Sciences content from printed material	Placing importance on recalling of Life Sciences content for high marks	Placing importance on recalling of Life Sciences content for high marks	Placing importance on recalling of Life Sciences content for high marks
Focusing on completing Life Sciences curriculum	Avoiding academic failure through the completion of curriculum		
Associating completion of curriculum as a way to academic success			
Knowing all that is required by the curriculum			
Recounting the volume of Life Sciences curriculum content	Feeling overwhelmed by the volume of Life Sciences content	Feeling overwhelmed by the volume of Life Sciences content	Feeling overwhelmed by the volume of Life Sciences content
Emphasising workloads of learning science			
Being frustrated for lack of direct instructions	Depending on teacher for Life Sciences content knowledge	Depending on teacher for Life Sciences content knowledge	Depending on experts for Life Sciences content knowledge
Relying on teachers teaching expertise			
Requesting teacher's expertise			
Placing expectation on teacher	Placing learning responsibility on teacher		
Taking teachers as knowledge deposit			
Relinquishing learning responsibility to the teacher			
Getting Life Sciences information other sources	Getting Life Sciences information from other sources	Getting Life Sciences information from other sources	
Getting interested in microbial world	Getting fascinated by micro world	Fragmented view of Life Sciences content knowledge	Fragmented view of Life Sciences content knowledge
Finding human studies interesting	Personalising human studies in Life Sciences contents		
Seeing oneself through the study of human body processes			

Table 4.6: Grade 11 initial codes and emergence of the themes (cont'd)

Initial codes	Focus codes	Sub themes	Themes
Appreciating one's body from the study of human body processes	Personalising human studies in Life Sciences contents	Fragmented view of Life Sciences content knowledge	Fragmented view of Life Sciences content knowledge
Referring to human studies as most important aspect of Life Sciences	Referring to human studies as most important aspect of Life Sciences		
Lacking flair for plant studies	Disliking plant studies content knowledge		
Disliking plant studies			
Finding no link between Life Sciences content	Experiencing no link within Life Sciences lessons and contents	Experiencing no link within Life Sciences lessons and contents	
Experiencing gaps in Life Sciences content			
Experiencing lack of continuity in Life Sciences topics			
Getting intrigued by new scientific information	Feeling happy about new scientific discoveries	Getting excited about innovation and discoveries in the real science world	Getting excited about innovation and discoveries in the real science world
Getting amazed by new scientific information			
Feeling good about new information	Feeling informed about the world of science		
Finding lesson on scientific innovation interesting			
Deriving interest in scientific news			

4.6.1 Emerging themes in Grade 11 interview

In the analysis of the Grade 11 interviews, the themes that emerged from a comparative analysis of the data were as follows:

4.6.1.1 Theme I: Depending on experts[1] for Life Sciences content knowledge

An analysis of the Grade 11 Life Sciences participants responses indicated that the participants in this group were dependent on the teacher's knowledge and expertise. Participants relied on the teacher to give direct instruction through notes and verbal classroom teaching. One example of this is given by Dom Gr. 11**:**

> *I would say that my teacher … doesn't explain the work in depth, and if we ask questions, she is not answering* (Dom, Gr. 11: Para 15)

This participant (Dom, Gr. 11) attested to the fact that whenever the teacher does not give such direct teaching, she feels unhappy, as indicated by this statement:

> *She won't answer any questions, that are in the notes and sometimes, it is frustrating when you want to know more* (Ste Gr. 11, Para 8)

One of the participants also mentioned that it is the teacher's responsibility to give the knowledge and they (participants) are to accept what the teacher gives.

> *She is supposed to know what the answer is, when in actual fact we just sit there, and we are just confused, and we don't know what is happening* (Dom Gr. 11 Para 15).

Apart from the teacher's knowledge, the participants also relied extensively on their textbooks which serve as the content knowledge provider in the Life Sciences.

4.6.1.2 Theme II: Fragmented view of Life Science knowledge

In the study, data obtained indicated Grade 11 participants have a fragmented perception of Life Science knowledge. Some participants reported that they experienced disjointedness in the way the Life Science topics are taught**.**

> *I would say that my teacher is not consistent with the topics, in different topics. Sometimes, it is difficult [to understand] and there's sometimes like big gaps* (Sto Gr. 11, Para 12).

[1] *Experts are assumed to be the teachers and the scientific knowledge represented as content in textbooks*

In addition, Dom Gr. 11 said:

> *I would say that my teacher jumps around our topics* (Dom, Gr. 11: Para 15).

The Grade 11 curriculum cuts across both the plant and animal domains of Life Sciences. The study also revealed that participants greatly prefer topics that deal with human anatomy and human processes rather than those of plants. For example, the statements of Ste Gr 11 and Sta Gr 11 respectively:

> *I like learning about how things work, like the human body, especially, because I like knowing what goes on in my body* (Ste Gr 11 para 19)

and

> *I find Life Sciences exciting. I do like to learn things about the body and stuff, but other than that, nothing else* (Sta Gr 11 para).

The findings revealed that some participants personalise the study of human processes and believe that it is the only aspect of Life Sciences that is relevant to them. One example is this statement by Ste Gr. 11:

> *I feel like I can know what is happening in my own body and why it works the way it is working …* (Ste Gr. 11: para 20)

Hence, participants tended to dislike studying plants, preferring to learn about animal and human science.

4.6.1.3 Theme III: Placing importance on recalling of Life Science content for high marks

Like the other grades, academic promotion and progress would appear to be one of the concerns of the Grade 11s. Participants placed importance on academic progress by giving attention to their homework and revising work done in class, in order to get high scores in tests. Whenever tests are not favourable in terms of marks or when tests require explanation, participants became discouraged. One example is Cat Gr 11. She complained about writing essays in tests. She said:

> *… the essays, I always struggle with [them], because, usually I study very hard. So, I know what is going on and I make sure that I know what is going on [what is in the notes]. It is annoying, because … you don't get marks very well for the essays, even if you write everything that you know. So, I just want to know the tips to [passing] the essays* (Cat Gr. 11 Para 18).

Ali Gr. 11 also attested to this in her statement as quoted below:

> *So, it is hard to get good marks especially with essays. The essays that we write in our test that makes it really difficult to get high marks* (Ali Gr. 11 Para 16).

In addition, some participants said that the work in this grade is voluminous and that they have limited time to complete the curriculum. For example, in Dom's comment, she said:

> *We have so much to learn and there are so many different aspects to learn about Life Sciences. You have to remember this part is based on this part … It is very complicated at times* (Dom Gr. 11 Para 25).

In addition, Ali Gr. 11 (Para 16) had this to say:

> *It is a huge workload to take on. So it is hard to get good marks especially with essays. The essays that we write in our test make it really difficult to get high marks.*

She attested to the difficulty in getting marks because of the volume of the work, but placed more emphasis on the importance of completing the topics than understanding the concepts presented in the topics**.**

4.6.1.4 Theme IV: Getting excited about innovation and discoveries in the science world

As mentioned in the statements of Ali (Gr. 11, Para 8) and Ste (Gr. 11, Para 4), at every beginning of every lesson, the teacher gave participants (Grade 11s) the innovation of the day by reporting items of scientific news and current issues in the scientific world to the class, so that the learners become aware of what someone with a background of Life Sciences can achieve. The teacher only shares this scientific innovation with Grade 11 participants, while in other grades she devised other activities for them. As a result of these accounts of how science and scientists work in the outside world, some of the participants in this grade realised the science goes beyond the classroom subject, but still remain puzzled as to how they themselves will be able to engage in this type of science. An example of this is the statement from Cat Gr. 11 below:

> *I've learnt that there is innovation everywhere. And breathing isn't just breathing. There's a whole process that happens, respiration. And plants make their own food by making photosynthesis. And it doesn't just rain, there's like a whole water cycle that happens for the water to get into the clouds* (Cat Gr. 11 Para 16).

This reveals to me that participants in Grade 11 have a great opportunity to see the science knowledge beyond the classroom and that it has an interrelationship with nature, which results in excitement about the subject in Grade 11.

Dom, Gr. 11 said:

> *I find it very interesting to learn what the functions of microorganisms are and how they actually cope in [inside] a person or in plants and animals* (Dom Gr. 11 Para 3).

Cat Gr. 11 also said**:**

> *It [Life Sciences] is very important because if you have Life Sciences you can understand how things work. And you don't have to just look at things and wonder. You can actually find out things, how it worked and everything* (Cat, Gr. 11 Para 6).

The Grade 11 participants were actually aware of the fact that Life Sciences is more than mere fragments of isolated information and that all Life Sciences content – animal, human, plants and ecology – are interlinked.

4.7 PRESENTATION OF GRADE 12 INTERVIEWS

In Table 4.7, I present the codes and the emergence of the themes for Grade 12. Comparative analysis of the data from 12 participants generated 50 codes and eight themes.

Table 4.7: Grade 12 codes and emergence of themes

Initial codes	Focus codes	Sub themes	Themes
Teachers teaching from printed materials	Listening to teacher's teaching	Depending on teacher's knowledge	Depending on experts for knowledge
Listening to teachers teaching for content knowledge			
Receiving extra information from teacher	Depending on teacher's knowledge		
Finding teacher's explanation helpful in examinations			
Assessing understanding of subject by ability to answer questions in class			
Using visual aids for learning	Using visual technology for learning purposes	Relying on experts for knowledge	
Finding workload of the subject overwhelming	Finding work overwhelming	Overwhelming learning process	Overwhelming learning process
Realising the volume of Life Sciences content			
Having too much of Life Sciences information to commit to memory			
Struggling with limited time during lessons			
Getting bored about lecture teaching method	Boring Life Sciences lessons		
Deriving no interest in lesson			
Preferring class work to test			

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Table 4.7: Grade 12 codes and emergence of themes (cont'd)

Initial codes	Focus codes	Sub themes	Themes
Receiving Life Sciences content from teacher	Accepting Life Sciences content knowledge	Prioritising content knowledge to indicate brilliance	Prioritising content knowledge to indicate brilliance
Accepting the content knowledge from the teacher			
Finding content knowledge important to proof brilliancy	Finding content knowledge important to proof brilliancy		
Revising the previous Life Sciences works			
Reviewing the previous work			
Writing frequent tests in order to remember facts	Creating mental picture to ensure retention of content	Creating mental picture to ensure retention of content	
Getting understanding through revision			
Focusing on small section of the subject per time in order to remember the facts			
Getting interested in human studies	Growing interest in human studies aspect of Life Sciences	Seeing study of human process as the most important aspect of Life Sciences	Seeing study of human process as the most important aspect of Life Sciences
Finding human studies easy to learn			
Deriving enjoyment in learning human processes			
Enjoying human studies			
Changing perception about Life Sciences because of human study aspect			
Making the study of human processes the most important part of Life Sciences	Making the study of human processes the most important part of Life Sciences		
Finding human studies lessons as most relevant			
Gaining understanding of oneself creates interest of the study of human processes	Personalising human studies		

Table 4.7: Grade 12 codes and emergence of themes (cont'd)

Initial codes	Focus codes	Sub themes	Themes
Getting to know what is going on in one's body Discovering new things about one's body Linking study of human processes with personal life	Personalising human studies	Seeing study of human process as the most important aspect of Life Sciences	Seeing study of human process as the most important aspect of Life Sciences
Disliking plant studies Lacking interest in plant studies Getting bored by plant studies	Finding plant studies disinteresting	Finding plant studies disinteresting	Placing plant study as less significant to life
Having difficulty in learning plant science Having to imagine plant science topics in order to understand	Finding plant science difficult to learn	Finding plant science difficult to learn	
Finding no link between plant studies and life application of plant's knowledge Finding plant studies as irrelevant to personal life Making no importance to personal life	Not finding plant study's significance in personal life	Not finding plant study's significance in personal life	
Focusing on learning for future career Deriving motivation for learning as a means to anticipated career	Deriving motivation for learning by focusing on career	Deriving motivation for learning by focusing on career	Career-driven education
Deriving motivation from science family background	Deriving motivation from science family background		
Advocating for link between Life Sciences content and life's experiences Advocating for a real life application	Advocating for real life application of Life Science knowledge	Advocating for real life application of Life Science knowledge and practical knowledge	Advocating for real life application of Life Science knowledge
Advocating for more practical sessions and interaction	Finding few practical sessions useful for understanding		

➡

Table 4.7: Grade 12 codes and emergence of themes (cont'd)

Initial codes	Focus codes	Sub themes	Themes
Getting understanding of Life Science knowledge through practical activities	Finding few practical sessions useful for understanding	Advocating for real life application of Life Science knowledge and practical knowledge	Advocating for real life application of Life Science knowledge
Enjoying small classes	Enjoying interactive class	Enjoying interactive class	Enjoying interactive class
Engaging in interactive classes			
Deriving no interest in the subject because of lack of class interaction			

4.7.1 Emerging themes in Grade 12 interviews

The themes pertaining to Grade 12 emerged from the comparative analysis of codes from their interview. These themes are presented as the emerging themes in Table 4.7 presented in the above section 4.7.

4.7.1.1 Theme I: Depending on teacher

In this study, the Grade 12 participants intimated that they depend on their teacher's knowledge and acquire SCK from her. The teacher becomes the supplier of knowledge. The opinions of participants in Grade 12 are exemplified by Cas. (Gr. 12) who stated:

> *I like the way my teacher teaches. She explains all the information and she gives us examples. And if she sees something, she'll just show us* (Cas Gr. 12 Para 14).

Most participants agreed that their teacher's responsibility is to transfer what knowledge she possesses to them. Therefore, the teacher takes on the role of knowledge source rather than a facilitator of knowledge.

> *I like the way my teacher explains most of the work. It is very clear and one can follow to understand and the fact that she doesn't use notes to teach the work, it shows that she knows what she's teaching* (Ana Gr. 12 Para 10).

Additionally, the participants assumed that the efficiency and effectiveness of the teacher is displayed by how much the teacher can explain and make them understand any Life Science concept or topic. Furthermore, participants requested that the teacher should give extra information that would be needed for tests or examinations.

4.7.1.2 Theme II: Overwhelming learning process

In the Grade 12 data, ‘overwhelming learning process’ stands out as a theme. The subject becomes overwhelming, because of the volume of the SCK that the participants have to learn.

Examples of statements affirming this are given below:

> *… it is so much work to remember, all at one go, it is quite overwhelming, but yes, it would, mostly just be that. And sometimes some things, almost can’t be explained. You just have to accept it* (Raf Gr. 12 Para 14).

This participant (Raf. Gr. 12 Para 14) believed that learners should just accept facts (become knowledge recipients) where they cannot understand what they are being taught.

> *The amount of work … Sometimes, when you eventually get to mid-year or end-year exams … that’s when you truly realise, how much work you have to study* (Meg Gr. 12 Para 14).

4.7.1.3 Theme III: Career-driven education

Satisfaction is necessary for ensuring persistent effort, continuity and eventually continued success**.** The Grade 12 participants pursued satisfaction by pressing for their goals. Some participants in this grade study Life Sciences purposefully to prepare for their future career. For example:

> *Because, if you do medicine … you would understand more than those who don’t take Life Sciences. So, it gives you an extra knowledge of understanding of the environment and of the world and the human body* (Mmp Gr. 12 Para 27).

Therefore, the choice of their favourite topic depends on the science profession they intend to go into. For instance, if it is medicine, the participant becomes more interested in human studies.

> *I love learning, especially about the human body, because I want to go into physio* (Meg. Gr. 12 Para 8).

For Jo Gr. 12, her interest lies not so much in plant science because she feels that it does not relate to what she would really need in the future.

> *And I don't like doing plants, because it doesn't really help me further on in life* (Jo Gr. 12 Para 18).

In addition, Mon, Gr 12 said:

> *I just don't think it will benefit me later in life to learn about them [plants]* (Mon Gr. 12 Para 25).

The benefit participants derive from their Life Science learning here is only as a prerequisite of a career opportunity. Therefore, the implication is that those who would not take up a career in science can be excused from learning science (Life Sciences) from the participant's point of view.

4.7.1.4 Theme IV: Advocating for real-life application of Life Sciences' knowledge

Realness in this context is defined as something tangible, for example situations that can be experienced. However, ***feeling in touch*** as described by Raf. Gr. 12 in the excerpt below refers to practical classes that are conducted in the laboratory and not the real-life context of the Sciences. Raf Gr. 12 said:

> *And then, sometimes very rarely we do practicals in class. And those are quite fun, because, they help you to understand the section that you're doing more. Because you feel in touch with what is actually going on. It helps with a better understanding as well* (Raf. Gr. 12 Para 6).

Take, for example, participants like Jo Gr. 12, who commented that although they are taught, but they were not given opportunity to understand how the concepts learnt can be applied in real life.

> *I think a lot of the stuff is not really learning the work, but application work. And a lot of times, we don't learn how to apply it in the class* (Jo Gr. 12, Para 18).

Jo Gr. 12 further said in her concluding statement in the interview that she would prefer more application of the subject, rather than learning the subject content alone. She said:

> *We could do more application work than just reading the booklet. To help us with our exam and help us with everyday life, [to understand] how things work instead of just reading* (Jo Gr. 12 Para 28).

Another participant said:

> *I like doing practicals where you can actually see …* (Kes Gr. 12 para 7)

Participants looked forward to a more interactive session in the Life Science class; more practical sessions than the regular classroom session of note taking, explanation, and tests that culminate in exams. They looked forward to application instead.

> *Sometimes I get bored because we just … sit and go through notes or listen to the teacher. We don't really get involved or do any interactive things in class* (Key Gr. 12 Para 12).

The lack of active engagement and application of acquired knowledge engendered boredom in participants.

4.7.1.5 Theme V: Fragmented view of Life Science knowledge

The participants' placed importance on and were happy to learn topics that relate to human processes and human anatomy, rather than learning about plant sciences. In most of the participants' statements, they mentioned that learning about human is the most important thing that they had learnt in Life Sciences

The Grade 12 participants perceived that Life Science knowledge is presented in the classroom as bits of fragmented information. However, many participants were interested in learning about the human body with which they could identify and relate to (Mmp. Gr. 12 para 16, Raf Gr. 12 para 10, Mon Gr. 12 para 10). They were attached to human anatomy, as they discovered explanations that related to their own bodies. Most participants saw the human aspect of Life Sciences as 'this is talking about me'. The response of Mik. Gr. 12, when asked about the most important thing in her Life Sciences experience, is one example here:

> *… just learning about all the process in nature, inside you … I think in a sense, that, I enjoy learning about how I function. So, I know why certain things happen with me, in that sense* (Mik. Gr. 12 Para 4, 6).

Another participant said:

> *… like the human [studies], you know what you look like on the inside. You know where everything is placed* (Raf Gr. 12 Para 10)

Yet another commented:

> *I enjoy learning about anatomy and the human like human interactions with society and the environment. That is the most interesting for me. It is mainly only mammals, that I really enjoy learning about* (Mon Gr. 12 Para 10).

Participants did not share the same feeling with plant studies. In this study, many participants had no flair for plant studies. Some were not interested while others were dissatisfied with the way aspects of plant science were taught in the classroom.

Mmp. Gr. 12 said:

> *"I don't know. Sometimes, like the plants are a bit boring … It doesn't interest a lot of people … Yes, it is a long chapter* (Mmp. Gr. 12 Para. 10, 12, 14).

Another participant says: "*The plants, I find it as very irrelevant and difficult to understand*" (Raf Gr. 12 Para 10).

Participants appeared to find plant studies a boring (Raf Gr. 12 Para 10; Mon Gr. 12 Para 18; Mmp. Gr. 12 Para. 10) and difficult to understand aspect of Life Sciences, because it does not really 'win their attention and interest'. For example, Mmp. Gr. 12 says:

> *When I'm interested, I will concentrate. [Otherwise, I will not] … like mainly plants in general* (Mmp. Gr. 12 para 18).

Another participant said:

> *But with a plant, you kind of, have to imagine and it makes it more difficult. I don't know, I find it a bit boring* (Raf Gr. 12 Para 10).

Relating to plants and the reason why botany must be learnt as part of the subject content seemed not to be clear to participants. Therefore, studying plants does not leave the feeling of 'this is talking about me and my wellbeing' like the studying of the human anatomy aspect of Life Sciences does. Mon Gr. 12 said:

> *I don't really enjoy learning about plants. But I enjoy learning about the relationship between humans and how we're affected with genetically modified plants* (Mon Gr. 12 Para 16).

Although Mon Gr. 12 mentioned the relationship between plants and humans when learning about plants, she still finds plant studies boring.

4.7.1.6 Theme VI: Prioritising content knowledge

When participants were asked about the most important things in their Life Science education, most of the participants recounted Life Science content knowledge. This suggests that what the participants learnt the most was the SCK.

For example, Mmp. Gr. 12's response to this question was:

> *… the [flow] of the heart, … the cycles of plants, because, we don't know how plants reproduce, because you see them just growing in general and then, the cycle of how pregnancy develops …. Like diseases in general that you don't know of and how you can get them. And different types of animals that we have and in which categories they're put into* (Mmp. Gr. 12 Para 26).

Also in this study, some of the Grade 12 participants felt special being science learners and could use the biological terms. Participants assumed that it attracts some form of prestige and makes them look brilliant. One of the participants said:

> *I'm a person who wants to know where is what, and be a formal person [using scientific jargon], speaking with others and say, oh, I hurt my fibula or something like that …* (Mik. Gr. 12 para 10).

Other participants who are not probably getting high marks in their tests study hard to improve their marks. However, the tests and examinations set at the school are based on SCK, and not on the application of such knowledge (in most cases). Hence, participants are keen to be able to recall the SCK in their examination. This is explained by Ana Gr. 12, when she says:

> *I do study, but I think I should just improve on my study work, and, I should learn how to apply myself in exams and tests, because, I figured out where my problem is. It is that, I don't get enough practice. So, I just learn the work and I think, I know it, when I actually don't practice* (Ana Gr. 12, para 18)

When she was asked what she meant by practice she said:

> *By practice, I mean, I get all the exam papers and go over old tests and try to understand a different approach to what we learn in class* (Ana Gr. 12 Para 20).

The participant therefore assumed that if she devoted her time to the revision of notes and past question papers to ensure that she retained the content in her memory, then she would pass the examination; this is fundamentally the reproduction of content knowledge.

4.8 OPEN-ENDED QUESTIONNAIRE

This research is case study research. Hence, the open-ended questionnaire in this instance was used as a multiple data source to corroborate the findings in the study.

Data from the open-ended questionnaire were analysed the same way as data from the semi-interviews (constant comparative data analysis). The questionnaire is attached as Addendum G. Data were coded and comparatively analysed until themes emerged (cf. Addenda I-M). Each grade was analysed separately and the findings and a discussion of the findings follow.

4.8.1 Presentation of the analysis of the Grade 8 open-ended questionnaire

The Grade 8 participants' perception of their current Life Science learning experience was that learning is centred on the acquisition of the body of Life Science knowledge (SCK) and of practical skills, which accounts for learners' promotion from one grade to the other.

In answer to the second question in the questionnaire, Grade 8 data showed that participants assumption that learning is solely the teacher's responsibility. Hence, whatever knowledge participants needed to acquire had to be supplied by the teacher. This became evident from the way the participants described what their teaching practice would be like if they were the teacher, using phrases like: "*I would ensure* participants understand …"

From the findings, I inferred that Grade 8 participants assumed that learning should be enjoyed, and this they did not experience in their education. Therefore, in answering the second question of the open-ended questionnaire, participants indicated that they would ensure interaction and promote joy in their classrooms.

Question 3 requested that participant should represent all they had learnt in class with a diagram. Participants accordingly indicated both the practical and subject content aspects of Life Sciences. An example is presented in figure 4.2. The participant here places Life Sciences at the centre of her diagram surrounded by some Life Science concepts that represent what she learnt in the classroom, for example cells, plants and DNA.

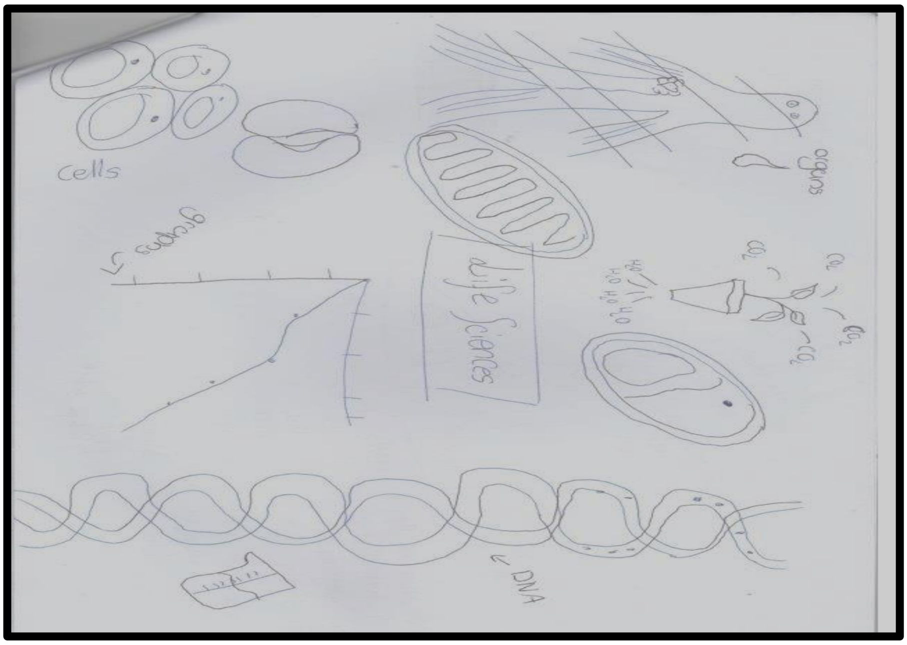

Figure 4.2: Diagram showing a summary of the learning experience

Findings from the Grade 8 open-ended questionnaires did not indicate whether the participants were exposed to the investigative skills as represented in the heuristic process of Life Sciences (cf. section 2.4.2.4). An analysis of the open-ended questionnaire for Grade 8 participants is attached as Addendum I.

4.8.2 Presentation of the Grade 9 open-ended questionnaire

The summary of the Grade 9's perceptions of their current Life Sciences education is centred on the acquisition of Life Science content knowledge. The CAPS aim is to equip learners with SCK and the essential skills necessary for Life Sciences and to promote an understanding of how the knowledge could be applied in everyday life (DBE, 2011:13). However, the findings in this study indicate that participants only see their Life Science learning as the acquisition of Life Science content knowledge and skills only, ignoring the third aim which is to promote the application of Life Science knowledge in everyday life.

Participants assumed that their Life Science experience would be better if it incorporated instructional strategies for the use of multiple sources for knowledge acquisition, promoted participants' interest in the subject, and promoted interaction among participants. The findings show that participants prefer to learn directly from the environment in a fun-filled way, where they could easily build interest in the subject. It was also revealed that, of the three CAPS aims, the Grade 9 participants focused on retaining Life Science content knowledge only, since recalling content is important for promotion to the next grade, and like the Grade 8s, they assumed that the teacher is accountable for their learning process and success. Grade 9 participants assumed that what should be learnt and how it should be learnt are the teacher's responsibility.

In addition, pursuit of a career also emerged as one of the reasons for learning Life Sciences. Participants take up Life Sciences as a subject of study because of the type of profession they planned to take up. The analysed data of the Grade 9 open-ended questionnaire in presented in Addendum J.

4.8.3 Presentation of the Grade 10 open-ended questionnaire

Grade 10 participants described their perception of what their current Life Science education represents as knowledge acquisition centred. In order to acquire this knowledge, participants assumed that teacher is obligated to supply knowledge and ensure the retention of that knowledge through constant feedback on frequent tests. Participants in this grade also agreed with the Grade 8 and 9 participants that interaction is a way to ensure knowledge acquisition. Grade 10 participants pointed out that more interactive learning would be an experience they would want in their Life Science learning process. The analysis of the data from the Grade 10 open-ended questionnaire in presented in Addendum K.

4.8.4 Presentation of the Grade 11 open-ended questionnaire

Like the other grades, acquisition of knowledge was the most important feature for the Grade 11 participants. However, they acknowledge that education should also involve the 'doing aspect', which is the learning of practical skills, and not just a theoretical understanding of Life Sciences. In addition, learning through interaction and in a relaxed fun-filled environment emerged as crucial to the Grade 11 participants but which they did not experience. Addendum L presents the analysed data for the Grade 11 open-ended questionnaire.

4.8.5 Presentation of the Grade 12 open-ended questionnaire

Apart from learning the content of Life Sciences, which results in knowledge acquisition, participants also felt that the application of the content learnt in the classroom is necessary. Hence, the Grade 12s assumed that Life Science knowledge should be extended to the outside the classroom. However, they were not currently experiencing this in their learning experience.

Also, participants assumed that Life Science teachers are responsible for passing on knowledge to learners and should use multiple sources to transfer knowledge in order for learners to retain the knowledge.

Findings revealed that participants identify what is most important in their educational experience as the Life Science knowledge acquired through their learning process. Addendum M presents the Grade 12 open-ended questionnaire analysis.

For a convenient overview of the emerging themes from Grades 8–12, addendum N presents a summary of Grade 8–12 perceptions of Life Sciences in the context of the CAPS curriculum. The emerging themes for the individual grades obtained from the open-ended questionnaire are attached as Addendum I-M.

In order to extract the overall themes for the Grades 8–12 as a whole, further comparative analysis was carried out**.** Table 4.8 presents the comparative analysis of question 1 categories from Grades 8–12 of the open-ended questionnaire.

Table 4.8: Summary of themes on question 1 (Open-ended questionnaire) Grade 8–12

Themes
Acquisition of content knowledge
Acquisition of skill for practical
Acquisition of knowledge as prerequisite for career

Three themes emerged from the comparative analysis of question 1 of the open-ended questionnaire: acquisition of knowledge, acquisition of skill for practical (which does not involve the scientific inquiry process) and acquisition of knowledge as prerequisite for career.

Question 2

The comparative analysis of question 2 subthemes from Grades 8–12 is presented in table 4.9, which shows the participants' perceptions of what Life Sciences is about from their experience and how they would have loved to be taught the subject.

Table 4.9: Emerging themes for question 2 from Grades 8–12

Theme
Teacher taking responsibility for participants learning process
Promoting interest of subject in participants
Acquisition of Life Science content knowledge using multiple sources
Using various methods to ensure retention of Life Science content knowledge
Promoting participants interaction
Giving participants opportunity to put Life Science content into practice

The themes from both questions 1 and 2 from Grades 8–12 are presented side by side in table 4.10.

Table 4.10: Combined themes for both questions 1 and 2 of the open-ended questionnaire

Themes	
Question 1	**Question 2**
Acquisition of content knowledge	Teacher taking responsibility for participants' learning process
Acquisition of skill	Promoting interest in subject in participants
Acquisition of knowledge as prerequisite for career	Acquisition of Life Science content knowledge using multiple sources
	Using various methods to ensure retention of Life Science content knowledge
	Promoting participant interaction
	Giving participants opportunity to put Life Science content into practice

Findings revealed that participants had acquired some of the Life Science content knowledge necessary for the pursuit of a degree; however, participants acknowledged that multiple instructional methods should be employed for easier content knowledge assimilation. The use of direct instruction alone did not enhance the participants' interest.

Participants in this study admitted that their interaction and engagement is essential for learning; however they had not experienced Life Science learning in such a way.

Furthermore, the theme: giving participants' opportunity to put Life Sciences content into practice emerged strongly in the analysis of question 2. Participants revealed that opportunities to experience the reality of science were lacking in their Life Sciences learning experience. Participants were not given opportunity to put the concepts that were learnt into practice.

4.9 DISCUSSION AND INTERPRETATION

In line with my research questions presented in chapter 1 (cf. section 1.6), this research sought to explore participants' perception of Life Sciences as everyday-life and scientific challenges. Guided by a socio-constructivist perspective, and using Kolb's (1984) experiential learning theory as guideline, themes were established based upon the perception of the participants gathered from the data collected.

Having comparatively analysed the themes from Grades 8–12, eight key themes emerged strongly from the study (from Grades 8–12). These themes are discussed in the following paragraphs. In addition, findings from the open-ended questionnaire were used in explicating the emerging themes for validity and triangulation purposes.

4.9.1 Life Sciences content laden (memorisation of content)

The body of Life Science knowledge refers to the factual aspect of the subject; that is, the content knowledge pertaining to the subject, as I discussed in chapter two (cf. section 2.4.1). The main theme emerging from this study was that participants regarded facts and subject content as the reason why they learnt Life Sciences as a subject, consequently seeing it as the most important for their academic success. Therefore, participants make efforts to access every fact available both from textbooks and the teacher's teaching for examination purposes, rather than for personal and societal benefit.

The study showed that participants assumed that the ability to recall Life Science content knowledge accurately is important for scoring high marks in assessments. Therefore, in order to ensure that they (participants) pass their tests, they place preference on content knowledge retention. Deng (2009), however, asserts that knowing a subject, including Life Sciences, is more than the mere acquisition of SCK.

Emphasis on the content of Life Sciences and the thought of being assessed based on this content knowledge gives participants direction regarding what is most important for their academic work. According to Ripley (2013), such needless emphasis gives participants the impression of what is really necessary for their studies. Moreover, it is evident that South African biology textbooks still lay much emphasis on the content of rather than the ‘doing’ of science (Ramnarain & Padayachee, 2015). This therefore indicates that our South African curriculum is centred on SCK and the recalling of the knowledge acquired to pass exams (Mnguni, 2013), as the learners’ perceptions imply. Ripley (2013) asserts that, apart from giving a false impression of what learning is, emphasis on content knowledge is capable of driving learners to rote memorisation of content which is also evident in this study.

Memorisation has infiltrated education. Memorisation has long been viewed as an inevitable part of the learning process (Langer, 2016). However, Langer (2016) argues that learning does not necessarily equate to memorisation. She affirms that memorisation predisposes participants to lose the very essence of learning, which is the application of constructed knowledge (Langer, 2016). Therefore, the application of Life Science knowledge in everyday life cannot be achieved until concepts learnt are understood beyond the reproduction of facts for examination purposes.

Although Au and Entwistle (1999) reported that Chinese learners opined that memorisation is a crucial part of examination preparation, it is arguably as a means to an end, that is, understanding of the subject content. However, in this study, memorisation and retention of content knowledge was a priority for the participants in the sense that test scores depend on how much of content they can retain and reproduce during exams and not necessarily for understanding.

Learners tend to rely on memorisation when it becomes difficult to understand concepts and relate concepts to reality (Au & Entwistle, 1999). This arguably leans towards surface learning. However, deep understanding of concepts is experienced where learners are empowered to apply constructs that proceed from their engagement with problem-solving ventures (Wang, Derry & Ge, 2017:162) and translating them in a novel situation. This is a skill generally required in the sciences (Life Sciences as well) (Parreira & Yao (2018). However, Donnelly (2014:1) asserts that traditional assessment methods do not foster deep thinking.

Furthermore, Langer (2016) argues that teaching remains on the level of facts and subject content which in most cases are expressed by educators as absolute and cannot be improved upon. In our world truth is not absolute (cf. section 2.4.1.1). Moreover, we are part of an ever-changing world, where knowledge needs to be reviewed and built upon. To have a meaningful deep understanding of concepts in Life Sciences there is need for interaction with the natural world (Forbes, Sabel & Zangori, 2015:657) and not just the passed-down facts.

Furthermore, learning is a messy process which entails learning, unlearning and re-learning. Participants in this study assumed that learning is a clear straightforward process, rather than a messy process of constant construction and reconstruction of knowledge. Moreover, part of the unique nature of Life Sciences is tentativeness (cf. section 2.4.1.1), which was not acknowledged by participants' learning process in this study.

Besides, in order to pass exams, participants limit their knowledge to what the teacher teaches in the classroom. This has the negative effect of stifling deep thinking and creativity and as such opposes the search for knowledge, which is also a tenet of the nature and structure of Life Sciences (cf. section 2.4).

Nevertheless, according to Komatsu and Rapplye (2018), there is the possibility that rote learning leads to high test scores. Langer (2016) asserts that this is not without high costs and negative consequences for learners. Komatsu and Rapplye (2018:802) recount some of the devastating consequences as "psychological pressure, forfeited childhoods, regimes of rote memorisation, lack of creativity and private outlays for cram schools". These consequences do not promote the aim of education which is to attend to concrete real-life issues and everyday application, as described by Pals, Tolboom, Suhre and Van Geert (2018) in the following statement.

> The main task of pre-university teachers is to aid students in developing a sound knowledge base … [E]stablishment of links between concrete situations and abstract concepts and … ability to solve science problems (Pals et al., 2018:227).

In this study, participants also indicated that the most important thing for their Life Science learning experience was the Life Science content knowledge acquisition.

However, Life Sciences is a combination of content and procedural structure (Lederman et al., 2017). Therefore, what the curriculum eventually is attaining, as revealed by this study, is to educate participants with mainly Life Science SCK, that is, the body of Life Science knowledge, namely, facts, concepts and conceptual frameworks, as I explained in chapter two (cf. section 2.4.1).

The examples below indicate that participants perceived SCK as the most important aspect of their Life Science learning. An example of a participant's diagram appears in figure 4.3.

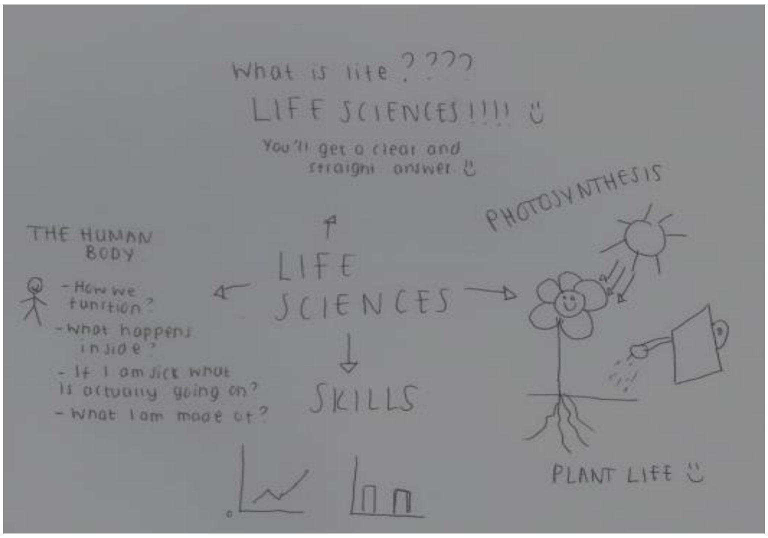

Figure 4.3: Diagram representing the most important thing in the Life Science class

The participant who drew this diagram (figure 4.3) as a response to the question of what is/are the most important things that happened in their Life Science learning experience, actually mentioned (from the diagram 4.3) that Life Sciences is about three things: firstly, facts and concepts (body of Life Science knowledge) by identifying human body and plants; secondly, the acquisition of skills; and thirdly, what she indicated 'a straightforward answer to question'. I presume that "a straightforward answer" means the process by which both the skill and the fact were acquired.

In another example below, figure 4.4, the participant indicated all the topics that she was taught during the lessons like atoms, the periodic tables (facts and concepts), as well as experiments and a bar chart, which can be classified as skills used in laboratory, which in some cases are learnt as content based (cf. field note II).

Figure 4.4: Diagram of most important aspects of Life Sciences learning

The participant who drew figure 4.5 represented the most important things she learnt in Life Sciences as graphs, pie chart and some topics and concepts, for instance skeleton, kidney, plants versus photosynthesis, fishes and relationship between human and animals. Like the other diagrams, this one (fig. 4.5) identifies skills and the body of Life Science knowledge. In all the diagrams cited above (fig. 4.3–4.5), none of the participants mentioned how the content relates to their own lives or life in general.

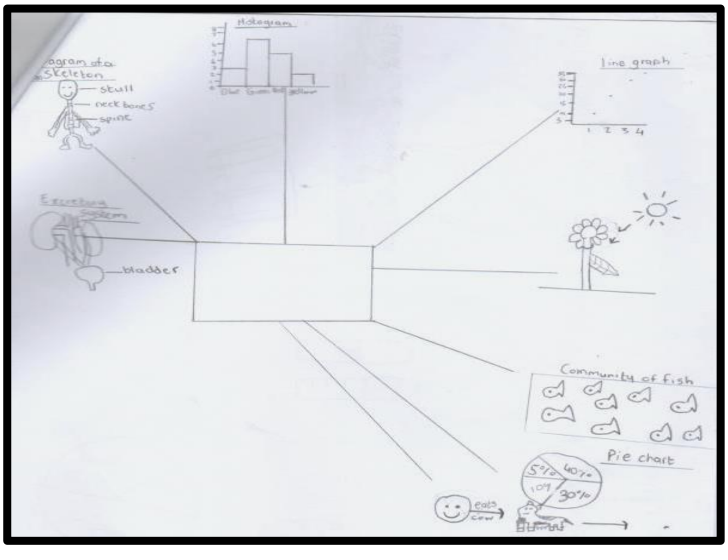

Figure 4.5: Diagram of topics learnt in classroom as most important aspect of Life Sciences

The participant who drew the diagram in figure 4.6 centralises Life Sciences as the core of various topics, which she indicated as photosynthesis, human body, cells, viruses, respiration, adaptation, ecology, chromosomes of life and fungi. These are all facts (body of Life Science knowledge). This participant did not mention anything about skill development or the structure of the investigative process in the Life Sciences.

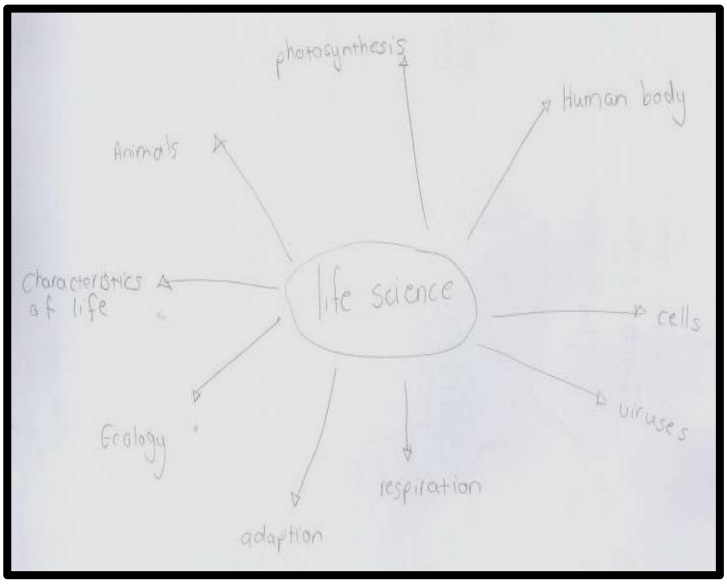

Figure 4.6: Diagram of Life Science learning as a pool of topics

The diagram in figure 4.7 reveals the most important thing the participant learnt in the Life Science class, indicating topics such as the kidney, cells as building blocks of the body, fish, plants and the photosynthesis process. She also includes the human system and its working. These topics, I assumed, are topics that are very suitable for application in real life; however, this diagram does not indicate whether she had learnt why these topics need to be learnt or their application. It is assumed that if she (participant) had learnt how these processes apply in real life or their significance in her life, it would have been part of what was drawn.

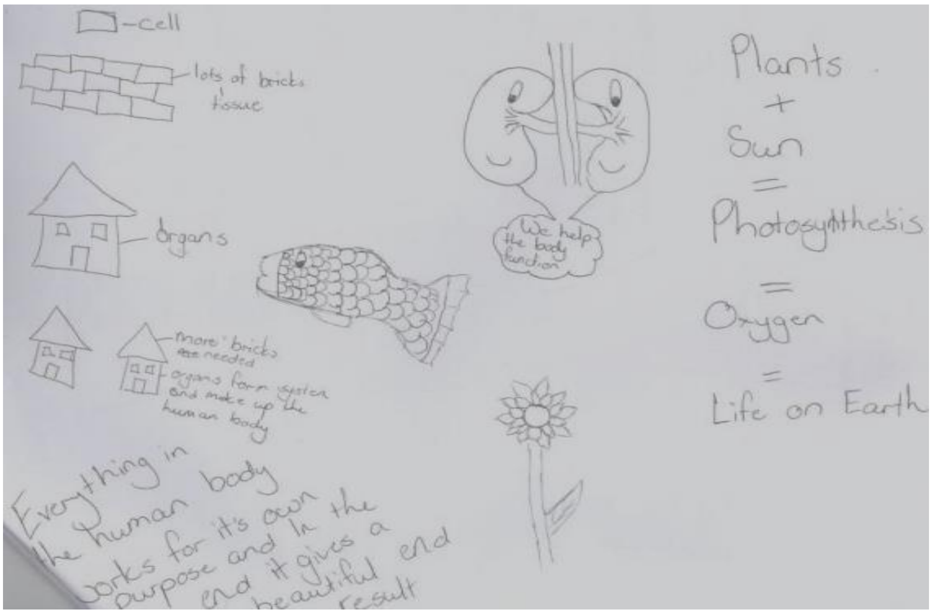

Figure 4.7: Diagram showing that what is most important in the Life Science class is the topics learnt

All the diagrams (figs 4.3–4.7) show contents or facts as the most important thing that participants were learning, although some participants also recognised the learning of skills through practical sessions. However, investigation and innovation were not mentioned. In addition, the application of the topics learnt and human being's responsibility for life were not regarded as part of what was learnt (or the most important thing) in the learning process.

Tentativeness is an important part of the nature of Life Science knowledge (cf. section 2.4.1.1), therefore in knowledge construction in the Life Sciences there is no absolute truth. Life scientists are always in search of new knowledge and understanding in any specific area of interest. Hence, scientific inquiry in the learning of Life Science knowledge becomes very important. Biologists pursue an understanding in these areas through scientific inquiry processes; hence, known facts are expanded as more knowledge is acquired in the area of study. Nayak (2016:3) also asserts that in our ever-changing world there is a need for knowledge to be increased and enhanced.

4.9.2 Reliance on teacher's knowledge

Direct instruction is a conventional teaching method adopted by many teachers in the classroom (Baker & Robinson, 2016:129). It involves teaching the subject content of Life Sciences. However, rather than teaching the content of the subject alone, Yeong

(2014:1028) advocates that our current society demands more pragmatic learning, where skills and lifelong learning can be enhanced.

Teaching facts without the development of learners' essential skills for holistic growth has a tendency to promote rote learning and dependency on teachers (Razzak, 2016:881). In a traditional learning culture, learners depend and rely on the teachers' knowledge (Bereiter & Scardamalia, 2014:35) to ensure that they pass their tests and examinations, especially where emphasis is placed on the replication of what was taught in the classroom.

In this study, it became evident that attaining a perfect replication of what the teacher taught participants was the participants' ultimate aim. From Dewey's viewpoint, education should be intended for and directed at the intrinsic development of learners, rather than serving any external purpose of a particular standard set by a board of examiners (Harðarson, 2018). Arguments on the relevance of assessment models driven by external standards, such like PISA are ongoing in the literature (Lingard, Martino, Rezai-Rashti & Sellar, 2015; Sahlberg, 2016). Although Harðarson (2018:538), appraising Dewey's standpoint, reported that some of Dewey's criticism of traditional learning might be excused during assessment but has negative consequences in practice, which is Dewey's concern in education (also, still a concern today's), is immense and requires attention. The development of skills like critical thinking and the ability to evaluate information to make a correct decision is deterred when participants rely solely on teacher's knowledge (Cheong & Cheung, 2008; Harlen et al., 2010:3).

It was evident in the study that participants perceived the teacher as the custodian of knowledge, thus they rely on the teacher's teachings or notes as the truth and as being infallible. Figure 4.8 presents one of the participants' diagrams indicating the teacher teaching in the classroom and learners sitting in a row, as recipients of the knowledge. The implication of this diagram is that knowledge is given directly to learners, who have no need to think or construct any form of knowledge for themselves.

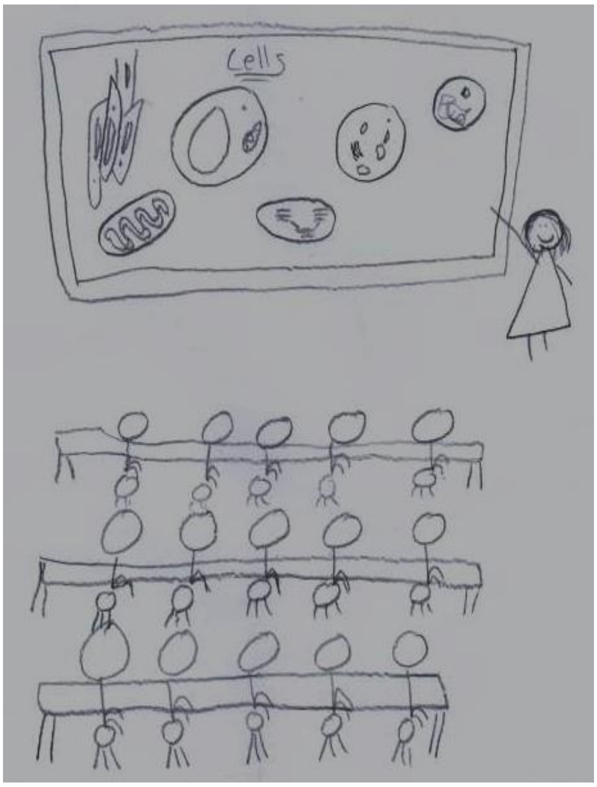

Figure 4.8: An example of the kind of instructional practice in the classroom

Reliance on the teacher for direct instruction can also be harmful to participants' deep understanding of the Life Science concepts taught (Razzak, 2016:881). In this study, participants assumed that the Life Science teachers are experts in the field. Hence, to them, any knowledge that must be acquired should be through the teachers or from textbooks. However, Lederman, Antink and Bartos (2014:286) assert that science literacy lies not only in knowledge of the subject content, but beyond that entails an understanding of the nature of scientific knowledge incorporated in scientific inquiry.

According to Yeong (2014), it is imperative for participants to understand the nature of Life Science knowledge construction in order to be critical thinkers. To evaluate and solve real-life issues, understanding of the nature and structure of Life Sciences (cf. section 2.4) is fundamental. Anderson and Clark (2012) assert that the nature and structure of Life Sciences are inseparable entities, and they have the ability to foster efficient Life Science knowledge building and learning (Jaleel & Verghis, 2015:8). However, the view of teachers on the nature of science has huge significance for participants' perceptions of the subject (Life Sciences) (Ecevit, Yalaki & Kingir, 2018:155).

Since the body of Life Science knowledge is structurally tentative by nature (cf. section 2.4.1), Lederman et al. (2014:289) assert that Life Science knowledge construction is progressive and should be ethically and justifiably pursued. Therefore, the known of today is a platform for knowing the unknown of the future. This has been how scientific knowledge construction is throughout the history of science. Understanding of the nature of science (Life Sciences) can be informed by what happened in the history of Life Sciences (Ecevit et al., 2018: 156).

The history of the Life Sciences reveals that from its inception, Life Science knowledge has not been absolute, rather it has been progressive in nature (cf. section 2.2.2). Ironically, Paulsen and Wells (1998) report that science learners are more prone to judging knowledge from the point of certainty and absoluteness. However, understanding the nature of science (NOS), including Life Sciences, includes understanding its tentative nature as one of the most important dimensions of scientific literacy. Therefore, in order for someone to be referred to as scientifically literate, a thorough understanding of NOS is required (Lederman, 1992; McComas, 2000). In other words, it is critical that participants understand NOS before they can be science literate citizens, who are responsible for using the scientific knowledge acquired for personal improvement and for society at large (Ecevit et al., 2018:155).

Scientific literacy is epitomised in the application of knowledge to everyday life situations (Anilan, Atalay & Kiliç, 2018:734; Briseño-Garzón, Perry & Purcell-Gates, 2014:81). Therefore, content knowledge does not equate to scientific literacy, since scientific literacy by definition is the meaningful use of scientific facts in daily decision-making and solving our day-to-day personal and environmental challenges.

According to Qarareh (2016:180), learning is said to occur only when knowledge is constructed; where the participants' prior understanding is a platform upon which new incoming knowledge is built (Bereiter & Scardamalia, 2014:35). Von Glasersfeld (2008:48) asserts that "[k]nowledge cannot be transferred, not even by communication". However, a lack of understanding of the dynamic nature of Life Sciences has consequently led to the perception of knowledge by teachers or textbooks as infallible and indisputable truth (Bereiter & Scardamalia, 2014:35). In order to discourage learners from misrepresenting science (Life Sciences), Lederman (1992) advocated for NOS to be taught in schools. Moreover, it is difficult to adequately and effectively transfer knowledge from teacher to learners, since the level of understanding differs in each learner (Jaleel & Verghis, 2015).

Furthermore, this study revealed that participants were evidently pleased when the teacher taught Life Science facts, concepts and conceptual frameworks, which in themselves, according to Bereiter and Scardamalia (2014:35), will not foster deep understanding.

4.9.3 Prioritising academic progress as centrally important

Academic promotion was revealed as an important issue for participants, especially when it comes to completing their secondary school education (Núñez, Valle, González-Pienda, & Lourenço, 2013:1314). Promotion means the movement of a learner from one grade to the next, after learners have met the minimum required level of achievement per subject in a particular grade. Progress from one grade to the next has been linked to the acquisition of content knowledge, rather than the development of the whole human being: physical, cognition, emotional and spiritual. As I described in the preceding paragraphs (cf. section 4.6.2), the design of our education system would seem to be centred on knowledge transmission from teachers to learners, which at its best only targets the mental development of the learners (Dimitrov & Wilson, 2002:48). In fact, the aim of education is to develop learners holistically, which should culminate in learners flourishing (Kristjánsson, 2019:10). Flourishing is more than the development of right character; it encompasses all that stands for a good life for the learners now and beyond the classroom (Kristjánsson, 2019).

The reproduction of SCK in exams is evident in assessment, and this is the criteria for academic promotion from one grade to the next in schools; consequently, learners strive to memorise content (cf. section 4.6.1) knowledge only for exam purposes.

It is understandable that every learner would desire steady promotion as they climb up the grades and since passing tests and examination is the way to get through to the next grade, many learners make every effort to achieve high marks in examinations. However, assessment based on content only suggests that learners memorise content rather than promote the application of knowledge, which would possibly increase the production of science literate learners and citizens. The most important thing for participants is dictated by what the curriculum in practice demands and presents as most important, whether it be the assimilation of content which in turn improves IQ or the holistic development of learners in order to meet the demands of the 21st century and beyond.

The 21st century learner is a problem solver and a critical thinker and is committed to lifelong learning (Fadel, 2008). Hence, creativity becomes crucial in a century where innovation is required for continuous human prosperity (Henriksen, Mishra & Fisser, 2016:28). Moreover, increasing socio-environmental problems are being experienced that await solution daily. Solutions to such problems come as a result of creativity of the mind stimulated by targeted instructional strategies (Amabile, 1996; Seechaliao, 2017). Problems are super complex and demand not just any solution, rather holistically approached answers. According to Henriksen & Mishra (2015), creativity is a process of providing holistically effective novel solution to problems. What is observed in most green economy approach solutions in years past has been noted recently to be a unilateral approach to solving pollution problems. For instance, Günter Pauli stresses the use of bio oil soap in order to prevent the pollution that is a root cause for the destruction of the orangutan's habitat (Gunter, 2018). The purpose of scientific knowledge is to find solutions to novel situations (Ozdemir & Dikici, 2017:52; Anilan, Atalay & Kiliç, 2018:734).

4.9.4 Advocating for the real-life application of Life Science knowledge

Based on the works of Kolb, Dewey and Lev Vygotsky, I assume that first-hand experience of reality is the best way of learning. Learning occurs when there is engagement with the reality, consequently engendering creative knowledge construction (Çibik, 2016:454) through the process of knowledge building upon prior knowledge. However, most formal classroom settings are inadequately equipped to foster such knowledge construction processes owing to the complexity of the experiential learning process (Wang, Derry & Ge, 2017:162).

Knowledge construction and its application are not confined to classroom experience alone. It is essential that learners understand how scientific knowledge is formed (Crowther, Lederman & Lederman, 2005). Therefore, if participants were to experience a deep understanding of Life Science concepts, drastic change in the conceptualisation of what learning is must be attended to (Antink & Lederman, 2015).

Lin and Schunn (2016:2–3) advocate for informal learning opportunities, where learners can be exposed to direct engagement with real-life issues and their inherent complexities as learning opportunities. Wawrzynski and Baldwin (2014: 56) assert that informal learning predisposes learners to a deep understanding of the real world.

In this study, it is evident that participants found it hard to link what they learnt in the classroom to their own lives. Hence, Life Science classes, which are supposed to be exciting, filled with creativity and curious adventurous endeavours are turned into 'boring' classes. In the study, participants mentioned that the irrelevance of the Life Sciences (plant science) was one of their most unpleasant experiences of Life Sciences. Relevance according to Glossary of Education Reform (2013) is defined as:

> Learning experiences that are either directly applicable to the personal aspirations, interests, or cultural experiences of students (*personal relevance*) or that are connected in some way to real-world issues, problems, and contexts (*life relevance*).

Therefore, participants could not relate what was learnt in the classroom to either their own lives or real-world issues. Harlen, et al., (2010:10-11) identify the issue of relevance as one of the key principles underpinning life science education. It is important that learners can relate what they learn in school to their everyday lives. Until then, learner interest in learning would be impaired.

Science, including Life Science learning, is fundamentally stimulated by searching for understanding of the natural world (Ozdemir & Dikici, 2017:52). It is underpinned by curiosity, questioning and creativity whereby finding answers to issues remains core (Antink & Lederman, 2015; Ozdemir & Dikici, 2017:53). Harlen et al., (2010:6) advocates that as a matter of importance there is a need to "systematically develop and sustain learners' curiosity about the world which promotes learners' understanding of their world". Moreover, there are rapid changes happening globally, which is all the more reason to keep pace with the changes in and understanding of our world.

The understanding of our world necessitates participants to be groomed in a scientific process of inquiry. Lederman et al. (2014:290) assert that scientific methods learnt by learners in school laboratories or classrooms are a composite of scientific inquiry. Therefore, scientific methods used in practical sessions may not necessarily substitute for scientific inquiry since they involve only a few scientific process skills and, in most cases, only the basic process skills are used (Ozdemir & Dikici, 2017:53).

However, Graham, Berman and Bellert (2015:26) and Anilan, Atalay and Kiliç (2018:734) assert that content learnt in the school environment without its correspondent application in everyday life comprises merely disjointed facts. Therefore, learning only becomes relevant when it is applied in solving personal and/or communal challenges (Kayili & Ari, 2015; Anilan, Atalay & Kiliç, 2018:734). It was evident from this study that practical sessions lacked authentic scientific inquiry, which is necessary for life and citizenry (Abed, Davoudi & Hoseinzadeh, 2015:110; Ozdemir & Dikici, 2017:53).

Investigation and laboratory experiments are mutually inclusive. There is no investigation without experiment; however, from my findings it would seem that the experiments that participants engaged in are limited to the basic scientific process skills which are usually given to learners in the form of a step-by-step methodological process, and as such limits the enquiry process that can lead to knowledge production (Edmondson & Novak, 1993; Lederman et al., 2017). This is what Ozdemir and Dikici (2017) refer to as a positivist view of science. Laboratory sessions serve merely to confirm scientific facts or concepts that have been taught in the classroom.

According to Shernoff, Kelly, Tonks, Anderson, Cavanagh, Sinha and Abdi (2016:54), learners' engagement in learning activities promotes their interest through cognitive, behavioural and emotional participation. This study revealed that participants have little or no mental engagement with the practicals they were involved in. Practical manuals are memorised or transferred, therefore the involvement of critical thinking and scientific creativity is hindered (Ozdemir & Dikici, 2017:53).

Besides, engagement is also key to participants' finding relevance in what they are learning as recorded by Otrel-Cass, Khoo and Cowie (2014). It is evident that during practical sessions, participants were exposed to basic scientific methods with few opportunities that foster thinking and imagination. It was evident that participants' investigative skills were not explored. Apart from unexplored investigative skills, participants also mentioned that practical sessions (which are referred to as the 'doing aspect of science' in the CAPS school curriculum) were seldom done.

Lelliott (2014:311) asserts that the South African Life Sciences curriculum has shortcomings which may negatively affect learners' science literacy. Some of this criticism could be linked to learners depending on teachers for knowledge, resulting in superficial learning and memorisation of content.

4.9.5 Fragmented view of Life Sciences content knowledge

The fragmentation of knowledge has been part of our world since the industrial era. Schooling is also patterned according to such a philosophy and principles (Young, 2013). Hence, subjects and topics are fragmented for easy assimilation. Authors like Bohm (2005) and Summerlee and Murray (2008) warn against such a philosophy and its consequences. Summerlee and Murray state in this regard:

> We reduce knowledge to bite-size pieces of information that can be clearly defined and standardized. We can then define the minimum amount of information that has to be learnt (memorized) and then we create standards that can be used to claim mastery of a particular subject (Summerlee & Murray, 2008:1).

They argue that piecing together bits of information will not lead to understanding (Summerlee & Murray, 2008:1), rather it engenders confusion and poor memory (Kristjánsson, 2019).

In this study, participants believed in the acquisition of knowledge in bits. Researchers maintain that the fragmentation of knowledge obstructs understanding (Ackoff & Greenberg, 2008; Stange, 2009:103). However, participants claimed to be satisfied when the teacher taught them the content knowledge of Life Sciences in bits, especially when it is needed to enhance their marks in tests. This study also reveals that participants lacked development in the area of Life Science knowledge application in novel situations, which is part of the core aim of science education (Çibik, 2016:454).

The study showed that participants could not relate the relevance of what they heard in class to their own lives or to the real world outside the classroom. This is not what is intended. Stange (2009:103) asserts that it seems that the more information we acquire in our information-based world, the less understanding of the world we seem to gain.

Although information has a role to play in education, it has been argued that use of the wrong approach and of information in the learning process will not help learners (Ackoff & Greenberg, 2008), rather the consequences will be the production of scientific illiterate learners and citizens (Anilan, Atalay & Kiliç, 2018:734).

Furthermore, participants in this study perceived learning as a predictable and straightforward process. On the contrary, learning is a complex interaction of myriads influences" (Hase & Kenyon, 2013:22). Sahlberg (2016: 138) states that "the nature of teaching from an open-ended, non-linear process of mutual enquiry and exploration to linear process with causal outcomes" is required for learning. Moreover, Ackoff and Greenberg (2008) argue the mismatch between the words learning and teaching. They claim that teaching can be done traditionally through information transfers, but this does not equate to learning. They assert that most of what is taught and memorised, is only available in learners' short-term memory, while knowledge constructed in an experiential authentic situation stays with the learner for longer (Ackoff & Greenberg, 2008:3).

As revealed by the study, Life Science content knowledge, which CAPS represents as strands, is not perceived as linked by participants. Hence, participants choose what seems interesting to them, for example human studies, and strive to get high marks in those aspects to cover up for the plant aspect of the Life Sciences, in which they have little interest.

In my findings, participants' interest in the human aspect of the Life Sciences is higher than in plants. Lohbeck et al. (2016:290), however, asserts that academic interest is crucial for cognition and ensuring the quality of learning. Neitzel, Alexander and Johnson (2016: 476) and Quinlan (2016: 102) also state that interest in any subject or topic will foster the enthusiasm and curiosity that are required for learning. Hence, academic or subject interest is crucial for the learning process to be effective. According to my findings, participants placed more value on human studies because they seem to have an interest in the topic.

According to the findings of this study, participants' interest in human processes relates to the fact that this educates them about what is happening in their body. This therefore agrees with the assertion of Lavonen et al. (2008) that the degree of the interest a learner has in a topic is dependent on the degree of the learner's perception of its relevance to their personal everyday living. However, the participants' interest in only certain aspects of Life Sciences (human studies) connotes detrimental consequences for problem-solving ability (Stange, 2009:100)

Çibik (2016:454) and Jacobson, So, Teo, Lee, Pathak and Lossman (2010:1694) assert that the perception of participants and/or teachers of the nature of knowledge is critical in informing the attitude and decisions made regarding learning in schools. The problem with fragmented perception is that it fails to appreciate the interrelatedness between these two major aspects of Life Sciences (plants and humans including animals).

According to Alashwal, Rahman and Beksin (2011:1530), fragmentation and specialisation are not only problems in the industrial sector but also in our education system (which is also evident in this study). The thought that knowledge can be divided into parts, learnt separately and then harnessed together to become a whole is a misconception of the nature of knowledge (OECD, 2004:34).

Fragmentation hinders a holistic view of knowledge. Everything about the living system is important, since it is a part of the whole. Therefore, the wellbeing of one impacts the other. For instance, one cannot think that healthy living is just about knowing diseases and how they are caused without a holistic understanding of the impacts and implications for plants, soil, air and the environment for instance. The OECD (2004:34) asserts that fragmented knowledge hinders the appropriation of the innate problem-solving ability in humans, where every concept in the living system can be addressed as a whole system and not as an individual entity.

4.9.6 Preferring interactive classes

An interactive class, contrary to a traditional instructional method in which the teacher becomes the giver of knowledge, has been proven to be a better way to foster efficient learning. It is usually uncommon because it requires more skill in carrying out such pedagogy. Interactive classes prevent the boredom that can set in due to lecturing and unidirectional instruction, which is prominent in a direct instructional method.

In this study, participants showed evidence of boredom during the classroom teaching and they also complained of boredom**.** The study showed that participants were not actively involved in the practical sessions conducted by the teacher. The sleeping participant is an indication that the participant was bored (cf. section 4.3.2.4, fig 4.1). However, Jaleel and Verghis (2015:8) stand vehemently against passivity in learning. They assert that in actual fact, learning only occurs when there is active engagement and negotiation of meaning by the community of learning that is involved (in this case, the teacher and the participants), as they both build on their prior knowledge to form new or improved knowledge. Taking sides with both Jaleel and Verghis (2015) and Bereiter and Scardamalia (2014), I agree that our learning culture needs to address how to involve participants in innovative knowledge creation through constructive active participation in their education (Newmann et al., 1996:1).

Furthermore, it was revealed that practical sessions are few because of the volume of work required by the curriculum for each term.

4.9.7 Casual attitude towards Life Sciences

It was evident that participants in this study could not link the reason why they were learning Life Sciences with its future benefits for their own lives or for the community (except for the ones who wanted to take up employment in the science field). This consequently led to participants' casual attitude towards learning of Life Sciences. Learners' bad behaviour has been reported as a serious concern in education (Crafford & Viljoen, 2013).

A lackadaisical attitude towards science (Life Sciences) has long been a concern for educational and scientific bodies (Pike & Dunne, 2011) and South African science learners are no different (Juan, Reddy, Zuze, Namome & Hannan, 2016). In this study, participants made light of the importance of Life Sciences as a subject that is relevant for them. The issue of the relevance of science education (Life Sciences) is not uncommon amongst learners (Stuckey, Hofstein, Mamlok-Naaman & Eilks, 2013:1). Agunbiade, Ngcoza, Jawahar and Sewry (2017:271) report that learners' attitudes are closely linked to how they perceive what is learnt in the classroom as related to their everyday life. Participants expressed their frustration as regards not understanding the relationship between what they are learning and its relevance for their lives. Juan et al. (2016) record that detachment from learning science and loss of interest is usually engendered by the instructional method employed by teachers. Traditional learning has been criticised for its lack of effectiveness in delivering learning (Vijayakumari & Umashree, 2016:44; Cajiao & Burke, 2015; Cerbin, 2018).

In this study, participants felt compelled to study Life Sciences as demanded by the school and the curriculum, even though they were not interested in some of the topics. Studies have revealed that learners' interest in sciences can be improved when learners see science learning as not obligatory but an enjoyable learning experience (Liu & Schunn, 2018). Moreover, Wanzek, Kent and Stillman-Spisak (2015:472) recorded that learners' interest plays a key role in facilitating learners' learning. Young and Shaw (1999:679) also assert that the extent to which learners place value on what they learn is a measure of the effectiveness of the learning that has occurred. For participants, studying Life Sciences (except for the few who were interested in taking up careers and of course those who had a scientific background) was regarded as a compulsory but unnecessary burden imposed by the school.

4.10 CONCLUSION

In this chapter, I presented the findings gathered from the study of 60 participants in total from Grades 8–12 Life Sciences classes. The findings revealed that participants perceived Life Sciences as a content-driven subject and, as such, they (participants) pursued the acquisition of the subject content knowledge, thus seeking direct instruction from the teacher and prioritising academic progress as the most essential purpose for achieving their career. However, this has meant that their studies focus on memorisation of content which only serves as a short-term solution for passing tests and examinations. Unable to link the purpose of learning the subject with their own lives, participants tend to lose interest in some sorts of learning especially the plant aspect of Life Sciences.

It is also noted that participants were biased regarding aspects of Life Sciences SCK, in that they prefer to study animal and human anatomy to plants, because they seem to enjoy the subject content that pertains to human anatomy more than plants. Furthermore, the study showed that participants faced difficulties in their learning process because of the lack of a scientific investigative-discovery process and little or no interactive classroom activities due to the volume of work to learn. They (participants) also prioritise Life Sciences content as a way to progress academically, since they perceive their Life Sciences learning as content based. Hence, participants consequently underplayed the significance of Life Sciences in life because they could not relate what had been learnt in the classroom and its significance to their own lives or the real world.

In the next chapter, which is my conclusion and recommendations chapter, I explain how my findings answer my research questions. I further discuss the significance of the study, make recommendations and present the final conclusion to the study.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In chapter 1, I discussed my educational journey through high school, which motivated this study. Since this study is framed within the context of CAPS, I also briefly discussed the Life Sciences curriculum, emphasising the aims and objectives of the document. In chapter two, I discussed the literature on Life Sciences and the intrinsic nature of the subject, as well as the implications of the nature of Life Sciences for science education and our society. Chapter three discussed my paradigmatic orientation, the methodology and methods that I employed in the research, justifying each method. An open-ended questionnaire and interviews were employed to gather rich, full data. The interviews were audio recorded and specific classroom events of interest were video recorded. A data analysis process with the 12 participants in each grade from Grade 8–12 was undertaken to ensure that the research questions were answered. I also discussed the ethical issues that were considered in the study and various data validation methods.

In chapter four, the findings of this study, presented as themes, were discussed. The themes were interpreted in the light of existing literature to either corroborate the findings or to reveal their inconsistency with the literature. This chapter (chapter five) provides a summary of the study in which I discuss my findings, comparing them to the literature on what the learning of Life Sciences means to learners, juxtaposing them with the knowledge of what CAPS has achieved. In this chapter, I situate my findings within my theoretical framework and I also discuss the implications and limitations of the study and make recommendations for further studies.

5.2 SUMMARY OF THE STUDY

Drawing from my personal experience as both learner and former teacher in a secondary school, I considered the challenge for CAPS documents in meeting the educational demands of our nation in this century (Du Plessis & Marais, 2015:114; Mnguni, 2013:6–7) regarding the requirement to be centred on learning to know and learning to do. In CAPS, knowledge is assumed to be what is acquired rather than knowledge construction based on the exposure to various learning experiences.

Teachers are saddled with the duty of imparting knowledge on learners. Unlike the type of pedagogy where learners take an active role in knowledge construction, traditional pedagogical activities are centred on the teacher as the knowledge transmitter (Hajhosseini, Zandi, Hosseini Shabanan & Madani, 2016:1). This role, however, positions our educational practice as unidirectional. I consider this ideology where learners are the passive receivers of knowledge as restricting creativity by limiting learning opportunities for learners and inhibiting other intelligences which remain uncultivated (Lundgren 2015:788; Slabbert et al., 2009:73).

Consequently, this practice has unintentionally limited the Life Sciences to a classroom event only, whereas the subject is in fact critical to everyday real-life situations, considering the various challenges the world is facing. Also, Life Sciences is heuristic in nature and, as such, demands that its unique disciplinary nature be reflected in the way the subject is taught in schools (cf. section 2.4).

Further, in chapter two I described the challenge inherent in our current education in that it lacks an ontological pillar which is the "learning to be" (cf. section 2.6.3; Barnett, 2007:7). This is the educational pillar that pursues the authenticity in learners, encouraging the development of fundamental human qualities. I would assume that only education that combine all the three pillars of education, namely, the epistemological (knowledge), practical (the skill) and ontological (being) pillars of education, would be relevant in meeting the ever-dynamic demands of our time (cf. section 2.6.3; Barnett, 2007:7; Banerjee, 2016).

As is evident in the literature, the 21st century demands more than facts and knowledge. Although accessing knowledge (facts) has its unique position in education (cf. section 2.4), the century we live in demands more than accumulating the facts. It requires skills such as creativity, critical thinking, problem solving, and tenacity amongst others.

This study is crucial and unique in that it explores, from the learners' perspective, what learners are actually and eventually learning in the Life Science classroom within the context of the current CAPS curriculum. Since curriculum has a great influence on what the learners learn, teachers teach and the outcome of teaching and learning activities, it follows that the aims of the Life Science curriculum should be clear to the teachers and learning should be assessed based on these aims. The aims of Life Science education will in turn inform the teaching and learning strategies that both the teachers and learners will adopt for a successful educational endeavour. However, the question still remains, is CAPS actually achieving its aim and purpose from the learners' viewpoint?

Therefore, my aim is to contribute to the knowledge gap in the literature to ensure a proper understanding of how learners perceive their Life Science learning experiences; in essence, to know the meaning learners are making of their Life Science learning in fulfilling the purpose of their learning. Hence, I reiterate my research question as follows:

My primary research question states:
Does learners' Life Science learning experience influence their understanding of Life Sciences as an essential daily life and scientific challenge?

Accordingly, the secondary research questions that enabled me to answer my primary question are as follows:

- What are the current curriculum demands of the Life Sciences?
- What are the challenges confronting school Life Sciences as fundamental to a daily life and scientific challenge?

I will therefore proceed in answering the questions as supported by the findings of this study.

5.3 CONCLUSION IN TERMS OF THE RESEARCH QUESTIONS

5.3.1 Secondary question 1

- What are the current curriculum demands of the Life Sciences?

Based on the findings of this study, learners' Life Science experience is such that memorisation and reproduction of facts are required. Although one central goal of CAPS is to teach learners to know (understand) and do science, the outcome of the curriculum is dependent on several factors, one of which is the instructional strategies employed.

The current educational demands of the CAPS, even if unintentional, are to produce learners who are unadventurous, passive receivers of knowledge (Lundgren, 2015), guided by a scholarly academic ideology (Mnguni, 2013). The study found that learners are engaged with a direct instructional teaching strategy. Hence, Life Science facts and concepts that are void of context were transmitted during the learning process (cf. figure 4.3; section 4.6.2). The challenge is that even while empowered with the disciplinary knowledge, as suggested by advocates of the centrality of content knowledge in education (Deng, 2013; Young, 2013), learners tend to be more dependent on teachers and are unwilling to become involved in personal knowledge construction.

A number of researchers have revealed that crucial educational goals cannot be achieved by transmission learning (Whannell, Quinn, Taylor, Harris, Cornish, & Sharma, 2018:38), as transmission learning does not support creativity. In fact, Fridland (2018:356) uses the term “high fidelity transmission mechanism” to describe transmission learning. He argues that teaching and not transmission of knowledge will engender innovation (Fridland, 2018:357).

Transmission of knowledge leads to learners struggling to assimilate Life Sciences content without an appropriate understanding of its application in varied contexts (cf. figure 4.3), which implies superficial learning. Nevertheless, memorisation may be useful for mastering terminology, such as that of the Life Sciences, but it is ultimately important that learners’ learning experience is versatile enough to allow concepts to be applied to new situations. If learners are unable to apply what is learnt in the classroom, then the implication is that learners’ creativity and their innate explorative traits are being silenced.

The demand for innovation cannot be overemphasised in a world that is experiencing ever-increasing challenges (Elert, Henrekson & Stenkula, 2017:2). Beyond technical skills, workplaces demand soft skills like creativity, innovation and the like (Barron & Darling-Hammond, 2008). However, this study revealed that learner’s experience is centred on content-based learning which does not promote learners’ affective potential. Furthermore, humans are social beings and to thrive in the life beyond 21st century, we need to connect in social relationships such that interdisciplinary knowledge is synergised. Teamwork is crucial to solving problems. However, the findings of this study did not strongly indicate the development of pro-social virtues in learners. Pro-social virtues, according to Lawson (2014:6), are a vital aspect of preparation for life.

Science is investigative by nature and the core aim is the production of knowledge where little is known. However, since learners do not actively participate in their own learning, the current Life Science curriculum therefore impedes more than it enhances the learners' ability to construct their own knowledge. Furthermore, as revealed by the literature, knowledge is futile when it is not context based.

Constant dependency on the teacher for information could impact negatively on learners' life as a future citizen. Science illiterate citizens are believed to be on the increase in our country, resulting in the general public being uninformed about simple scientific issues that involve everyday living, making them unable to take responsibility for their own wellbeing and the wellbeing of society. It would be challenging if citizens were to depend on scientists to make every day scientific choices and decisions.

From this study, I have realised that assessments foster memorisation and reproduction of Life Science facts which can be easily achieved without a deep understanding of the concepts. Assessments were based on tests and examinations which are structured for direct answers, even when the question requires a phenomenon to be explained. Other forms of assessments that may be beneficial such as self-reflection and peer assessments were not used. Self-reflection for instance cuts across all facets of life whether in daily life or work life. It is a crucial skill that would need to be developed if it were part of the assessment criteria. Moreover, a major purpose of the CAPS curriculum is to develop learners' skills and prepare them for the workplace, but this was not reflected in the findings. Workplace demands include skills and the fundamental human virtues of tenacity, team spirit and creativity amongst others, which may be acquired through engagement in learning experiences that are grounded in real-life scenarios. In this study, it was evident that this had not been achieved.

Holistic development of learners is assumed to be one of the main purposes of education and not just mental development (Slabbert et al., 2009). Gardner (2008) accentuates the importance of developing the five minds of the future, namely a disciplined mind, an ability to synthesize information, and creatively devise solution, a respectful and ethical mind, as a way to thrive in and beyond the 21st century. It is known that essential employability criteria are not based on content knowledge only but on creative and innovative ability, which is in high demand in the 21st century workplace (Dyer, Gregersen & Christensen, 2011; Wright & Jones, 2018:9), and is the foundation for most scientific discoveries (Li et al., 2015:191).

Due to the demands of CAPS, which requires that learners should memorise content, understanding the nature of Life Sciences is yet to be achieved. It is impossible to separate the nature of Life Sciences from itself. The nature of Life Sciences dictates the way scientific knowledge can be constructed. Learners in this study were not exposed to the way scientists engage with the environment in order to proffer solutions to world problems. Inquiry is a major part of Life Sciences, however, I discovered that the learners in this study did not carry out inquiries. Although the learners acknowledge that practical sessions were conducted, these sessions were few (at most, three times in a term) and were not fundamentally investigation based; rather they could be said to be prescriptive. Learners were required to work towards the same outcome that had been taught in the previous lesson and all steps which learners had to follow were written down in the laboratory manuals that were handed to them in the practical class. In the practical sessions, learners merely carried out the instructions in the manual. Therefore, no cognitive engagement or brain tasking experience to place that could provoke new insights and knowledge.

Besides, there is no link between what is done in the laboratory and what actually happens in life. In real life, practical day to day science is not performed as seen in the laboratory. It is a fact that not all learners will eventually become scientists, therefore I question the relevance of laboratory sessions carried out with direct instructions on what to do, how to do it and the outcome in the labs.

Real-life situations rarely present easy solutions (outcomes). Most discoveries and scientific progress are grounded in what is happening in the real world. Brainwork (critical thinking, creativity) begins immediately they (scientists) come in contact with anything that is unresolved, or a puzzle or problem. The first contact is not the laboratory for testing, rather deep creative thinking occurs, strategies are mapped and hypotheses through which reality is tested are postulated. The inherent dynamism that is represented in scientific inquiry can be effectively learnt only by engaging in scientific inquiry in the way scientists do.

The findings revealed that learners are more interested in making academic progress from their current grade to the next than in acquiring knowledge that they can apply to their own lives. One can say that academic progress is important, since it constitutes evidence that learning has really occurred during time spent in the current grade.

5.3.2 Secondary question 2

- What are the challenges confronting school Life Sciences as fundamental to a daily life and scientific challenge?

The 21st century is a knowledge-laden century. Much of the information on any subject can be easily accessed electronically (Loesch, 2017); however, not all information on the internet is true. Access to blog writings and various information on wikis authored by just anyone exposes the current generations to a great deal of information; both useful and, sadly, false information. This overwhelming amount of information engenders difficulty in identifying the actual truth from the multitude of information. Hence, the 21st century demands that learners be well equipped with the ability to critically analyse information and discern right from wrong information in order to benefit from the technology that has become part of our existence. However, I discovered from this study that aspects of human development (which Gardner calls the minds of the future) were untapped and undeveloped.

Learning in 21st century is a life-long exercise which involves learning, unlearning and relearning (Toffler, 2011). However, life-long learning can only occur when learners are highly motivated (Oudeyer, Gottlieb & Lopes, 2016:263–264). The findings of this study revealed that learners are not intrinsically motivated to learn Life Sciences as a subject. This could be one of the reasons for the reduction in the number of science learners in our nation. Only a few pursue careers in science fields. The consequence is a dearth of scientists at the university level.

Furthermore, this study revealed a careless attitude to studying Life Sciences by participants, since the subject is presented to them as a school subject that does not go beyond the classroom. Moreover, failure to recognise the significance of what is learnt in the classroom as relating to their daily experience is arguably an indication that learners are not really learning what is important to them. Oudeyer et al. (2016:263–264) assert that complexity and novelty in the learning process are vital components that assist learning and the retention of what is learnt. However, participants' experiences in this study revealed a simple straightforward process of 'give and take' of information between the teacher and the learners. Where learning takes place transformation should occur (Hoggan & Cranton, 2015:6). Learning facilitates changes in learners' reasoning and perceptions, especially where re-learning and/or unlearning is required.

In order to enjoy the transformation experience, learners need to engage in experiential learning where learners get in touch with the realities of what they are studying. Bernstein (2000) states that contexts have a huge impact on learning. They motivate learners and enhance the understanding of the underlying concepts, the principles of Life Sciences and its connection to everyday decisions. I realised from this study that most learners' perceptions of Life Sciences is that it is only meant for school purposes. Although a few acknowledged that it is necessary for everyday life issues, they could not attest to the fact that they applied the knowledge they acquired in the classroom to their daily lives. Hence, transference of scientific knowledge to new and novel situations outside the classroom is hindered by the mindset that Life Sciences is just a subject taught in the classroom.

In addition, owing to the dichotomy that exists between school Life Sciences and Life Sciences in the real world, learners see the subject as unimportant for their daily lives. To eradicate this problem experiential learning may be suggested.

Moreover, in this study, the nature of science seems not to be emphasised in learners' Life Science learning experiences. Even during practicals, which are supposed to be an avenue for learning the investigative nature of Life Sciences, this did not happen. It therefore cannot be ruled out that the instructional method plays an important role in learners' perception of Life Sciences. However, deep understanding comes with experience.

According to Reed and Pease (2017:56), part of the benefit of engaging learners in an investigative learning process is to improve their reasoning abilities and to elicit rigour, integrity, dedication, curiosity and sense of purpose, consequently influencing learners' abilities and behaviour. Harlen et al (2015:7) also attests to the fact that curiosity is centrally vital to science education. Furthermore, in line with Wong and Hodson (2009), there is incompatibility between school science and scientific rigour which requires cognitive reasoning outside the school.

Although understanding Life Science concepts in high school is important, understanding is an outcome of active engagement with experiential and investigative learning. In agreement with Kuhn (2007), I believe that science is a way of knowing, therefore inquiry would enhance its understanding better than direct instruction.

It is well known that scientific inquiry seeks to proffer solutions to problems, which is a desirable quality that education needs to offer. Besides, an investigative instructional method forms a link between real life and classroom Life Sciences, which should empower learners with the ability to translate and transfer concepts learnt in the classroom to what is applicable in real life.

Learning rooted in reality is fundamental to problem solving. Problem-solving is an inevitable part of human lives. It cuts cross all sectors, whether it be in scientific endeavours or the workplace (Funke & Greiff, 2017), especially in view of the environmental and socioeconomic problems experienced in the world. Real-life problems are obstacles to achieving certain set goals (Duncker 1945:1 in Funke & Greiff, 2017), for instance ecological, health, political wellbeing amongst others. Nevertheless, since problems are dynamically interconnected, complex situations, operational intelligence (Dörner, 1986) is required in addition to mental knowledge.

Interaction plays a huge role in learning (Ginting, 2017) and problem solving and are key to unlocking various human problems. Collaboration and interaction is therefore a vital skill in the 21st century and should be developed from the classroom (Ginting, 2017). Moreover, it fosters pro-social behaviour that improves academic achievement (Caprara, Kanacri, Gerbino, Zuffianò, Alessandri, Vecchio, Caprara, Pastorelli & Bridglall, 2014).

In addition, superficial and content memorisation will result in science illiterate citizens. Superficial and content memorisation could also be of a great consequence for the quality and quantity of scientists in society. In a globalised world such as ours, learners' understanding of Life Sciences beyond the classroom is important in raising responsible citizens. It is obvious that instead of people being responsible in the way the live, their lifestyle is destroying the environment even that of the supposed elites. Conversely, scientifically literate citizens will be careful to make choices that are best for the mutual existence of all living organisms in their ecosystem. Addressing this prevailing nonchalant attitude of humans towards the environment, Hawken (2009) declared the world as being in its declining state which demands a quick reaction from all its inhabitants.

Apart from the fact that participants' learning experience was superficial, it was also found to be fragmented into small bite-sized pieces of information. Although this was meant to enhance the easy handling of the vast amount of information available as evident in the Life Sciences, it negatively affects a holistic understanding of Life Sciences and its concepts. Life Science content is learnt as discrete stand-alone concepts, hence obstructing the participants' construction of links between Life Sciences concepts.

5.3.3 Primary question

- Does learners' Life Science learning experience influence their understanding of Life Sciences as an essential daily life and scientific challenge?

In this study, participants acknowledged the importance of Life Science content and the need for practical sessions to further clarify the subject content. However, participants often query the use of Life Science knowledge especially topics like plants, evolution and cells for their daily life. Life Sciences is a subject with many applications in the real world (Dutfield, 2017) and scientific expertise is needed to apply the knowledge to everyday life (Collins, 2014). Everyone, young and old, is responsible for saving the world from declining. The culture of heal and not steal, as Hawken (2009) stated in his Portland University speech, is important because we are all stakeholders.

Participants perceived that learning Life Sciences is a means of becoming employed and did not see it in relation to a harmonious environment or improving their personal quality of life. With this mindset where there is no proper appreciation of the essence of the subject, it would be difficult to raise a Life Science-literate society (Holbrook & Rannikmae, 2009:275).

Participants' perception of Life Sciences is that Life Sciences is all about learning the subject content. Holbrook and Rannikmae (2009:275) explain that placing Life Science contents knowledge as central to Life Science learning will hinder its application in real-life situations. These authors believe that for a long-term solution to our challenges, knowledge of the application of scientific principles in real-life engagement is central. Gräber et al. (cited in Holbrook & Rannikmae, 2009:275) describe science literacy as the consisting of three components: what do people know? (body of Life Science knowledge), what can people do? (process structure of Life Sciences) and what do people value which is a fundamental human virtue? However, in this study it would seem that the emphasis on the content of Life Sciences means that participants fail to experience the usefulness and applicability of Life Sciences outside the classroom (except to acknowledge that human anatomy reveals what happens inside the body).

Life Sciences should go beyond the classroom experience. The whole world is about interaction between the living and non-living and everyday learners experience such. Therefore, it is important that every science learner are able to link all Life Science concepts including plants and ecology to their everyday life. Moreover, Life Science knowledge is inextricably linked with the ability to judge and make scientifically based decisions on everyday issues (Mooed & Kaiser, 2018:45). Making choices is what everyone will have to do at certain point of life. Since, choices and decisions are determinant of one's experience, it is therefore important to consider all options and always make the right choice. Hence, science literate citizenry is important for making ethically and scientifically based judgements (Brilakis, 2015:1).

Most 21st century challenges are fundamentally Life Sciences oriented. These ever-increasing challenges, which involve human health, environmental issues, food security, population growth, conservation and the like, require a deep understanding of living systems and how they work. An understanding of the Life Sciences starts with an understanding of the nature and structure of science (Holbrook & Rannikmae, 2009:275) and how relevant Life Science concepts are to our day-to-day life. Science practised in schools and by professional scientists basically have the same approach to solving problems, that is, a scientific process of inquiry. As such, learners should be exposed to experiences that empower them to apply this same principle of scientific inquiry in situations un their own lives. The aim of these scientific inquiries is to improve human life. Both the practice of sciences within the school and outside the school are essential to the survival of the human race. Therefore, the purpose of science transcends the confines of the school.

Hecker, Haklay, Bowser, Makuch and Vogeland Bonn (2018:241) assert that the purpose of science is to provide innovative solutions to situations and events that threaten human existence. Despite the nature and operation of science discussed in chapter two, solutions to many of the world's challenges are still far from being found. Many of these challenges are blamed on human actions resulting from expending nature's resources without adequate care for the consequences of such actions (Vlek & Steg, 2007; Steg, Lindenberg & Keizer, 2016).

5.4 NEW INSIGHTS DERIVED FROM THE STUDY

In this study, learners acknowledged that their Life Sciences experience is subject content based, thus believing that learning and application of Life Science concepts ends within the school confines, except for the learners who intend to take up a career in a Life Science-related field. Although practical sessions were conducted in the Life Sciences classes, these practical sessions are few and at most three times in a three-month school term. However, the assumption of learners is that the purpose of practical sessions is to elaborate on subject content and not as a way of developing Life Science investigative skills that culminate in innovation and problem-solving skills.

Seeing Life Science practical sessions as a means to enhance content knowledge could account for the gap between the school science and what the scientists do in the real world as attested to by Harlen et al (2010). Inquiry is part of the nature of Life Sciences and without it, Life Sciences would not be what it is. However, in this study, practical sessions were used as a way to confirm the subject content that was learnt in the classroom.

Furthermore, learners do not experience the practicality of Life Sciences (apart from the study of human systems) in their daily life. The link between Life Sciences as a classroom subject and Life Sciences as experienced in the real world was not evident in their learning experience. Therefore, learners were not exposed to problem-solving challenges. Since learning is basically the transfer of SCK from teachers to learners, and assessment is fact based, it becomes difficult for learners' creativity and investigative abilities to be explored.

In addition, learners were not engaged in the process of knowledge construction. All information and knowledge of Life Sciences were taught by the teacher and learners had to replicate this knowledge in their exams. Hence, learners perceived the body of Life Science knowledge as an absolute truth, which does not require improvement and cannot be improved upon. This means that whether or not learners are able to make meaning of the content, if they can reproduce the content in the examination there is a possibility of learners getting high marks which evidently is the learners' goal. Learners are not given the opportunity to be constructors of knowledge and thus improve upon the knowledge acquired, which is the hallmark of the nature of Life Sciences.

5.5 REFLECTING ON THE LIMITATIONS OF THE STUDY

This study is limited to one of girls' school in the Gauteng public school system. The participants were girls in every grade from Grade 8–12. Twelve participants were interviewed in each grade. Accordingly, rich data were generated from the participant, which afforded valuable findings for the research.

Furthermore, classes were purposively selected with all the classes selected being taught by the same teacher. Hence, the study is limited to one teacher's teaching and teaching methods. However, the teacher had been teaching Life Sciences for over a decade.

5.6 IMPLICATIONS OF THE STUDY

This study is intended to contribute to the body of knowledge on the learning experiences of Life Sciences learners and how to improve their learning experiences to meet the demands of the 21st century. Through this study, I was able to evaluate the impact of learners' engagement with Life Sciences as a school subject on their perception of the subject in relation to their own lives and life beyond the classroom context, especially in the 21st century and its unique demands it places on humans.

Furthermore, I highlight the implication of the findings of this study in the following three areas:

5.6.1 Significance of the study for CAPS curriculum developers and policy makers

This study revealed that learners are not exposed to learning experiences that meet the demands of the 21st century. The findings showed that learners were oblivious to the way most of Life Science topics would be useful in the real world. This resonates with what Mayoh and Knutton (1997) and Stuckey et al. (2013:1) have found: learners do not seem to find Life Science knowledge useful when it comes to their everyday lives.

In this study, lack of experiential learning in the CAPS curriculum, as experienced by the learners, was depicted in the category, 'advocating for realness'. Authors like Lelliots (2014), Mnguni (2013), and Du Plessis and Marais (2015) have criticised the CAPS curriculum recording, with regard to a critical analysis of the CAPS and previous Revised National Curriculum Statements (RNCS), a shortfall in CAPS in terms of fulfilling the demands for scientific literacy. In understanding the impact of the curriculum on learners, this study further exposes the shortcomings in the curriculum from the learners' point of view, unveiling learners' perceptions of the curriculum they are being taught.

This study revealed that the CAPS curriculum does not address the issue of relevance to learners. Although, it is noted that the definition of relevance may vary from one stakeholder to another and from one person to another, Stuckey and his co-authors summarise relevance in education in terms of three dimensions, namely, learners' career path, learners' personal lives and the society in which they live (Stuckey et al., 2013:19). I agree that the policy makers and curriculum developers need to integrate these three definitions of relevance to address the concerns of a holistic approach to Life Science learning and teaching. Furthermore, I agree that relevance, no matter what definition it takes, must have positive consequences, addressing both the present and future way of life of the learners (Stuckey et al., 2013).

In this study, learners used the word 'relevant' interchangeably with interest. Though the two differ in meaning, the challenge to the curriculum developer is to ensure that the curriculum is presented in such a way that learners see its relevance in their everyday lives and their future endeavours, emphasising the humanistic implications of the subject (Čipková, Karolčík, Dudová, & Nagyová, 2018). In so doing, learners' interest can be stimulated, so that even those learners who are not taking up a career in the sciences may still find it relevant to their daily lives (Gilbert, 2006:19).

5.6.2 Significance of the study for Life Science teachers

Dealing with unmotivated learners is frustrating for teachers. This study explored the perceptions of Life Science learners of their learning as designed by the teachers. Therefore, this study stands to reveal to teachers on what learners are actually learn as a result of their (teachers') teaching. Learners, presumably, are evidence of teachers' effectiveness and the effectiveness of prevailing educational practices in the classroom.

This study revealed that learners tend to be unmotivated and reasons for their disinterest include disjointed Life Science content, lack of experiential learning and content-focused lessons. This finding could inform instructional interventions designed by teachers to ensure that the aims of their educational practice are achieved. Transference of scientific facts and content will not result in the society (Holbrook 2005) that is required to benefit learners' personal lives and to build the harmonious communities that are needed in the 21st century.

5.6.3 Significance of the study for learners

This study agrees with Barnett (2012) and Lundgren (2015) that we need an education system that will enhance an understanding of the unknown future. My findings show that learners believed that getting better qualifications automatically secures a good life in terms of job security outside school. However, this is not always the case. In developing countries, securing a good job can be an economic escape from poverty, therefore, learners and parents alike look forward to such moments where there would be a sudden end to poverty. However, in our radically changing world, employment trends and job security are unpredictable. Pursuing a particular job because it seems lucrative may be uncertain as it could change from being a well-paid job to not in a short period of time.

Success as defined by learners is to pass exams and be promoted to the next grade. Looking critically at this perception, their definition of academic success may not be apt. Academic success should be seen as the development of the learner's whole entity (body, intellect, soul, and spirit) through a holistic approach to teaching and learning. This only can ensure our thriving as social beings.

5.7 RECOMMENDATIONS FOR FUTURE STUDIES

As the study was conducted in the girls' school, it would be interesting pursue this further by exploring whether there is a possibility of any differences in learners' perception of their Life Sciences learning experiences based on gender. This study has explored the learning experiences of learners in Life Sciences. However, I propose the need to further explore learners' learning experiences in other sciences such as the physical sciences to see how they meet the educational demands of the 21st century. Furthermore, this study addressed learners' perception of Life Science as a daily and scientific challenge, it did not carry out an investigation of the strengths and weaknesses of Life Science CAPS. It would be interesting in further research to investigate this area.

Since the purpose of education is not only for economic gain but to build science literate citizens who will take responsibility for their lives and coexist harmoniously with the world systems in their community, it is important that a study like this be conducted to serve as an instrument to assess how adequate our South African science education is in preparing learners for life and the life of their community now and in the future. An in-depth look at social justice theory as it pertains to the Life Science curriculum could be researched in further studies.

5.8 FINAL REFLECTION

Many authors have acknowledged that scientific knowledge is not only 'to know'; it is also essential that learnt concepts influence learners practically in their daily living. The everyday necessity of science and its applicability to every decision that is taken in society cannot be overemphasised. The challenge is that while scientific knowledge is accumulated by learners it has not been able to inform people's daily decisions. According to Mooed and Kaiser (2018), this does not resonate with the educational aim of Life Sciences. In this study, it was found that learners believed that the Life Science concepts taught in the classroom were applicable to the workplace only.

In addition, one challenge that we (learners and citizens) face is that of ignorance of the third purpose of education. As Stuckey et al. (2013:19) state, societal relevance is a vital aspect of learning. As a society we need to take personal responsibility for the world and consequently apply an understanding of scientific knowledge in creating a better and a safer world.

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ADDENDUM A: FOUR STRAND DIVISION OF THE SOUTH AFRICAN LIFE SCIENCES CONTENT KNOWLEDGE

ORGANISATION OF LIFE SCIENCES CONTENT FRAMEWORK ACCORDING TO FOUR KNOWLEDGE STRANDS			
KNOWLEDGE STRANDS	**GRADE 10**	**GRADE 11**	**GRADE 12**
1: Life at molecular, cellular and tissue level (molecules to organs)	All living organisms consist of atoms that combine to form molecules, which make up cells, the basic units of life. Plant and animal cells have a complex organisation that enables them to carry out the basic processes of life, that is, movement within and around other cells, nutrition (cells either produce food or process introduced food), respiration, excretion, growth, reproduction and stimuli response. Cells are specialised and combine to form tissues that perform particular functions. The tissues are arranged into specialised organs and carry out particular functions. This strand introduces learners to life at the molecular, cellular, tissue and organ level (links to Grade 9).	There is a wide variety of life forms that exist in various habitats and display many roles. This section exposes learners to an array of life forms that ranges from microorganisms to macroscopic plants and animals. These are organised according to a man-made classification system based on observable features. Learners explore the roles of organisms in an ecosystem, including microorganisms that are a major cause of disease. This strand also includes some evolutionary development in plant and animal phyla.	All living organisms consist of atoms that combine to form molecules. Of these, deoxyribonucleic acid (DNA) carries the genetic code for cell specialisation and cell functioning, and DNA packages as genes determine the features of the organism and how it functions. Plant and animal cells have a complex organisation that enables them to carry out the basic processes of life (i.e. movement, nutrition, respiration, excretion, growth, reproduction and stimuli response). Cells are specialised and form tissues that perform particular functions. Tissues are arranged into specialised organs that carry out particular functions. In order to understand species, speciation, biodiversity and change, it is essential to understand how DNA and chromosomes enable continuity and change.
2: Life processes in plants and animals (processes that sustain life)	Learners explore the anatomy of plants and animals in regard to support and transport systems. With reference to animals, the different support systems are compared, with a focus on the human support system and locomotion. Learners study the transport systems of the human body.	Organisms require energy to survive. This is obtained in one of two ways: by harnessing radiant energy from the sun and transforming it into chemical energy for use (autotrophs) or by ingesting other organisms (heterotrophs). The energy transformations that sustain life include photosynthesis (light energy is converted into chemical energy for food), animal nutrition (food is processed so that it can enter the cells) and cellular	This strand continues to investigate the ways in which animals and plants are able to respond to their environments in order to ensure their survival.

ORGANISATION OF LIFE SCIENCES CONTENT FRAMEWORK ACCORDING TO FOUR KNOWLEDGE STRANDS			
KNOWLEDGE STRANDS	**GRADE 10**	**GRADE 11**	**GRADE 12**
		respiration(breaking down sugars such as glucose into a form that the cell can use as energy). Gaseous exchange between an organism and its environment is necessary for photosynthesis and cellular respiration. In mammals, life processes involve the removal of carbon dioxide from the body by the lungs and later the removal of nitrogenous wastes through the kidneys.	
3: Environmental studies (biosphere to ecosystems)	Organisms interact with other organisms and with the environments in which they live in order to survive and produce offspring. The study of these interactions is called ecology. This section is structured to expose learners to some of the interactions that occur in nature and to the terminology and concepts that describe them. For the Grade 11 curriculum, the terminology and concepts selected here will be used across all strands where appropriate. This will enable learners to contextualise the meaning of these terms and concepts within the familiar contexts of their local areas and within Southern Africa as a whole. The local-area context is also used to introduce how humans influence the environments in which they and other organisms live. The effect that man has had on the environment, both locally and globally, will be	Organisms interact with other organisms and with the environments in which they live. This section is structured so that learners can explore the impact of people on their environments (global, international and local). Learners are encouraged to seek and suggest solutions to local environmental problems. The intention is that learners will become more informed and more sensitive to environmental issues and will modify their behaviour to lessen their impact on the environment. Note: Human Impact on the Environment must be completed in Grade 11, but this topic will be examined in **both** Grade 11 and in the National Senior Certificate at the end of Grade 12. This knowledge strand emphasises the interrelatedness and interdependence of human impacts and the environment.	

ORGANISATION OF LIFE SCIENCES CONTENT FRAMEWORK ACCORDING TO FOUR KNOWLEDGE STRANDS			
KNOWLEDGE STRANDS	**GRADE 10**	**GRADE 11**	**GRADE 12**
	examined in more detail in Grade 11. This section also builds on the knowledge acquired during the Senior Phase.		
4: Diversity, change and continuity (history of life on earth)	Life exists in an extensive array of forms and modes of life that scientists organise according to man-made classification systems. Modern life forms have a long history, extending from the first bacteria approximately 3.5 billion years ago. South Africa has a rich fossil record of some key events in the history of life. Changes in life forms are related to climate changes and movements of continents and oceans over long periods of time.		Life exists in a variety of life forms, and it is in the study of DNA, genetics and inherited characteristics that life at molecular level intersects with Strand 4: Diversity, change and continuity. In order to understand species, speciation, biodiversity and change, it is essential to understand how DNA and chromosomes enable continuity and change. It is necessary to have a good comprehension of the work covered earlier in the year on DNA, genetics and heredity in order to understand the concept of change, natural selection and evolution. This knowledge strand is expanded by exploring the mechanisms of evolution, specifically human evolution in Africa.

ADDENDUM B: LETTER TO PRINCIPAL

The Principal

INVITATION: EXPLORING LEARNERS' PERCEPTION OF LIFE SCIENCES AS AN ESSENTIALLY EVERYDAY-LIFE AND SCIENTIFIC HUMAN CHALLENGE.

My doctoral study explores learners' perceptions of Life Sciences education to reveal what they are actually learning within the context of the prescribed curriculum and expected educational practices and their consequential outcome. This will reveal the impact of our Life Sciences education in the face of the demanding challenges of the exponential increasing potential devastation of our planet and everything that lives in and on it.

This research is aimed at contributing to the general call for improving the quality of the poor current science and mathematics education in South Africa and, additionally, contributing to sustaining a flourishing living environment as citizens in general, as well as an appropriate orientation, preparation and inspiration to follow a career in this exciting field where qualified, competent professionals are in desperate demand.

The study will take place within the normal school context, the daily school programme and fulfilling the requirements of the existing departmental curriculum. I herewith ask for consent of the participation of one class in each of the Grades 8 through 12 in the Natural/Life Sciences of which Mrs Ford is the teacher. The learners will initially complete an open-ended questionnaire and I will audio-record an initial semi-structured interview with you. I will be making as many as possible class observations throughout the first term and continuing into the second term if and when necessary. I will also, as unobtrusively and non-invasively as possible, audio-visually record significant educational events in relation to this study (like some of the practicals). I will also conduct and audio-record another semi-structured interview with you as well as one with each of a selection of about 12 learners in each of the classes outside school time. All participation is voluntary, and participants may, at any time, opt not to participate with any consequences whatsoever. The identities of your institution and your individual learners will be protected at all times: only my supervisor and I will have access to the recordings, pseudonyms will be used when the study is reported, and all data will be destroyed after the research has been completed.

My sincere appreciation for approving the participation of the indicated participants of your school in this endeavour. Please do not hesitate to contact me with any concerns that you might have regarding this participation.

Please complete the following:

I (Name and surname) ______________________ the principal of ______________________________ (School) herewith give my consent to participate voluntarily in this study.

________________________________ ________________________

Signature of Principal **Date**

________________________________ ________________________

Signature of Researcher: Deborah Ali **Date**
Mobile Phone: 0768140757
Email address: hephjoeali@yahoo.com

12/01/2016

________________________________ ________________________

PROF JOHANNES A SLABBERT **Date**
Supervisor

ADDENDUM C: SAMPLE OF THE CONSENT LETTER TO THE TEACHER

The Subject Teacher

INVITATION: EXPLORING LEARNERS' PERCEPTION OF LIFE SCIENCES AS AN ESSENTIALLY EVERYDAY-LIFE AND SCIENTIFIC HUMAN CHALLENGE.

My doctoral study explores learners' perception of Life Sciences education to reveal what they are actually learning within the context of the prescribed curriculum and expected educational practices and its consequential outcome. This will reveal the impact of our Life Sciences education in the face of the demanding challenges of the exponential increasing potential devastation of our planet and everything that lives in and on it.

This research is aimed at contributing to the general call for improving the quality of the poor current science and mathematics education in South Africa and, additionally, contributing towards sustaining a flourishing living environment as citizens in general, as well as an appropriate orientation, preparation and inspiration to follow a career in this exciting field where qualified, competent professionals are in desperate demand.

The study will take place within the normal school context, the daily school programme and fulfilling the requirements of the existing departmental curriculum. I herewith ask for consent of your participation. This study will involve one class in each of the Grades 8 through 12 in the Natural/Life Sciences of which you are the teacher. The learners will initially complete an open-ended questionnaire and I will audio-record an initial semi-structured interview with you. I will be making as many as possible class observations throughout the first term and continuing into the second term if and when necessary. I will also, as unobtrusively and non-invasively as possible, audio-visually record significant educational events in relation to this study (like some of the practicals).I will also conduct and audio-record another semi-structured interview with you as well as one with each of a selection of about 12 learners in each of the classes outside school time. All participation is voluntary, and participants may, at any time, opt not to participate with any consequences whatsoever. The identities of your institution and your individual learners will be protected at all times: only my supervisor and I will have access to the recordings, pseudonyms will be used when the study is reported, and all data will be destroyed after the research has been completed.

My sincere appreciation for your participation in this endeavour. Please do not hesitate to contact me with any concerns that you might have regarding your participation.

Please complete the following:

I (Name and surname) ________________________ Natural/ Life Science Subject teacher of

________________________________ (School) herewith give my consent to participate voluntarily in this study.

__________________________________ __________________________

Signature of Subject teacher **Date**

__________________________________ __________________________

Signature of Researcher: Deborah Ali **Date**
Mobile Phone: 0768140757
Email address: hephjoeali@yahoo.com

12/01/2016

__________________________________ __________________________

PROF JOHANNES A SLABBERT **Date**
Supervisor

ADDENDUM D: SAMPLE OF CONSENT LETTER TO THE PARENTS

The Parent/Guardian/Caregiver

INVITATION: EXPLORING LEARNERS' PERCEPTION OF LIFE SCIENCES AS AN ESSENTIALLY EVERYDAY-LIFE AND SCIENTIFIC HUMAN CHALLENGE.

My doctoral study explores learners' perception of Life Sciences education to reveal what they are actually learning within the context of the prescribed curriculum and expected educational practices and its consequential outcome. This will reveal the impact of our Life Sciences education in the face of the demanding challenges of the exponential increasing potential devastation of our planet and everything that lives in and on it.

This research is aimed at contributing to the general call for improving the quality of the poor current science and mathematics education in South Africa and, additionally, contributing towards sustaining a flourishing living environment as citizens in general, as well as an appropriate orientation, preparation and inspiration to follow a career in this exciting field where qualified, competent professionals are in desperate demand.

The study will take place within the normal school context, the daily school programme and fulfilling the requirements of the existing departmental curriculum. I herewith ask for consent of your participation. This study will involve one class in each of the Grades 8 through 12 in the Natural/Life Sciences of which your child is one of the learners. Your child will initially complete an open-ended questionnaire and I may also audio-record a semi-structured interview with your child later on, all about his/her experiences in his/her Natural/Life sciences classes. I will also, as unobtrusively and non-invasively as possible, audio-visually record significant educational events in your child's classes (like some of the practicals). Your child's participation is voluntary and he/she may, at any time, opt not to participate with any consequences whatsoever. The identity of the school and your child's own personal identity will be protected at all times: only my supervisor and I will have access to the recordings, pseudonyms will be used when the study is reported, and all data will be destroyed after the research has been completed.

I sincerely appreciate your child's anticipated participation in this study. Please do not hesitate to contact me with any concerns that you might have regarding this participation.

Please complete the following:

I (Name and surname) ______________________ Parent/Guardian/Caregiver of ______________________

(Learner's name and surname) herewith give my consent that the indicated learner may participate voluntarily in this study.

________________________________ ________________________

Signature of Parent/Guardian/Caregiver **Date**

________________________________ ________________________

Signature of Researcher: Deborah Ali **Date**
Mobile Phone: 0768140757
Email address: hephjoeali@yahoo.com

12/01/2016

________________________________ ________________________

PROF JOHANNES A SLABBERT **Date**
Supervisor

ADDENDUM E: SAMPLE OF THE CONSENT LETTER TO THE LEARNERS

The Learner

INVITATION: EXPLORING LEARNERS' PERCEPTION OF LIFE SCIENCES AS AN ESSENTIALLY EVERYDAY-LIFE AND SCIENTIFIC HUMAN CHALLENGE.

My doctoral study explores learners' perception of Life Sciences education to reveal what they are actually learning within the context of the prescribed curriculum and expected educational practices and its consequential outcome. This will reveal the impact of our Life Sciences education in the face of the demanding challenges of the exponential increasing potential devastation of our planet and everything that lives in and on it.

This research is aimed at contributing to the general call for improving the quality of the poor current science and mathematics education in South Africa and, additionally, contributing towards sustaining a flourishing living environment as citizens in general, as well as an appropriate orientation, preparation and inspiration to follow a career in this exciting field where qualified, competent professionals are in desperate demand.

The study will take place within the normal school context, the daily school programme and fulfilling the requirements of the existing departmental curriculum. I herewith ask for consent of your participation. This study will involve one class in each of the Grades 8 through 12 in the Natural/Life Sciences of which you are one of the learners. You will initially complete an open-ended questionnaire and I may also audio-record a semi-structured interview with you later on all about your experiences in your Natural/Life sciences classes. I will also, as unobtrusively and non-invasively as possible, audio-visually record significant educational events in your classes (like some of the practicals). Your participation is voluntary and you may, at any time, opt not to participate with any consequences whatsoever. The identity of your school and your own personal identity will be protected at all times: only my supervisor and I will have access to the recordings, pseudonyms will be used when the study is reported, and all data will be destroyed after the research has been completed.

My sincere appreciation for your participation in this endeavour. Please do not hesitate to contact me with any concerns that you might have regarding your participation.

Please complete the following:

I (Name and surname) ______________________________Learner in Grade________ of _____________

______________________________ (School) herewith give my consent to participate voluntarily in this study.

_________________________________ _______________________

Signature of Learner **Date**

_________________________________ _______________________

Signature of Researcher: Deborah Ali **Date**
Mobile Phone: 0768140757
Email address: hephjoeali@yahoo.com

12/01/2016

_________________________________ _______________________

PROF JOHANNES A SLABBERT
(Supervisor) **Date**

ADDENDUM F: SAMPLE OF THE INTERVIEW PROTOCOL AND INTERVIEW QUESTIONS.

Welcome to this interview session. My name is Deborah and I am a PhD student from the University of Pretoria. I am conducting a study on learners' perceptions of Life Sciences as a daily life and scientific human challenge. I am interested in the improvement of the quality of what you are learning in your Life Sciences classes. In order to do this I need your help in expressing your experiences in your Life Science classes. There are no right or wrong answers. Even if the questions are about what you have learnt we are not interested in the content detail but only those things that you can easily remember.

Your confidentiality will be taken as utmost priority and whatsoever information is given here will be reported as anonymity where pseudonym will be used in reporting.

Audio recording will be done for record purposes and that all our discussion may be captured and that there will be no loss of information. Even if the questions are about what you have learnt we are not interested in the content detail but only those things that you can easily remember.

QUESTION 1
Describe in a few good, full sentences what normally happens in your Life Sciences classes/lessons.

QUESTION 2
What do you like most about your Life Sciences classes/lessons?

QUESTION 3
What do you like least about your Life Sciences classes/lessons?

QUESTION 4
Make a list of the most important things that you have learnt in your Life Sciences classes/lessons.

QUESTION 5
Can you draw your own unique picture of all the most important things you have learnt in your Life Science classes up to now and how all of them fit together?

Thank you so much for your cooperation I may still need to call on you if there is need for clarification.

ADDENDUM G: OPEN-ENDED QUESTIONNAIRE

YOUR LIFE SCIENCES EDUCATION EXPERIENCE
Qualitative open-ended questionnaire

In continuation of the study on learners' perceptions of Life Sciences as a daily life and scientific human challenge, which I interviewed you on; I have set these questions for clarity of views. I am interested in the improvement of the quality of what you are learning in your Life Sciences classes. In order achieve this, I would request that you narrate clearly your experiences of your Life Sciences classes. You will be of great help to us, if you would answer these few questions to the best you can. Please remember that this is not a test of some kind and there are no right or wrong answers. Even if the questions are about what you have learnt we are not interested in the content detail but only those things that you can easily remember.

Please answer the questions on the paper provided. Please write your name and your grade at the top of each page that you use. Remember give the number of the question for which you are giving an answer.
Thank you.

QUESTION 1
Considering what you have learnt in Life Science so far, what would you say is the purpose of your life science Education?
QUESTION 2
If you were employed as a life science teacher, describe how best you would prefer to carry out your job for learners' to achieve quality learning experience?

QUESTION 3
Draw your own unique picture of the most important things that you have learnt in your Life Sciences classes up to now and how they fit together to show your understanding of life Sciences.

PLEASE MAKE SURE THAT YOU GIVE THIS QUESTIONNAIRE AND ALL THE PAPERS THAT YOU HAVE USED TO ANSWER THE QUESTIONS TO THE TEACHER.

Thank you so much for your cooperation !

ADDENDUM H: GDE APPROVAL

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no: D2016 / 026

GDE RESEARCH APPROVAL LETTER

Date:	**26 May 2015**
Validity of Research Approval:	**26 May 2015 to 2 October 2015**
Name of Researcher:	**Ali Y.D.**
Address of Researcher:	**P.O. Box 11509; the Tramshed; Pretoria; 0126**
Telephone / Fax Number/s:	**076 814 0257**
Email address:	**hephjoeali@yahoo.com**
Research Topic:	**Exploring the experiences of Grade 10 learners in Life Science education**
Number and type of schools:	**ONE Secondary School**
District/s/HO	**Tshwane West**

Re: Approval in Respect of Request to Conduct Research

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

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

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter;
2. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB);

Mdaledo
2015/05/27

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Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

3. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned;
4. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, SGBs, teachers and learners involved. Participation is voluntary and additional remuneration will not be paid;
5. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal and/or Director must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage;
6. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year;
7. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
8. It is the researcher's responsibility to obtain written parental consent and learner;
9. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources;
10. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations;
11. On completion of the study the researcher must supply the Director: Education Research and Knowledge Management with one Hard Cover, an electronic copy and a Research Summary of the completed Research Report;
12. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned; and
13. Should the researcher have been involved with research at a school and/or a district/head office level, the Director and school concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

....

Dr David Makhado

Director: Education Research and Knowledge Management

DATE: 2015/05/27

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za

ADDENDUM I: ANALYSED DATA GRADE 8 OPEN-ENDED QUESTIONNAIRE

Description of learners' perception of their current life science education	
Life Sciences teaches about life	Acquisition of Life Sciences content Knowledge
Life Sciences teaches general knowledge	
Life science teaches about things that happens in the world	
Life Sciences teaches you some skills	Acquisition of skills
It prepares you for future career	Preparation for career
Description of learners' perception of how life science education should be	
I will teach the learner	Learning as teacher's responsibility
Making sure that there is interaction in class	Learners' engagement
Giving room for discussion in the class	
Allowing learners to do frequent experiments	
Ensuring that learners enjoy class activities	Promoting joy during learning
Ensuring less boredom during lessons	
Ensuring less home works	
Ensuring flow and continuity of topics so that learners will remember what is taught	Ensuring retention of content knowledge
ensuring that lesson is presented in a way that it can be easily remembered	
frequent quizzes so that learners will commit content into memory	
All about plants animals and their relationship	Life Science content (substantive life science structure)
All about experiments, human, animals, plants	
All about animals, plants and chemistry of life	Life Science content (substantive life science structure)

ADDENDUM J: ANALYSED DATA GRADE 9 OPEN-ENDED QUESTIONNAIRE

Description of learners' perception of the purpose of their Life Sciences education		
Life Sciences is to learn about the world	Acquisition Life Sciences content knowledge	Acquisition of Life Sciences content knowledge
Life science is to understand the relationship existing in the world		
Life Sciences is to understand the purpose of organism Life Sciences is to be aware of life processes		
Life Sciences is to know when and why bodily processes occur		
Life Sciences is to be aware of human body		
Life Sciences is to know what makes for a healthy body		
Life Sciences is to the knowledge of plants animals and humans in learners		
Description of learners' perception of how they will teach life science		
Ensure interest in learners for the subject	Promoting interest of the learners	Promoting interest of the learners
Using of diagram to ensure understanding of Life Sciences content	Use of various instructional methods	Acquisition Life Sciences content knowledge
Using diagrams for understanding of Life Sciences content		
Using practical sessions as instructional methods understanding of Life Sciences content		
Using tangible visual instructional instrument to teach	Using multiple source for Life Sciences content knowledge acquisition	
Using diagrams for teaching		
Using of Power Point for teaching		
I will ensure that learners understand the Life Sciences content I will give detailed teaching to learners	Teacher taking responsibility for learners learning	Teacher taking responsibility for learners learning
Using test to ensure retention of Life Sciences content so that they can pass exams	Retention Life Sciences substantive content	Retention of Life Sciences substantive content
Ensure that learners can recalling Life Sciences content in exams		
Use of cooperative learning	Learners interaction	Learners interaction

ADDENDUM K: ANALYSED DATA GRADE 10 OPEN-ENDED QUESTIONNAIRE

Description of learners' perception of the purpose of their life science education		
Life science is to give information on living things	Acquisition of life science content knowledge	Acquisition of life science content knowledge
To learn about what happens in the body		
To know basic life structure		
To learn life science		
To teach about different processes around us		
To use life science in everyday	Use in everyday	
Description of learners' perception of how learners will teach life science , if they were teachers		
Explaining life science content clearly to learners	Retention of life science content and its understanding as teacher's responsibility	Retention of life science content and its understanding as teacher's responsibility
Ensure retention of life content in learners brain		
Explain until all learners understand the topics		
Using video to explain the concepts	Ensuring understanding of life science content by various instructional method	
Testing of knowledge life science content	Testing of knowledge life science content to ensure retention of content	
Frequent test to ensure that life science content is retained		
Giving rewards for good academic performance to encourage learners	Giving rewards for good academic performance	
Promoting discussion in class	Promoting learners interaction	

ADDENDUM L: ANALYSED DATA GRADE 11 OPEN-ENDED QUESTIONNAIRE

Description of learners' perception of the purpose of their life science education	
Life science is to broaden one's knowledge of life	Acquisition of life science content knowledge
To inform learners on vital information	
Life science is to learn about the environment and nature	
To know what happens in one's body and the processes in the body	
To give information about oneself	
To help me learning about what I love	
To know how the body works	
To give understanding of life in order to accept it	
Remove this row	
Description of learners' perception of how learners will teach life science	
Ensuring that learners grasp concept	Teacher taking responsibility for learning
Giving diagram for understanding the subject content	
Passionately teaching learners	
Giving learners extra notes	
Giving weekly test to ensure retention of the life science content	
Encouraging passion in learners	Promoting interest of the subject in learners
Ensuring that learners are interested in the subject	
using fun experiment to teach the concepts	
Ensuring fun atmosphere for learning	
Using internet videos for teaching	Use of various instructional method to ensure learning
Allow interaction for easy understanding	Promoting learners interaction in order to retain life science knowledge content
interaction to remember what is learnt	

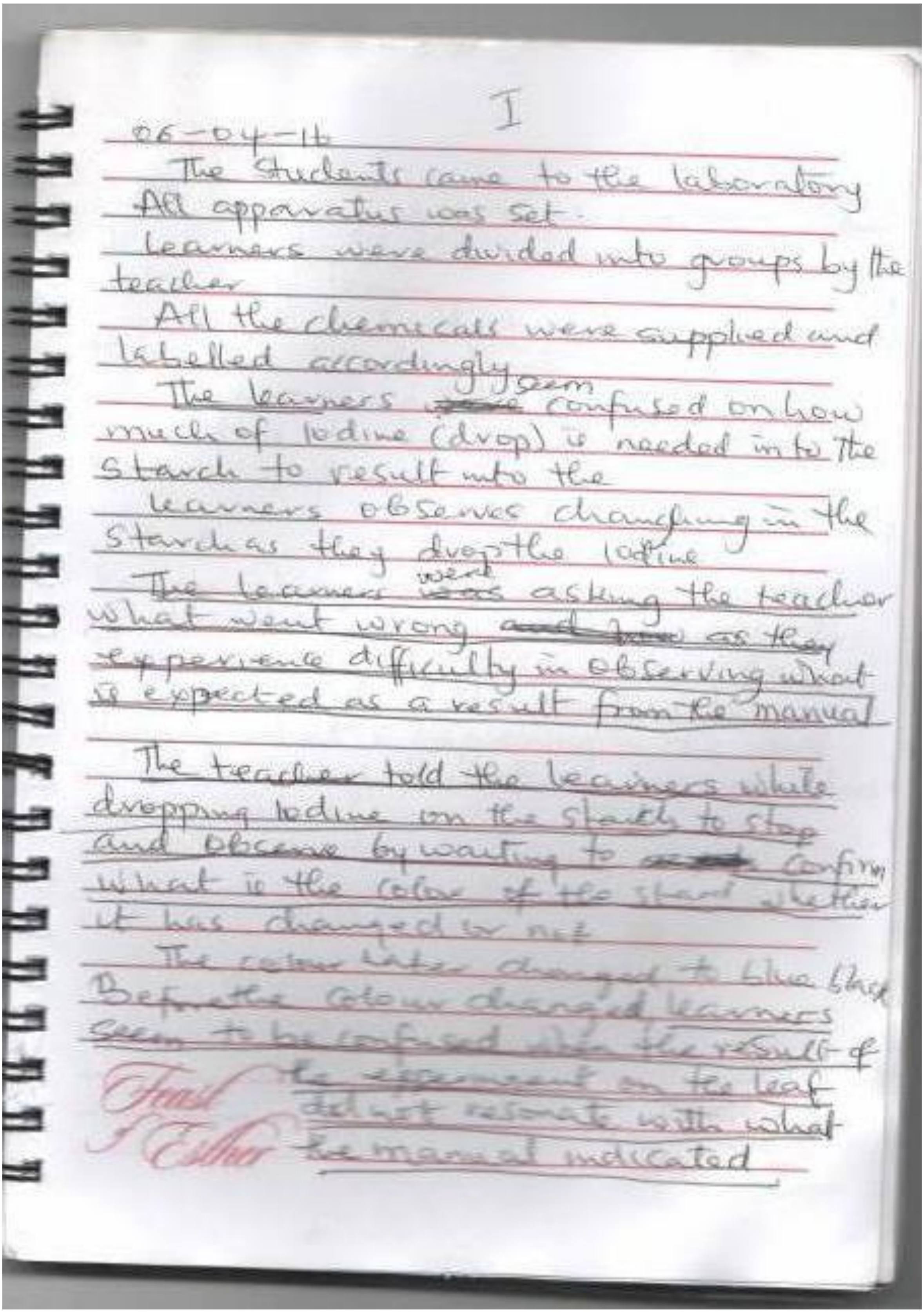
ADDENDUM M: ANALYSED DATA GRADE 12 OPEN-ENDED QUESTIONNAIRE

Description of learners' perception of the purpose of their life science education		
Life science is to know about nature	Acquisition of knowledge about life and nature	Acquisition of life science content knowledge
to know how nature works		
to know how human body works		
to know how to prevent disease and stay healthy		
To know things that others might not know		
Application of learnt concepts	Application of learnt concepts	Application of learnt life science concepts
Description of learners' perception of how life science education should be		
Giving learners practical things to do	Giving learners opportunity to put life science content into practice	Giving learners opportunity to put life science content into practice
Ensuring the use of knowledge in their lives		
Allowing questions from learners about their confusions in the subject		
Teaching is about having knowledge	Teacher taking responsibility for learners learning process	Teacher taking responsibility for learners learning process
Explain the subject contents		
Giving learners printed material and notes on the topics		
Explaining the notes given to learners		
Use of multiple sources of information to ensure that knowledge is acquired	Use of multiple sources of knowledge acquisition	Use of multiple sources of knowledge acquisition
Using power point to teach life science concepts		
Using video to teach life science concepts		
Regular assessment of knowledge in order to ensure retention of life science content	Retention of life science content knowledge	Retention of life science content knowledge
Ensuring learners know how to answer questions in examinations		
Using visual for purpose of recalling life science content in the examination		
About skeleton, kidneys, heart, mitochondria	Life science Content	Life science Content
About body system, health, cells, scientific method	Life science Content	
About bodily process	Life science Content	

ADDENDUM N: GRADE 8-12 OF THEMES FROM OPEN-ENDED QUESTIONNAIRE

Themes		
1st	2nd	3rd
Grade 8		
Acquisition of knowledge	Learning as teachers responsibility	Life Sciences contents
Acquisition of skill	Promoting joy during learning	Life Sciences content
Preparation for career	Ensuring retention of knowledge	
Grade 9		
Acquisition of knowledge	Promoting interest in learners	
	Acquisition of knowledge	
	Teacher taking responsibility for learners learning process	
	Retention of Life Sciences substantive content	
	Promoting learners interaction	
Grade 10		
Acquisition of knowledge	Retention of Life Sciences content and its understanding as teacher's responsibility	
Use in everyday	Ensuring understanding of Life Sciences content by various instructional method	
	Testing of knowledge Life Sciences content to ensure retention of content	
	Giving rewards	
	Learners interaction	
Grade 11		
Acquisition of knowledge	Teacher taking responsibility for learning	
	Promoting interest of the subject in learners	
	Use of various instructional method to ensure learning	
	Promoting learners interaction in order to retain Life Science knowledge content	
Grade 12		
Acquisition of knowledge	Giving learners opportunity to put life science content into practice	Life Sciences Content
Application of learnt concepts	Teacher taking responsibility for learners learning process	
	Use of multiple sources of knowledge acquisition	
	Retention of Life Sciences content knowledge	

ADDENDUM O: OBSERVATORY NOTE I



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06-04-16

The Students came to the laboratory
All apparatus was set.
learners were divided into groups by the teacher
All the chemicals were supplied and labelled accordingly
The learners seem confused on how much of iodine (drop) is needed into the starch to result into the
learners observes changing in the starch as they drop the iodine
The learners were asking the teacher what went wrong as they experience difficulty in observing what is expected as a result from the manual

The teacher told the learners while dropping iodine on the starch to stop and observe by waiting to confirm what is the colour of the start whether it has changed or not
The colour later changed to blue black
Before the colour changed learners seem to be confused with the result of the experiment on the leaf did not resonate with what the manual indicated

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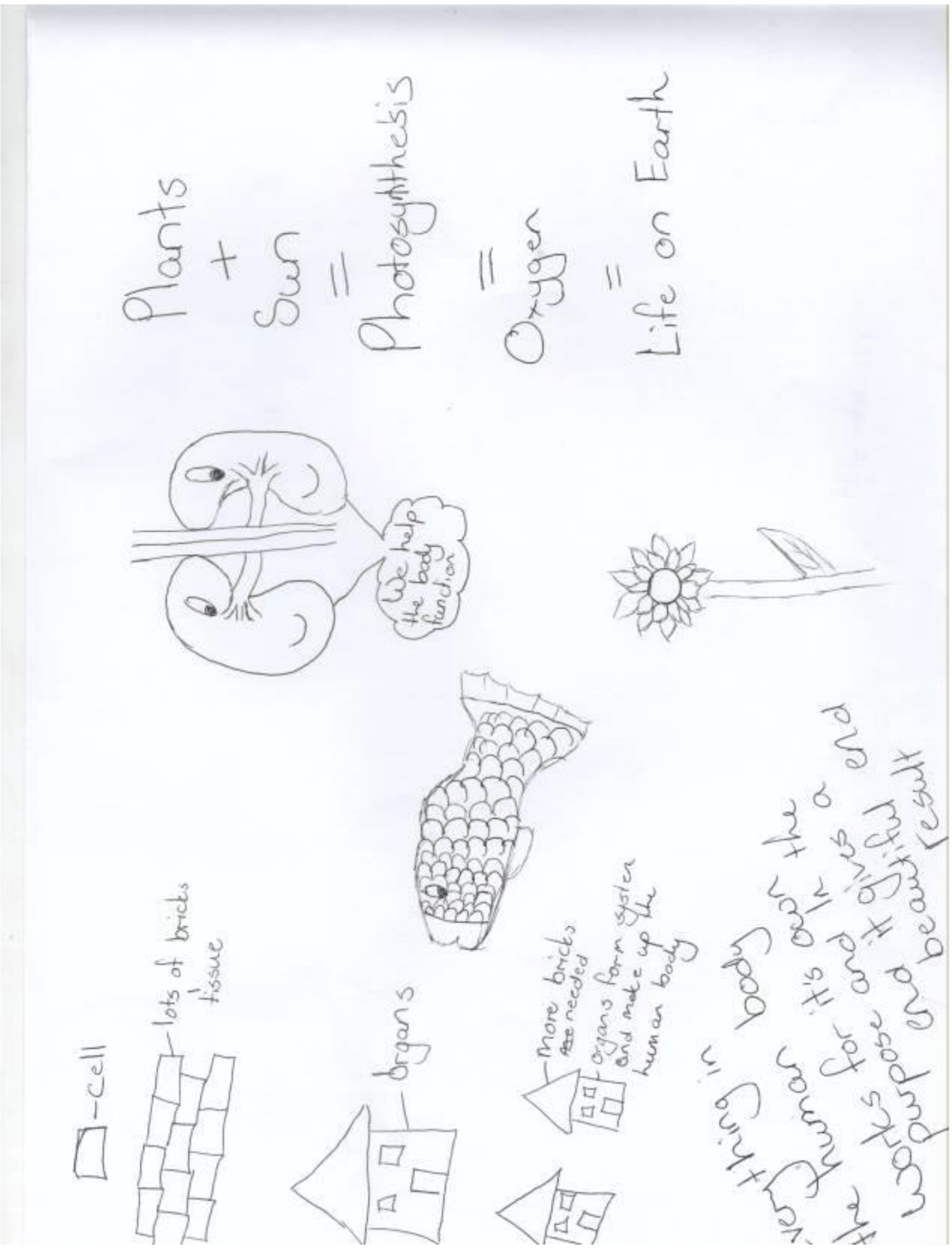
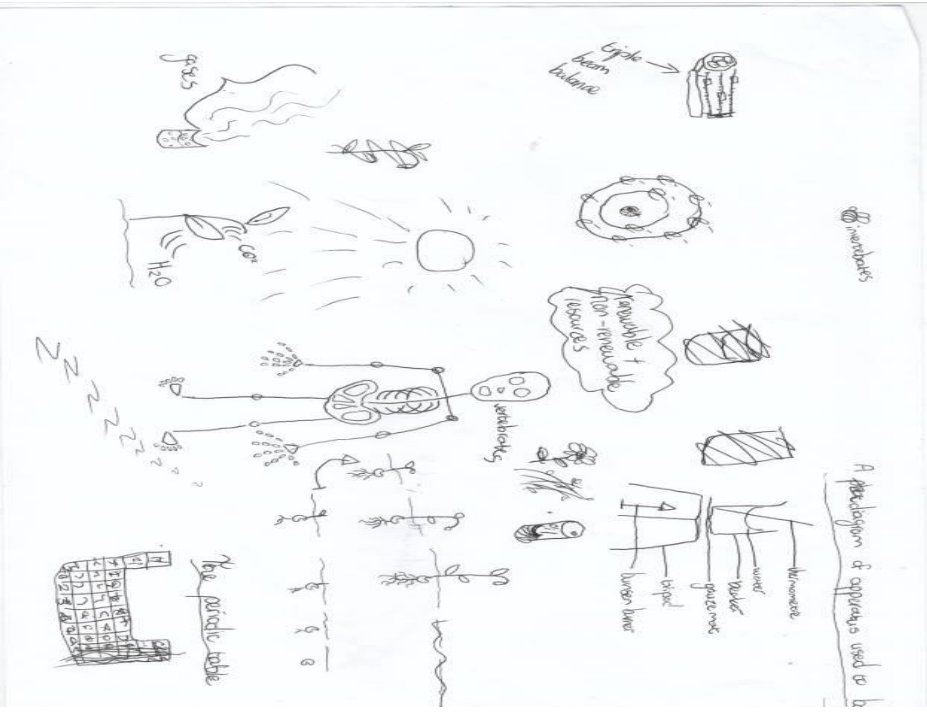
ADDENDUM P: RANDOMLY SELECTED LEARNERS' DRAWINGS




triple beam balance
invertebrates
renewable + non-renewable resources
vertebrates
the periodic table
thermometer
wood
beaker
gauze mat
tripod
bunsen burner