Investigating the Development of Experiential Skills in Grade 11 Life Sciences

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Submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy

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Johannesburg, South Africa

March 2023

ETHICAL CLEARANCE CERTIFICAT E

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R14/49 Mc Pherson-Geyser

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H20/11/41**
PROJECT TITLE	Investigating the Development of Experiential Skills in Grade 11 Life Sciences
INVESTIGATOR(S)	Ms G Mc Pherson-Geyser
SCHOOL/DEPARTMENT	Education/
DATE CONSIDERED	20 November 2020
DECISION OF THE COMMITTEE	Approved Risk Level: Minimal
EXPIRY DATE	15 February 2024

DATE 16 February 2021 **CHAIRPERSON** ______________
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I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

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ACKNOWLEDGEMENTS

Philippians 4:13, “I can do all this through Him who gives me strength.”

I would like to convey my sincerest gratitude to all individuals who contributed to my completion of this dissertation.

Firstly, to my Lord, Jesus Christ, for providing me with the necessary strength and ability in the perseverance of my studies. I would not have been able to complete this study without His guidance in my journey as an academic, or without His help bringing the necessary people into my life to assist me along the way.

My supervisor, Dr P. Kavai—I express my thanks for all the roles you played throughout my journey, as my study leader, mentor, and a source of encouragement. Thank you for all your assistance and expertise, especially over the non-contact sessions of Covid-19. It was a growing process, but together we have made a new contribution that will hopefully assist and inspire the teachers in Life Sciences. Your assistance and direction over the different academic degrees and years will always be valued and appreciated.

My parents, Jeffrey and René Mc Pherson—I thank you for your inspiration, drive and encouragement. Thank you for your guidance and for your caring ways. Your sacrifices have made me the woman I am today. You believed in me, while giving me the opportunity to study and achieve my dreams.

Geysers, I feel blessed to have found a new family who has supported me in my studies.

The University of Witwatersrand for their support, and for believing in my contribution to education.

My data analyst, Dr O.A. Solomon for the guidance and assistance in my quantitative data analysis.

AROS for their financial aid in the completion of my degree.

My colleagues for their understanding throughout this learning curve, and for showing care when needed.

I express my gratitude to all my friends and family for your encouragement, precious friendship, and interest.

Lastly, I would like to thank my husband, Stephan Geyser, for making me laugh, wiping away my tears, cheering me on, and keeping me strong. For giving me a beautiful daughter, EllaVé Geyser, while supporting my dreams. You were a promise from God that I would have a friend for life.

ABSTRACT

The aim of this study is to investigate the development of experiential skills in Grade 11 Life Sciences learners, and the influence of experiential skills on learner proficiency. The study seeks to gain insight into experiential skills development as a teaching approach, while aligning assessments with the needed cognitive levels for improved proficiency. South Africa's educational system uses the Curriculum Assessment Policy Statement (CAPS) to guide teachers in developing and assessing learners' Life Sciences proficiency, which tests the extent to which skills and knowledge are applied successfully in assessments.

Experiential skills involve a cyclic process, the stages of which are necessary to the achievement of a desired performance objective (Lalwani, 2020). However, Mc Pherson-Geyser et al. (2020) argue that teachers' limited knowledge of experiential skills is challenged when they are faced with the four modes of experiential skills development, namely: concrete experiences, reflective observations, abstract conceptualisation, and active experimentation (Kolb & Kolb, 2005). When developing experiential skills in the Life Sciences classroom, the correct tool as a guiding source is needed, and this study uses lesson plans as that tool. Competent lesson planning is vital for effective teaching and can be used to best facilitate the development of experiential skills among learners across each topic covered in the classroom (Daft & Marcic, 2014).

The study reported an interconnection between the interpretivist and positivist paradigm when applied in a mixed method study containing both qualitative and quantitative approaches. Qualitative descriptive case studies were used to analyse experiential skills development lessons, which were created using the conceptual framework. Concurrently, quantitative pre, during, and post-testing—together with questionnaires completed by 66 learners—explored the extent to which the experiential skills developed influenced learner proficiency.

Findings from both the quantitative and the qualitative approaches were triangulated to give an in-depth understanding of the study. The qualitative data proved that

effective lesson planning by the teacher bears a significant influence on learner experiential skills development. Conversely, it can be hypothesised that the ineffective use of lesson planning can negatively influence learner experiential skills development. Therefore, understanding what aspects are needed in designing an effective experiential skills lesson shows itself to be of great importance in the process. The quantitative data findings clearly indicate that there were significant differences between the means of the pre-test and the during-test, as well as the pre-test and post-test, across the entire group of 66 learners. A significant difference was found between the answers and explanations learners gave in the pre-test, as compared to their answers and explanations in the during and post-tests, displaying different levels of Bloom's Taxonomy, a classification system used to distinguish levels of cognition.

The participating learners also indicated that there was a significant improvement in their experiential skills, which in turn had a positive influence on their proficiency in assessments. I perceived that moving towards a more student-centred classroom assignment was most effective when it included the development of all four modes of experiential learning. Learners identified that the lessons, and the sequence in which they were taught, allowed for the development of a variety of experiential skills.

In the pre-test, results showed that if learners merely complete assessments for the sake of complying with the Department of Education's requirement, without developing the related experiential skills, there is no long-term benefit for upcoming assessments as the skill will soon be forgotten or lost. The study showed that these experiential skills can be acquired through experiential skill lesson planning. I then developed a tool to assist teachers when planning for experiential skill lessons using the given conceptual framework. If the tool is implemented and used effectively to develop experiential skills, teachers may fulfil more than the requirements in the Curriculum Assessment Policy Statement of the Department of Education. This study recommends research into the use of this tool in the development of experiential skills, measuring the tool's effectiveness both in classrooms and during assessments, and identifying any attributes and shortcomings which would influence overall learner proficiency.

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08 March 2023

To Whom It May Concern

This letter serves to certify that the 2023 research proposal by Genevieve Mc Pherson-Geyser in partial fulfilment of the Doctor of Philosophy, “Investigating the development of experiential skills in Grade 11 Life Sciences learners”, has been proofread for grammar, spelling and punctuation by the undersigned, and that a number of corrections were recommended.
I the undersigned take no responsibility for corrections and amendments not implemented in the final copy submitted for examination purposes.

Sincerely yours,

Karen Runge

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LIST OF ABBREVIATIONS

B.Ed.:	Bachelor of Education
PhD:	Doctor in Philosophy
CAPS:	Curriculum Assessment Policy Statement
ELT:	Experiential Learning Theory
FET:	Further Education and Training
GDE:	Gauteng Department of Educations
PCK:	Pedagogical Content Knowledge
WSoE:	Wits School of Education

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CHAPTER 1
GENERAL ORIENTATION

1.1 Introduction

This study seeks to investigate the development of experiential skills in Grade 11 Life Sciences learners, and the influence experiential skills have on learner proficiency. Experiential skills develop personal understanding, knowledge, skills and attitudes through analysis. Experiential skills are acquired over a series of learning stages related to the subject or area of learning at hand, with each of these stages allowing a learner to reach a performance objective through practical experience (Kolb & Kolb, 2005; Kolb, 2006; McDonald, 2020). Experiential skills are skills that are acquired and developed through the practical application of knowledge and may have a positive effect on the proficiency of learners. These experiential skills are; to understand, observe, reflect, analyse, judge and create (Kolb & Kolb, 2017). Over the course of my master's studies, I observed that teachers struggled to develop experiential skills in their learners, despite efforts to incorporate hands-on practicals into their lessons. In the master's study, teachers were required to develop a lesson which would allow learners to move from the theoretical aspects of the lesson to its practical application using experiential skills activities developed by the teacher. This proved to be a challenge for the teachers, as they did not have any training or understanding of experiential skills and the implementation thereof.

According to Kolb (2005), the challenge of developing experiential skills is exacerbated by teachers' limited knowledge of the four modes of experiential learning, namely: concrete experiences which include the experiential skill to understand context, reflective observations which include the experiential skills to observe and reflect, abstract conceptualisation which include the experiential skill to process through analysis, and active experimentation which include the experiential skills to judge and create. Ensuring that these modes are incorporated into lessons, driven by the levels of Bloom's Taxonomy from lower to higher cognitive levels which teachers already received training for by the Department of Education, may guide teachers in developing the necessary skills for improved proficiency in their learners. Proficiency in Life Sciences, refers to a high degree of skills and knowledge in the sciences concerned with the study of living organisms (Mathew, Amudha & Sivakumari, 2021). In this study learners demonstrate proficiency by applying these experiential skills and the knowledge of its value to different situations in both lower and higher cognitive levels to their work in order to complete their assessments successfully. This chapter opens with contextual background evidence regarding this study, voices the purpose statement, presents the research questions, provides the objectives, and closes with a brief discussion on the significance of the study, as well as identifying the main concepts in the research.

1.2 Background of the Study

Brink (2015) argues that Life Sciences cannot continue unless skills development and content education work in conjunction with each other, and that South African society should understand the crucial role of this connection. Experiential skills are important in our South African society, as they can be used to create and verify knowledge or to analyse truths and belief systems (Thuketana, 2020). Teachers are exposed to many modern teaching strategies over their careers, and most of these strategies utilise experiential learning as a scholastic platform (Kolb and Kolb, 2017). From this, it could be deduced that certain skills are needed in order to develop a degree of proficiency in a Life Sciences learner. Further, teachers may have limited knowledge on how to develop experiential skills in their learners (Girvan, Conneely & Tangney, 2016), and this in turn creates further challenges for learners who attempt to achieve the higher cognitive levels of Bloom's Taxonomy.

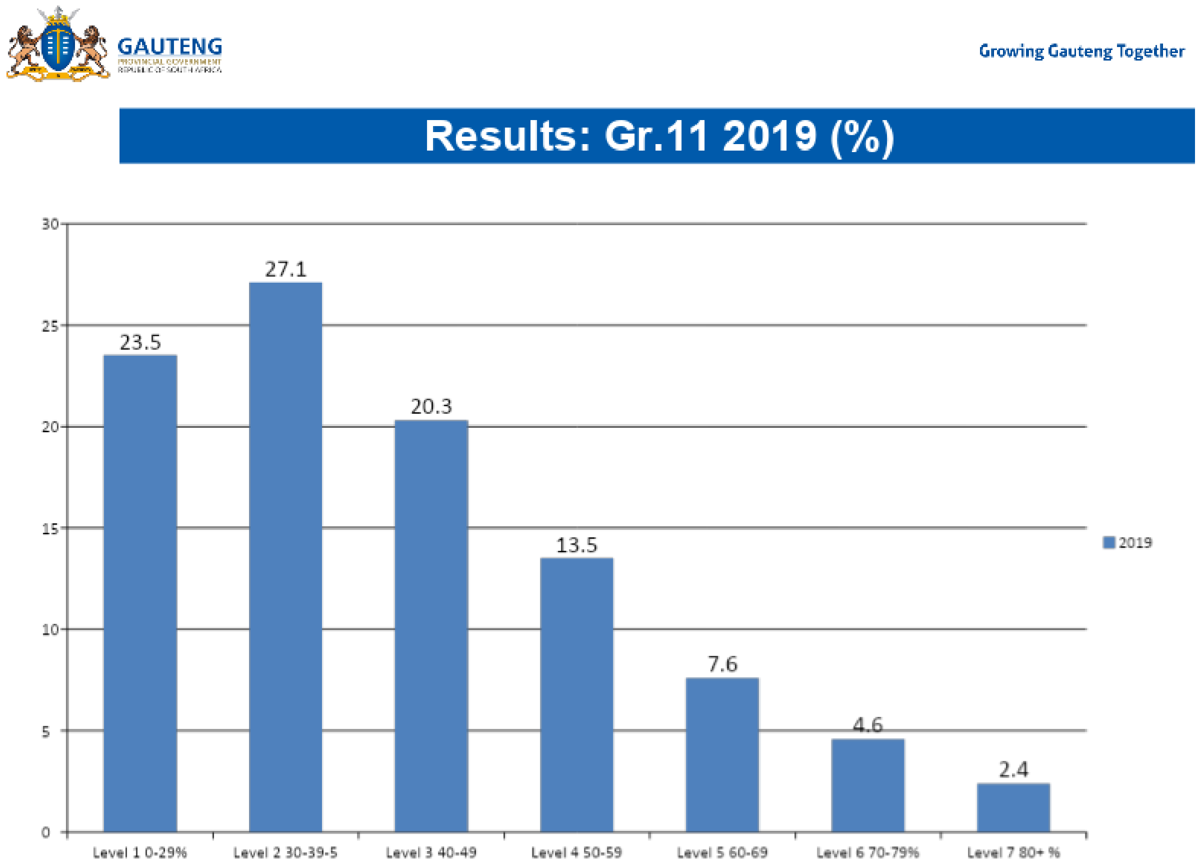
This study was prompted by my master's research study which demonstrated the limitations found among teachers to implement experiential learning and develop experiential skills. I then decided to take up this study to see whether lessons planned by the teachers with emphasis on experiential skill development on the part of the learners would lead to learner proficiency these skills include; understand, observe, reflect, analyse, judge and create (Kolb & Kolb, 2017). (Kelly, 2017) affirmed that, in due course development of these skills would lead to the development of higher cognitive levels of Bloom's Taxonomy which then influence proficiency of Life Sciences learners. Chan (2023) confirms that teachers struggle to change long-standing practices and accommodate quality experiential learning. Besides the findings from my previous study, I also attended a roadshow, a school district meeting giving feedback on the previous end-of-the-year results for all grades in the Further Education and Training (FET) phase. I observed the learner performance analysis for 2019, which indicated that the majority of learners were challenged in their attempts to answer more complex questions. They demonstrated that they had not yet achieved some of the higher cognitive levels necessary to acquire a fuller, more holistic degree of understanding. Finally, a 2020 amendment by the Department of Education (DoE) to Section 4 of the official document known as the Curriculum Assessment Policy Statement (CAPS) further motivated the need to carry out this study. This amendment requires an increase in the number of informal practicals completed during the term; these practicals are then formally assessed towards the end of term in order to determine whether the learner has achieved proficiency in the Life Sciences themes they have been taught. This directive policy has been developed for each subject, and it details the specifics of the content covered, the knowledge and skills that should be developed, the assessments that should be completed, and the time allocations for each. The CAPS (2011) Further Education and Training (FET) for Life Sciences consists of four sections, as follows. Section 1: Introduction to the Curriculum and Assessment Policy Statement; Section 2: Introduction to Life Sciences; and Section 3: Content covered in Grade 10, Grade 11 and Grade 12. Section 4 focuses on assessments, and these are divided across the Life Sciences practicals, identifying the assessment requirements for Life Sciences end-of-year examinations. As a practitioner, and by observing my learners, I realised the need for the development of experiential skills and recognised the lack of alignment with the practical aspect of the Section 4 assessments. Teachers had no training in developing their learners' skills to a degree sufficient for the successful completion of practical assessments, and teachers furthermore lacked the fundamental knowledge to align specific skills with their assessments when evaluating proficiency in their learners. This study investigated the development of experiential skills through a series of experiential learning lessons in the Life Sciences classroom, and established the influence this would have on the proficiency of learners in and outside the classroom.

1.3 Statement of the Problem

In 2019, the Minister of Education instructed a change to the CAPS document that would be implemented in 2020, where informal practicals were increased, and more scientific skills were required in order to complete practical assessments (DoE, 2019). Taking into consideration the limited degree of knowledge among teachers on experiential skills development as mentioned in the introduction (Mc Pherson-Geyser et al. 2020), as well as the lack of training available for teachers to implement the amendment, this expectation by the DoE presented a potential challenge. As a practitioner, I saw a gap between the development of experiential skills and the content taught. The DoE demands that teachers learn continuously, and that practical lessons must meet the imposed amendment—practical lessons and the amendment aim to develop proficiency in learners in and outside the classroom (Suryani & Widyastuti, 2015).

There is a demand for skills development in learners. While an increase in practicals in the amended Section 4 suggests learners be continuously assessed, learners struggle to achieve most, or all, cognitive levels needed to apply their knowledge effectively in these assessments (Roadshow Statistics, 2020). This indicates that, in terms of content, the subject questions in themselves may be difficult, despite being phrased within reach of a lower cognitive level. The opposite may also be true when asking for a higher-order thinking skill when using standard language, as shown in the end-of-the-year examination statistics for Grade 11 in 2019 (Figure 1.1), (Roadshow Statistics, 2020). Jansen (2011) argues that there is a collapse in the South African education system. A breakdown of alignment between experiential skills development and content with continuous assessment on a higher cognitive level signifies the severity of this problem and makes a loud call for intervention. Hence, it is necessary to develop experiential skills in learners.

Figure 1.1 Roadshow statistics for end-of-year exams in skills development in Grade 11 Life Sciences, 2019



The graph in Figure 1.1 clearly indicates that there are limitations on the higher cognitive levels developed in learners. A proficient learner in Life Sciences should be able to align the levels of cognitive demand with the level of difficulty in an assessment. The levels as detailed by the graph indicate that the majority of learners fall under the category of levels 1 to 4, confirming that learners in the 2019 examination only mastered the lower cognitive levels. Category questions for levels 1 to 4 are seen as low-order questions where information is simply recalled. The minority of learners achieved levels 6 or 7—the levels which indicate that the learner is proficient in most or all of the cognitive levels. Category questions for levels 6 and 7 are grouped on the higher cognitive platform, allowing learners to interpret information, analyse its importance in the context of the knowledge learned, and judge its significance in real-life situations.

Underdeveloped skills due to the lack of knowledge of experiential learning hinder learners in the creation of new experiences in the Life Sciences classroom (McDonald, 2020). Teachers may not know about experiential skills development, or they may struggle to incorporate all the skills required by learners in real life. The problem as outlined above leads to the following research question: *How does the development of experiential skills influence the proficiency of Life Sciences learners?* To be able to understand my motivation behind answering this question, the study rationale will follow.

1.4 Rationale

It is hoped that by investigating the development of experiential skills in Grade 11 Life Sciences learners, the findings of this study will provide information to the DoE and other relevant stakeholders on strategies which could be used to develop methods and strategies to aid experiential skills development in learners. This in turn may have an improved influence on the proficiency of learners, better enabling them to interpret questions on all the cognitive levels of Bloom's Taxonomy. Experiential skills should create opportunities for the learner to take a personal role in the direction of their learning through first-hand experience (Bartle, 2015). UC-Davis (2011) posits that learners are involved in practical problems, and that learners want the freedom to be involved with challenging content while discovering solutions and observing their own progress in the learning process.

The study will allow the DoE as well as Life Sciences teachers to critically reflect on the implications of limited experiential skills in learners, and the requirement of these skills as a necessity in the Section 4 amendment. It will discuss the failure to teach learners the innate skills needed alongside their core discipline knowledge, and further suggest that conventional teaching strategies are not effective in developing proficient learners who demonstrate competence in their assessments (Bartle, 2015).

At the end of this study, I used the collected data to design a tool for Life Sciences teachers to develop their leaners' experiential skills in any theme. With this tool, teachers may use experiential skills development and learners' existing knowledge from Grade 11 together as a strategy to provide practical experiences inside the classroom, thereby developing the necessary experiential skills to optimise knowledge attainment in learners.

1.5 Purpose of the Study

The purpose of this study is to investigate the development of experiential skills in learners, and the influence these skills have on learner performance within the current context. Considering the need for experiential skills in the directive given by the DoE in the amended Section 4, a series of experiential or practical-based lessons that are aligned with the content provides an insight into the development of experiential skills needed to be proficient in a Life Sciences examination or task, either practically or in society. My ultimate goal was to develop a tool from the data I collected, with the aim that going forward this tool would assist teachers in developing experiential skills among their learners.

1.6 Objectives of the Study

The following objectives will be addressed in this study:

a. To create a series of lesson plans that focus on developing experiential skills.
b. To determine the extent to which experiential skills development influences the proficiency of the Life Sciences learner through a series of lessons.
c. To establish how a series of lessons through experiential-based practicals aligned with lesson content help to develop the experiential skills in learners.
d. To establish how learners perceive experiential-based practicals as aligned with lesson content.

1.7 Research Questions

The following questions will guide this study:

Primary research question:

How does the development of experiential skills influence the proficiency of the Life Sciences learner?

1.7.1 Sub-research questions

Secondary research questions:

i) *What aspects are considered when creating experiential skills development lesson plans?*

ii) *To what extent does the development of experiential skills influence the proficiency of Life Sciences learners?*

iii) *How do the series of lessons through experiential-based practicals aligned with content help develop experiential skills in learners?*

iv) *How do learners perceive experiential-based practicals as aligned with content?*

1.8 Significance of the Study

To understand the value of this study, one needs to consider its intended objectives and audience groups (Hamilton & Corbett-Whittier, 2013). This study aimed to establish the extent to which experiential skills have been developed and the influence these skills have had on learner proficiency. As discussed in the problem statement, "Once a problem has been formulated, research can be provided to supply pertinent information for this study" (Icobucci & Churchill, 2010).

If Life Sciences lessons are conducted by teachers who do not have the necessary skills to facilitate the strategy of experiential skills development, these lessons only resemble experiential learning, and do not create any practical or effective impact (Andrews et al., 2011). This study is significant in providing valuable insight into the current status of experiential skills development. This will inform the DoE of the initiative to develop or train teachers who are confident in applying experiential skills development to the various practicals completed throughout the year, as required by the Section 4 amendment. Arguably, this is the first study of this nature to be conducted within Life Sciences in the South African context. As there is a dearth of literature on experiential skills development, specifically in Life Sciences education, the findings from this study would help to plan for better support for learners in making use of experiential skills. This could better gauge the efficacy in Life Sciences classrooms and assessments, showcasing the possible attributes and shortcomings which influence learner proficiency. After identifying the significance of the study, the ultimate goal was to create a tool. This tool could assist teachers not only in correctly applying the development of experiential skills in their lessons, but also in allowing teachers to develop lessons for skilled learners to acquire all four modes of experiential skills development. This in turn could further allow teachers to fulfil the mandate given by the DoE in the amended Section 4 for Life Sciences.

1.9 Concept Clarification

To aid the clarification, consistency and development of the study, the following concepts are explained:

Experiential learning: This is the theory that affirms; the best way to learn something is to have experience of it. It furnishes an overall (holistic) model of the education process and is a multi-linear representation of learner development (Kolb, 2006).

Experiential skills: This covers the series of stages which allow a learner to achieve a degree of performance proficiency through experience (McDonald, 2020). Experiential skills include a variety of skills such as observing, reflecting, analysing, and creating.

Experiences: This is the practical observation of key relevant facts, or the participation in key relevant events inside or outside the classroom (Acampado, 2019).

Lesson plans: These are guides teachers follow, which dictate what will be taught and how learning will be measured (Loveland, 2014).

Modes: Kolb’s model is divided into two modes of acquiring experience, namely *Concrete Experience* and *Abstract Conceptualisation*. It is further divided into two modes of transforming experience, namely *Reflective Observation* and *Active Experimentation* (McLeod, 2017).

Concrete Experience: This is content knowledge, constructed by experts, which learners should understand (Kolb, 1984).

Abstract Conceptualisation: This is the practical application of knowledge through hands-on experience (Dhanapal & Shan, 2014).

Reflective Observation: This is the process of analysing insights and understanding reached through practical experience (Kolb, 1984).

Active Experimentation: This involves the testing of knowledge acquired and its practical implications in real-life situations (Kolb & Kolb, 2017).

Proficiency: This indicates the degree of skill acquired according to cognitive levels or expertise both inside and outside the classroom (Pellegrino, 2013).

Life Sciences: In layman's terms, this can be seen as a body of knowledge and the processes of an existing and ongoing phenomenon which combines living things and their interactions with their surroundings (ArtiFacts, 2019).

1.10 Preliminary Chapter Classification

The preliminary chapter classification serves as an outline for this study, which is supported by the hourglass illustration of the chapters' structure.

Chapters

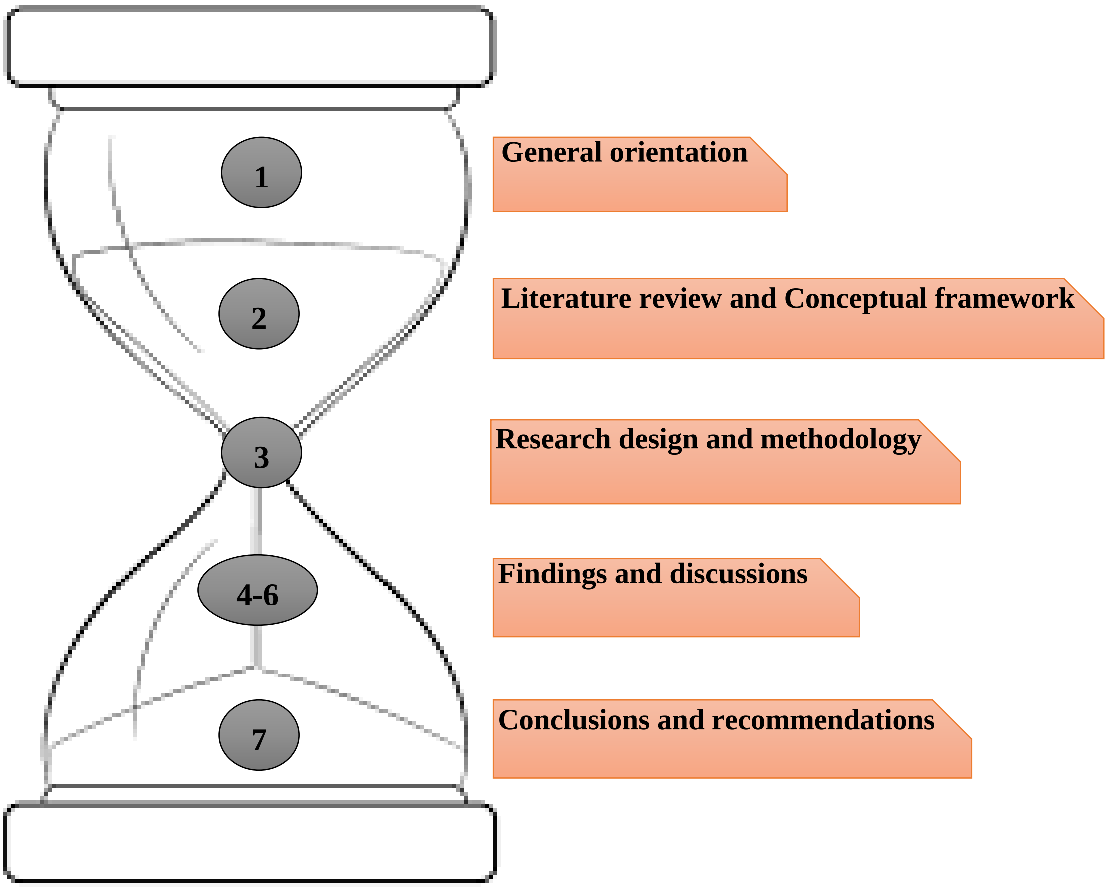


Figure 1.2 Hourglass chapter classification (modified from Lionel, 2015)

The hourglass illustration is a reader-friendly way of interpreting chapters. Lionel (2015) identifies that the adoption of this model will ensure an effective and complete design by following the three key characteristics such as a generic start, a focused study, and comprehensive conclusions. The general orientation is shaped in Chapter 1 and considers the background analysis. Chapter 2 includes the literature review of the established problem, and the existing gap of implementing experiential skills that are filled by using specific research questions. The focus study forms part of the pragmatic and original section of the study, focusing on the root of the problem by designing a conceptual framework and using data collection and observations. Chapter 3 is devoted to the research design, which meshes in with the qualitative and quantitative measures of the study. Chapter 4 covers the analysis of the results, leading the way to the fifth and final chapter at the bottom of the hourglass. Chapter 5 to Chapter 7 aim to match results to the problem statement and fill the gaps by identifying implications or areas of significance such as better support for teachers concerning experiential skills development and its effective implementation through lesson planning which may form the basis for further research.

Chapter 1 provides an orientation and overview of the problem that the research faces, and which represents the focus of this study. The chapter goes on to address the problem and the manner in which the problem will be approached in the study. The chapter begins with the background information relevant to the problem, as well as identifying the research questions (primary and secondary). Further, it offers a preliminary literature review, and concludes with a brief discussion on the research methodology. An hourglass illustration of the chapter framework of this study is also provided.

Chapter 2 commences with an in-depth analysis of experiential skills in the literature review. The different theories underpinning experiential learning—such as the father of experiential learning, Kolb's theory, and also Dewey's theory—are discussed, identifying the skills and influencing factors that affect learning and teaching in the Life Sciences classroom. Chapter 2 continues with an in-depth discussion of the incorporation of an experiential skills development model in the Life Sciences classroom. Different key modes, skills, outcomes, and the attributes of those outcomes, are then examined.

Chapter 3 is devoted to the research design, data collection methods, data sampling and collection, and data analysis and interpretation. The chapter further builds on the methodology by observing, explaining and interpreting the results. The chapter begins with the research design and with a discussion on the target population.

Chapters 4-6 zero in on the study's findings, with a coherent discussion of these results. Demonstrating original thinking, these findings will show what the research has reinforced regarding what is already known in the area of experiential skills development. These chapters will outline new findings and identify clear links between the various pieces of literature that have been reviewed.

Chapter 7 commences with a brief and concise recap of the study, followed by an overview of the link between the primary and secondary research questions, a summary of the main findings, and then finally presents the conclusions and recommendations. Successively, the conclusions will be formulated according to the secondary research questions. Recommendations pertaining to different aspects of the research questions are further framed. The conclusion of this chapter focuses on the limitations of the study and the contributions of the conceptual framework and proposes possibilities for future research using the tool developed in response to this research.

1.11 Chapter Summary

This chapter provides a synopsis of the study, highlighting some of the previous research on the development of experiential skills. The conclusion of this chapter consists of a brief discussion on the significance of the study by questioning the quality of South African Life Sciences education. This chapter’s preliminary outline leads into the subsequent chapter of the literature review and conceptual framework.

CHAPTER 2
LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

The main purpose of this chapter is to detail the role of the literature in providing direction for this study. The literature review provides key perspectives for the critical analysis of the meanings behind the research questions. An in-depth discussion of the development of experiential skills is presented, followed by an overview of the different theories which underpin experiential learning. The literature review articulates the skills which learners need, and the possible influence these skills may have in the Life Sciences classroom. A conceptual framework with four different key modes and their attributes is then discussed. The chapter concludes with the proposed application of these key modes in experiential lessons.

2.2 Literature Review

2.2.1 Skills development in the Life Sciences classroom

In order for learners to develop skills effectively, efficient classroom practices conducted by well-trained teachers are a necessity. The efficacy of skills development ensures total functionality of the education system. This statement is supported by Usman (2016), who argues that achieving educational objectives contributes to the upgrading of the quality of educational services. The CAPS document uses its objectives to identify knowledge areas, and each of these areas should be developed in all sections of Life Sciences (DoE, 2019). The main knowledge area of notable importance highlighted is scientific knowledge. Besides this, there are two other knowledge areas which should be equally valued, and these are the ‘process’ and the ‘attitudes’ by which the learner develops (Maranan, 2017). The ‘process’ concentrates on the skills which the learner will use in the future. The ‘attitudes’ direct the learner’s response in terms of curiosity and enthusiasm in asking questions and solving problems. By contrast, Robinson (2001) argues that teaching often leads to ritual knowledge where the culture of teaching rejects detailed scrutiny while teaching.

There are many characteristics related to experiential learning which are needed for the development of skills in the Life Sciences classroom. Dewey (2001) and Kolb (1984) both outline the skeleton of experiential learning by stating five main activities:

Involvement:	Learners must be active in the lesson, both physically and mentally.
Reflective thought:	If learners have been active during the lesson, and have reached a conclusion, the current learning objective should be reflected upon.
Meaning:	The lesson's outcomes should not be forced onto the learner, but rather learners should be given a chance to assign meaningful interpretations to the learning process.
Subjectivity:	The experience should be formed by each learner's own view of the world, and not automatically take on the teacher's view.
Human experience:	Experiential learning opportunities must be provided as part of the learning process.

The foundation of each lesson centres on the skills that are important for learner development. These skills are grouped in a logical order of increased sophistication (Dewey, 2001; Durham, 2017; Kolb, 1984), and they are as follows:

- Observation (concrete experiences)
- Communication
- Classification (abstract conceptualisation)
- Measurement (active experimentation)
- Inferences (reflection)
- Prediction

Every Life Sciences lesson should begin with observation as a way to stimulate all the senses of the learner, as sensory stimulation is essential to learning about the world (Maranan, 2017). Observations and communication work hand-in-hand as the active source of the experiential lesson, and this is provided through the effective sharing of observed information. Classification is indispensable; it forms an expected part of

CAPS, as it clears the path for a better understanding of the object or phenomena within given contexts. Through the use of experiential skill development, there is a shift from the passive learning experience to an active learning experience in which a learner can acquire the necessary skills. Life Sciences, as it is usually taught where learners just listen and complete assessments (Mc Pherson-Geyser et al. 2020), active learning does not do this, hence the need to establish how experiential development lessons operationalise skills, linking it to learner proficiency in Life Sciences. Unlike observations, inferences and predictions are not gathered through direct evidence but rather via interpretation. The successful integration of these skills in the Life Sciences classroom will ensure a richer learning experience that has a more meaningful impact on the learner.

2.2.2 Experiential learning in South African classrooms

In the 1980s, in South Africa, reformed education used this specific approach of experiential learning as an antidote to the type of education which up until that point was considered traditional (Clark et al., 2010). Today, experiential classrooms around the world encourage learners to make use of actual scenarios and case studies, requiring an active approach in order to transfer prior knowledge from the teacher to the learner (Chan, 2023). Chan (2023) explains that in the classroom, feedback from teachers becomes more important than in other forms of learning, as this feedback can relate to real-life experiences and therefore have very real practical implications for learners.

It is important for teachers to understand that the South African classroom is diverse in culture, language, and learning style. That each learner has his/her own needs when it comes to learning (Conway, 2017). This is in line with Kolb’s prediction that experiential learning adheres to different approaches in the classroom (Kolb, 2005). As stated by Ramaroka (2007), experiences from outside the classroom should be brought into the classroom, as prior knowledge helps achieve the objectives of the current discipline theory.

Following the need for experiential skills development in the South African classroom, experiential learning raises awareness of the challenges that teachers and learners might face if experiential learning activities were completed (McPherson-Geyser et al., 2019). According to Mc Pherson-Geyser et al. (2019), South African teachers face many ambiguities in the conceptualisation of the term ‘experiential learning’. Uncertainty of experiential learning and the diversity of the modes could enhance the uncertainty of skills development when changes are made to the curriculum.

When the curriculum was changed to CAPS, teachers should have been equipped to successfully integrate experiential learning strategies into their classrooms (Passarelli & Kolb, 2011). Further, the amendment to section 4 in 2020 specifically states that time for reflection should be allowed during assessments, thereby enabling learners to connect learning concepts with their own real-life experiences, as likewise suggested by Passarelli and Kolb (2011). The amendment to section 4 requires time and real-life experience, and this contributes to the challenges found in the South African education system such as cramped classrooms, limited or no resources, a lack of teachers, and poverty. Teachers face these challenges on a daily basis, where a lack of training to implement the amendment to section 4 can create further uncertainty or exacerbate a resistance to change. Therefore, learners should take part in activities that will capture thinking processes similar to those of other, well-implemented learning experiences.

Over the years, informed guidelines sent to teachers in tandem with changes to the curriculum would have aided them in successfully incorporating these adjustments into the necessary teaching strategies. As a practicing teacher, I can attest that no training has been given on strategies, but has been given on what to implement as quickly as possible.

The Experiential Learning Theory, a theory that focuses on learners obtaining new knowledge through experiences, offers a profoundly different overview on the learning process as compared with other, traditional theories. These differences are seen in changed teaching methods, which moved away from the traditional foundation of rational, idealist epistemology. From this shift, a very different outlook on education arose—one which entails the proper relationship among learning, work and other life activities, and the creation of knowledge itself (Kolb & Kolb, 2005).

The new Life Sciences Curriculum Assessment Policy Statement (CAPS) consists of specific, learner-focused goals, where the learner becomes responsible for their own learning. This statement is supported by Ramaroka (2007), who posits that the success of the learning system depends on how well it is understood, and that human resource development is fundamental to maximising and enriching the effect of learning. With this in mind, it would be of great advantage to teachers to recognise how effective an experiential learning model would be in a goal-oriented curriculum requiring a range of skills. Experiential learning is more than just letting learners 'do something'. As stated by Ramaroka (2007), unless experiences outside the classroom are brought into the Life Sciences classroom and integrated into the goal and objectives of the discipline theory, learners will not readily connect their outside goals and experiences with their in-class learning. Without a meticulously designed curriculum complete with opportunities for reflective skill building, learners may never carry key lessons beyond the four walls of the Life Sciences classroom and into their everyday lives.

There are three clear-cut applications of experiential learning in Life Sciences classrooms:

Field-based experiences: Assessment that takes place prior to learning and the implementation of experiences from outside the classroom aims to develop the learner through classroom-based learning. The field of experiential learning in further education training is to ensure that the application is utilised in assessments (Chan, 2023).

Practical experiences: Practical assignments prepare learners for careers through experiential learning. The idea of volunteering in a certain field of interest and incorporating a reflective component, thereby placing emphasis on the transfer of experiential learning, urges learners to solve problems in a bigger social context (Chan, 2023; McLeod, 2017). Practical learning opportunities ensure an analysis of social problems by using community resources to identify and take responsibility for the social problems that are addressed.

Credit for prior learning: Learning that takes place prior to time spent in the classroom is of interest in experiential learning, and reflects the acknowledgement key to Life Sciences classes where meaningful learning takes place in an informal setting (Chan, 2023). Provision is made for individual assessments of prior learning, and uses a range of learning opportunities or styles to ensure that the necessary teaching and learning styles are created.

The method of outcome-based education focuses on achieving different objectives. Though this style may be commonly used among teachers, they are likely unaware of the other teaching styles available to them, and which might better suit their teaching goals. Resources offered by schools to motivate and elevate outdoor experiences, especially in South Africa, are scarce. South Africa is widely recognised as a country with educational challenges, namely its overcrowded classrooms, lack of resources, limited number of qualified teachers, and general poverty and poverty-related concerns (Du Plessis & Letshwene, 2020). These challenges all place strain on the creation of a learning environment where deep learning sessions take place, and where all learners can receive the attention they need. These problems are further intensified for the teachers working within South Africa's townships (commonly understood as underdeveloped areas in the industrial sector, with a variety of learners from villages, and in close proximity to residential areas) and rural schools (commonly located outside urban areas and in small settlements, and often operating under unfavourable conditions). This shows the struggle teachers face when attempting to develop learning skills in an environment which requires the consideration of external challenges. Teachers are then encouraged to instead develop experiential skills through thinking processes that are related to the learners' needs and surroundings, rather than those of other, well-implemented learning experiences.

Different learners respond best to different learning styles, and effective teaching takes this into account both in the lesson planning stage and later in the classroom itself. While different learning styles can be accommodated by experiential skills development, full school curricula make it difficult to accommodate different learning styles (Gentry et al., 2013). A review of literature on the experiential learning in South African Life Sciences classrooms show that most research has been done on experiential learning and the style of teaching in the curricula (Gentry et al., 2013). Research on experiential skills in South Africa linking it with the development of these skills through the use of a series of experiential skill development lesson plans are yet to be carried out, hence my choice of this focus area.

2.2.3 Using Bloom's Taxonomy in the classroom

Bloom's Taxonomy is a model designed for the classification of educational learning objectives, and was created in 1956 by Benjamin Bloom (Armstrong, 2010). This model contains six levels of complexity, which teachers (including teachers in the Life Sciences) may use to create their own assessments and to develop different skills among their learners in the classroom. Depicted as a stairway, in this model learners begin at the bottom and climb to higher orders of thinking as they progress up the levels (Armstrong, 2010). The lowest levels of Bloom's Taxonomy refer to the knowledge and comprehension of a subject, such as Life Sciences. Lower-order thinking skills are mostly stimulated by a teacher in a classroom, through lecturing. Learners absorb knowledge and are able to reproduce what has been heard. The highest levels are analysis, synthesis, and creation (evaluation), the attainment of which may be limited due to contextual factors. Clearly Bloom's Taxonomy has stood the test of time (Forehand, 2011), as teachers are still groomed to use Bloom's Taxonomy through Curriculum Assessment Policy Statement (CAPS) training.

In order to promote higher-order thinking skills, the six levels of Bloom's Taxonomy are divided into three domains (Armstrong, 2010):

- Cognitive: Mental skills (knowledge)
- Affective: Growth in feelings and emotional areas (attitude or self)
- Psychomotor: Manual or physical skills (skills)

These three domains can provide the enhancement needed for learning and teaching Life Sciences through experiential learning. By implementing these three domains when teaching or learning Life Sciences, and using them in collaboration with assessments, teachers may achieve maximum results and skills development in the Life Sciences classroom. Each of the framework's six categories requires that the previous skill first be attained before progressing to the next, more complex skill. This approach allows teachers and learners to identify higher-order thinking skills, and to modify their teaching and learning habits accordingly (Crowe et al., 2008). The graphic representation below, which indicates each level of Bloom's Revised Taxonomy, is more verb-oriented to ensure the development of skills through the use of the hierarchal model, Figure 2.1 (Schultz, 2005).

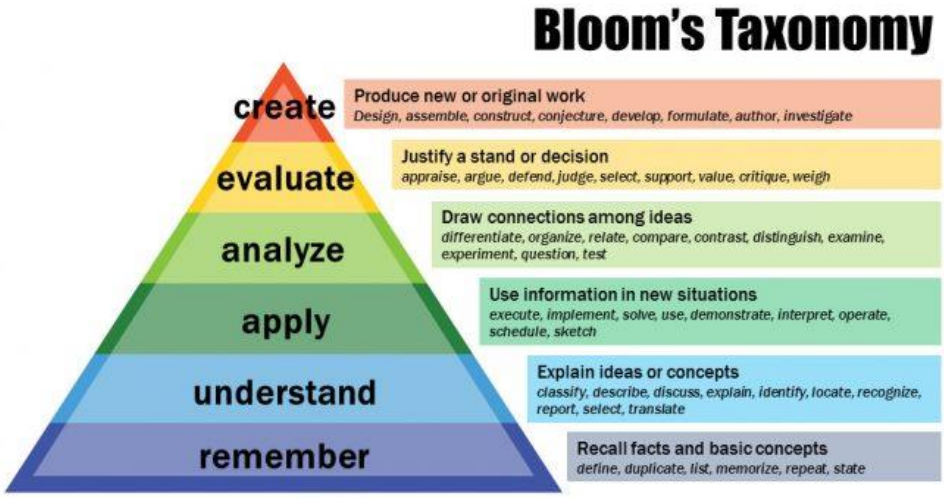


Figure 2.1 Bloom's Revised Taxonomy (Schultz, 2005)

Common vocabulary was used in the development of this model. The model allows for the development of skills in a manner which follows a learner's thinking process in order to achieve the assessment goals set out by the teacher (Kelly, 2017). This vocabulary should not only be utilised for assessment purposes, but also in the manner of learning and asking questions used in the Life Sciences classroom. By linking the cognitive levels of Bloom's Taxonomy to experiential skills that needs to be developed in a Life Sciences learner (Kolb & Kolb, 2017), a clear interrelation can be drawn. Taking this into consideration, the use of the cognitive levels which teachers are trained to utilize in assessments and the development of a proficient learner dictates a need for research in South African Life Sciences classrooms.

2.2.4 Lesson plans used by teachers

The purpose of planning is to schedule tasks, identify skills that need to be developed, and plan tasks according to a timeline that seem impossible, and to make them possible (Jeseviciute-Ufartiene, 2014). To maintain a core plan of action, a tool is needed. According to De Janasz, Wood, Dowd and Gottschalk (2009), effective time management necessitates a knack for fruitfully earmarking time and resources to achieve outcomes concerning lesson planning; a knack which could be further developed by the three knowledge areas of Life Sciences. Management skills allow teachers to control their lesson plans more effectively, increasing personal productivity and reducing stress levels. Marshall (2012) highlights that lesson planning works to guide a teacher, whereas Woodward (2001) explains that lesson plans do not have to be in written form, as a teacher's ability to be more adaptive in their way of thinking ensures a positive response from learners.

Experiential skills development should be seen as an asset, not a burden. Although management skills in experiential learning have several benefits for teachers, some learners can be time idlers (time wasters), and do pose challenges. Time idlers affect the management of teaching time through their procrastination and indecision, their need for constant discipline, and their lack of audio skills, as well as incurring other disruptions such as drop-in visitors and delayed administrative paperwork. Teachers who have developed skills in organisation can take the time constraints into account and adapt their classroom techniques to overcome unproductive outputs (Daft & Marcic, 2014). In this study I want to determine the extent to which experiential skills development influences the proficiency of the Life Sciences learner through lesson preparation. The fact that teachers according to research are faced with challenges while teaching are not uncommon, instead of wasting time on the same skills or skills that are not examinable at a higher cognitive level, the competence of South African Life Sciences teachers in planning and developing experientials skills has not been established.

2.2.5 Time management

Time management is the ability to prioritise and act on a given task, as required by Curriculum Assessment Policy Statement (CAPS), according to its importance and its urgency. Efficient time management also involves effective delegating skills (Griffen & Van Fleet, 2014). According to De Janasz et al. (2009), time and resources can be earmarked to aid the fruitful achievement of given outcomes, and this skill can be further developed by the three knowledge areas of Life Sciences. Dividing time is a skill that allows teachers to control their lesson plans more effectively, increase personal productivity, and reduce stress levels.

Experiential learning aids time management, as time should be seen as an asset and not as a burden (Kolb, 2006). Although dividing time in experiential skills development has several benefits for teachers, time idlers and other such disruptions must be taken into account when planning. Teachers who have developed organisation skills are serious about how their time is used, and may regularly utilise different time management techniques to ensure productive outputs (Daft & Marcic, 2014). One such technique involves the use of alphabet letters or colours to prioritise tasks and activities, where ‘A’ or ‘Red’ activities are highly important (urgent), ‘B’ or ‘Yellow’ activities require attention, and ‘C’ or ‘Green’ activities are not urgent or could be delegated to a competent college. Another technique is the ‘Pareto 80/20’ rule of time management (Knoch, 1997; Panella, 2002; Tracy, 2007). This rule suggests that 20% of activities and effort produces 80% of the results. Teachers, because of their knowledge of Life Sciences as well as their understanding of learners in a particular theme, will know how to identify which 20% of activities will produce the 80% of value. Additionally, teachers can focus on one activity at a time in order to thoroughly develop skills to improve the results. According to De Janasz et al. (2009), these techniques are not aimed at filling every minute of the working day, but rather should be incorporated as a means of balancing time. Time is needed to complete and plan effectively in the Life Sciences classroom, and to allow for the unexpected.

2.2.6 The term ‘practical’ versus ‘experiential’ in the Life Sciences classroom

Given that Life Sciences subject matter relates to the material world, teachers should include acts of showing and telling in their lessons. The common perception among teachers of Life Sciences combines into the subjective term: ‘practical’ (Ali, 2019). In this sense, the term is used to show that Life Sciences is counted as a ‘practical’ subject, meaning that—if the subject is taught according to the syllabus and to its upmost potential—everything in a Life Sciences lesson should be hands-on. The misconception which has followed the use of the term ‘practical’ is the misuse of the term ‘experiential’ as an accurate synonym.

The term ‘practical’, in its more stereotypical sense, should rather be seen as a gateway to one of the modes in the completion of experiential learning. Kolb (1984) and Dewey (2001) both state that the scientific literacy of a specific theme can only be obtained if the nexuses between different skills and knowledge types are achieved. The knowledge of a theme and its interconnections with other themes is only attained through experiential learning, by providing learners with different learning modes, such as higher-order thinking skills (stimulating concrete experiences), observation and reflection, formation of knowledge through abstract concepts, and the final testing of implications (Ali, 2019; Dewey, 2001; Kolb, 1984).

2.2.7 Student-centred learning

When considering experiential learning, one needs to look at the role of the learner in the process. Learner-centred lessons focus on the learners over the content covered by the teacher in the classroom, and more emphasis is placed on learning than on teaching (Wohlfarth et al., 2008). Life Sciences emphasise critical thinking, experiential learning, reflections, and real-world assignments. This is supported by Keengwe et al. (2009), who have collectively focused on three pedagogical areas which explore the depth and scope of the learners’ ability to learn. These areas work in harmony with experiential learning, as they accommodate each learner's unique identity in their learning styles, stimulate learning through experience in learning activities, and integrate technology into the classroom.

According to Weimer (2012), in lessons given in various institutions on learner-centeredness, all experiential lessons comprise of five elements:

- the teacher's focus is on the learners
- the teacher guides and facilitates learning
- the teacher promotes active student engagement
- the teacher promotes learning through interactive decision making
- the teacher is a reflective and ongoing learner

2.2.8 Deep learning

‘Machine learning’ refers to only interpreting and presenting the shallow facts of a lesson, rather than selecting the appropriate content to achieve the desired, multi-dimensional understanding of the issues pertaining to a particular problem (Chevallier, 2011). ‘Deep learning’ by contrast gives way to a layered, nonlinear approach where a learner moves from teacher-centred learning to learner-centred learning. This transition ensures that the learner builds on their knowledge of the content in layers, while internalising the knowledge in order to later adapt the answers where applicable to other themes. It further equips the learner to judge the value of the answers in real-life situations.

Deep learning can also be summarised as using knowledge gained from different lessons within an activity or assessment, as deemed significant (Sarker, 2021). Deep learning focuses on the critical examination of fresh ideas, assimilating prior knowledge, and applying these ideas when solving problems in new scenarios (Mathew et al., 2021). When learners link the knowledge that they have absorbed with knowledge that is compartmentalised, this leads to superficial memorisation of knowledge for assessments, and limits their understanding or long-term memory of working material (Mathew et al., 2021). When learners show interest in what they do, understand what has been presented, and use these factors for application purposes (characteristics of deep learning) in Life Sciences, this facilitates the pace of memorising (DeLotell et al., 2010). Most importantly, learners need feedback as a source of reflection on new discoveries, and to help in the process of developing working memory into long-term memory. It is important to emphasise that the transfer of knowledge necessitates attention, organisation, and repetition. I am of the opinion that the need for deep learning (DeLotell et al., 2010) together with the 5 elements of experiential lessons (Weimer, 2012) may also be considered when developing lesson plans by Life Sciences teachers when implementing experiential skills using different cognitive levels.

2.2.9 Global overview of experiential learning

Betty McDonald (2020) posits that experiential learning forms part of experience-based learning (Figure 2.2), and this forms part of common terms such as action learning, active learning, active-based learning, action research, adventure learning, apprenticeship, community of practice learning, and cooperative learning. It is essential to note the similarities between these experience-based learning methods and experiential learning itself.

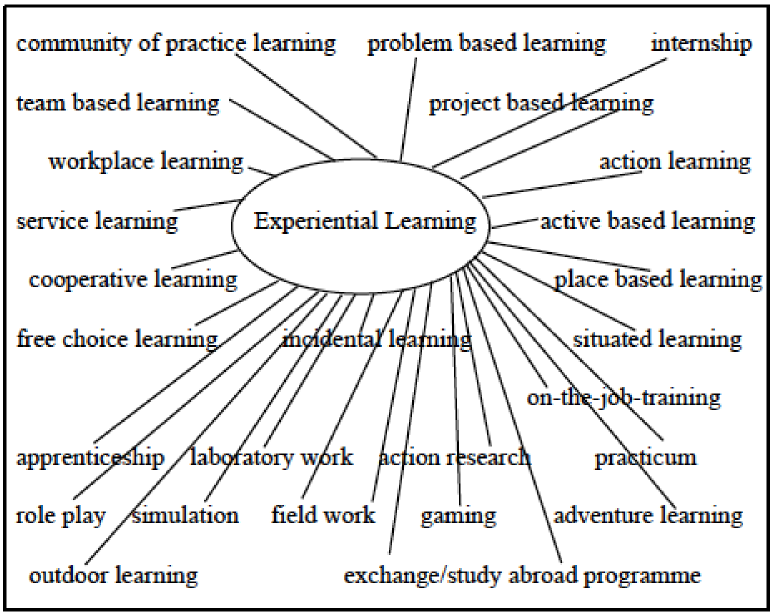


Figure 2.1 Some kinds of experiential learning (McDonald, 2020)

Studies from different areas in the world show the success of experience-based learning. The success of the 'guide by the side' practices, where a teacher facilitates learning rather than being the direct source of knowledge, in turn initiates success in experiential learning. Through various approaches, experience-based learning assists in developing a classroom where learners actively participate. The authors of constructivist teaching through experiences at Flinders University, Australia, revealed that the blending of methods—namely constructivist teaching—can lead to learners actively participating in self-learning (Szili & Sobels, 2011). This teaching approach shows how experiential learning can be directly tied to an increase in critical thinking and problem-solving skills (Kyounga et al., 2013). Experiential learning methods require an inventive approach to teaching which can be implemented in every Life Sciences classroom, ensuring that learners engage with the material and support the teacher, and that inquiry in the classroom is encouraged (Karge et al., 2011).

It is by participating in current experiences and utilising new knowledge that learners are able to assimilate knowledge in a practical manner which benefits them. 'Experiential learning' as a term should not be confused with the terms 'experiential' and 'practical'. Taking notes, writing, reading and the scaffolding support given by a teacher, all form part of experiential learning. Heard et al*.* (2020) describe 'Reading and Writing for Critical Thinking Project' across Central Europe and Central Asia as a means to train teachers to focus on processes of learning which will develop critical thinkers, which is a key element needed in experiential learning. Additionally, experiential learning promotes skills which are of use when finding solutions in other fields, such as marketing. As a strategic tool, experiential learning ensures that an individual can be successful in more than one discipline (Randa, 2017). According to Bates (2015), using the tools associated with experiential learning ensures an improvement in problem-solving skills among proficient learners, and implementing the approach in overcrowded classrooms is purported to be positive.

When deliberating how self-learning activities are incorporated into a medical physiology course for learners in Atlanta, Georgia, Carroll and Huang (1997) showed how the process developed characteristics of experiential learning. Matthews (2007) rationalises that teaching methods in Oman are designed to follow a 'learn by doing' approach. Experiential learning incorporates active and hands-on learning, with the goal of developing universal student skills. At the Macquarie, Australia, 500 third-year undergraduate university students participated in surveys to ascertain the value of experiential learning. The university expressed that 60% of those surveyed considered the approach of experiential learning to be essential, and the minority of those surveyed (13%) contradicted this notion (Hawtrey, 2010). At a research-intensive educational institute in Australia, the implementation of experiential skills learning resulted in lecturers increasing exam questions which addressed higher-order thinking skills by 51%. Carrying out this change in the teaching and learning approach ensured a collection of skills could be demonstrated by learners (White et al., 2016). Roleplaying has also been used to engage learners in experiential learning. Final-year science students from an Australian university were involved in an activity that contributed to the development of "critical thinking and problem-solving skills, communication skills, and lifelong learning skills" (Chuck, 2011).

In a case study done in Iran at a higher engineering institute, cooperative learning and inquiry learning were combined in the larger classrooms. The class focused on engaging in learning, and this resulted in the advancement of learning and behavioural attitudes which embrace critical thinking (Salehizadeh & Behin-Aein, 2014).

At Central Michigan University, USA, a study surfaced where learners looked at three different approaches: (a) only discussing content, (b) only writing about the content, and (c) both discussing and writing about the content. The results evidenced that learners showed proficiency in assessments on the concepts they had learned using more than one approach. This improved proficiency could be a result of the increased ability to communicate in more than one way on a certain idea (Linton et al., 2014). It is worth mentioning that in Sydney, Australia, a study was conducted which focused on determining if assessments used in examinations were improved by assessing performance throughout the year. These results showed no influence on learner proficiency whatsoever, leading researchers to conclude that it is the method by which the learners learn that ensures improved proficiency (Grosas et al., 2016). It takes initiative from the teacher on the topic or concept to obtain results.

In Malaysia, an action research team tasked themselves with finding ways to incite deep learning in Malaysian classes. The goal was for learners to actively discover new knowledge, and the higher levels of positivity seen in learners as a result were marked (Yew et al., 2016). Deep learning can also be complimented by Bergmann and Sams (2012), who established the idea of a ‘flipped classroom’, which is a learner-centric approach (Heinerichs et al., 2016). In the South African educational system, the focus is on promoting learning in larger classrooms where there are too many learners to one teacher (Danker, 2015). As a result of COVID-19 and the changes lockdowns brought to how schooling is conducted, the approach to teaching focused on transferring knowledge and teaching material through a flipped classroom approach. An online platform was used in place of the classroom, where learners worked through problems and actively participated in collaborative learning. Facilitated learning, through a flipped classroom approach, will allow learners to develop higher-order thinking skills through deep learning (Danker, 2015). Online learning conducted together with contact sessions is known as ‘blended learning’ (Heinerichs et al., 2016). Blended learning entails assistance from a teacher through online instruction before class, followed by a contact session after class. This ensures that content is applied during class and that assessments are conducted after class. This type of instruction ensures that learners become proficient in the desired knowledge at higher cognitive levels, which includes application, analysis, and evaluation. A similar study to the flipped classroom was done in Dallas, USA (Heinerichs et al., 2016). When implementing an approach such as experiential learning, learners find themselves in an 'experiential learning classroom' where experiences are developed through deep learning.

2.2.10 Theories underpinning experiential learning

Experiential learning theories normally attempt to provide holistic models of the learning process. For this study, the experiential learning theories of David Kolb (1984) and John Dewey (2001) will be examined to identify the elements which influence learning and teaching in Life Sciences.

- *Kolb's theory of experiential learning*

Renowned American psychologist David Kolb's model (Figure 2.3) explains and categorises a learner's learning style, as different learning styles will have different impacts in the classroom. Kolb's model is divided into two modes of experience acquisition, namely *Concrete Experience* and *Abstract Conceptualisation*, and two modes of transforming experience, namely *Reflective Observation* and *Active Experimentation* (McLeod, 2017).

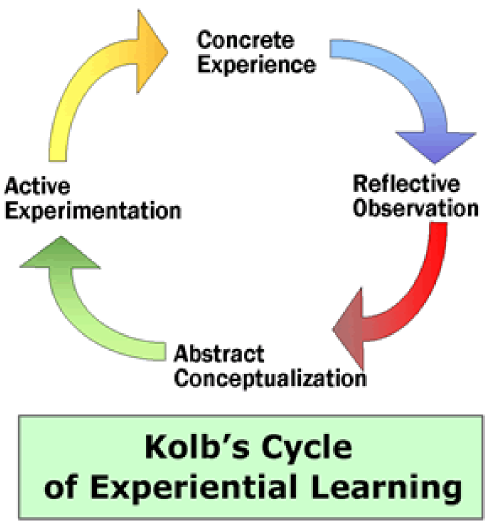


Figure 2.2 Kolb's cycle of experiential learning (McLeod, 2017)

Kolb's model of concrete experiences is the basis for observations and reflections by the learner. These reflections are assimilated into abstract concepts from which new implications for action can be made. These implications can be actively tested, and serve as guides in creating new experiences. Kolb (1984) also developed a model to assess and identify an individual's learning style from one of four prevalent learning styles. As Dhanapal and Shan (2014) describe, these learning styles include 'diverging' (these learners work well in group settings with activities, for example brainstorming), and 'assimilating' (these learners prefer lectures; they explore analytical models and take time to reflect on matters), 'converging' (these learners prefer to experiment with new ideas and practical applications), and 'accommodation' (the ability to learn from hands-on experiences). The benefits of Kolb's experiential learning theory are to provide direction for the necessary range of educational methods to match specific learning styles, and to provide an effective link between theory and practice.

- *Dewey's theory of experiential learning*

John Dewey states that among the uncertainties of different teaching and learning styles, the main qualm resides between education and personal experience (Kolb & Kolb, 2005). Dewey put an extensive amount of effort into hypothesising about how people see, experience, and make sense of the world around them. He used the term 'reflective thought' to describe the process through which people learn from their observations and personal experiences (Dimova, & Kamarska, 2015). Dewey concluded that progression through the learning process meant moving from inductive to deductive reasoning.

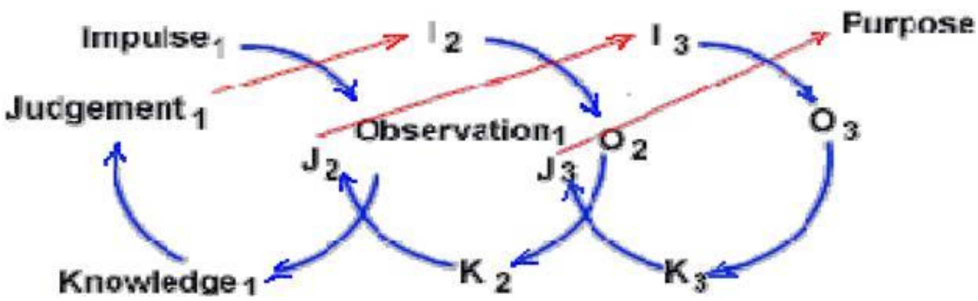


Figure 2.3 Dewey's model of experiential learning (Dewey, 2001)

Dewey's model (Figure 2.4) presents the nature of learning by describing how the impulses of concrete experience feed into high-order, purposeful action. This model can be explained simply through the use of these stages and how they interlink. By following their impulse, the learner will make observations and obtain knowledge. This model is known for its cyclic advances of learning, incorporating each phase of impulse (I_2, or I_3) and judgment (J), knowledge (K) and observations (O). In order to go through the learning process and reach the deductive reasoning stage, a learner must first pass through the four aforementioned stages (Alberta Education, 2010; Dimova & Kamarska, 2015).

Both Dewey and Kolb form one group among experiential learning scientists by offering theories with certain characteristics. Kolb focuses on experiential learning as something dimensional (a choice) which assists in the process of learning, whereas Dewey offers a unique twist of inductive and deductive reasoning. Both theorists focus on the improvement of experiential learning in the classroom, but neither addresses the skills that should be inherited by the teacher and developed by the learner when applying experiential learning. When combining these different theories, the following conclusion could be made regarding the elements which influence teaching in Life Sciences: Learning must be based on learners' previous experiences; learners must have time to think about their experiences and reflect on them; and learners must apply their new skills in a real-life situation (Bates, 2015). In addition to this, the experiential learning theories of Kolb and Dewey will now be outlined in order to show which elements may influence different learning and teaching styles. According to Kolb (1984), effective learning is acquired when a learner progresses through a cycle of four stages, as follows:

Stage 1: Undergoing a concrete experience
Stage 2: Observing and reflecting on that experience
Stage 3: Forming abstract concepts (analysis) and generalisations (conclusions)
Stage 4: Testing the hypothesis in future situations, resulting in new experiences

Dewey (2001) believed that his cyclic learning model must be spread over five steps. These five steps are as follows:

Experience: The learner must take part in an activity or experience before being shown how to do it.
Share: The learner must share his/her observations and findings.
Process: During their analysis, the learner processes his/her findings and reflects on them.

Generalise: The learner connects the experience to real-life examples.

Apply: The learner applies what he/she has discovered in a new, real-life situation.

When combining these different theories, the following conclusion can be made regarding the elements that influence teaching styles (Bates, 2015):

- Learning must be based on the learners' previous experiences
- Learners must have time to think about their experiences and reflect on them
- Learners must apply their new skills in real-life situations

In order to influence teaching and learning in the Life Sciences classroom, a teacher's chosen teaching style should therefore be based on a combination of the elements discussed in these two theories.

2.3 The Conceptual Framework

Early proponents of experiential learning include William James, John Dewey, Kurt Lewin, and Paulo Freire (Kolb & Kolb, 2017). These founders proposed change, identified concepts, and demonstrated the key elements of this type of learning. Although most of these researchers agree that experiential learning is beneficial, there are differences related to how many steps are involved in the learning process, the sequential order of the learning steps, and the terminology used. Regardless of these differences, experiential learning is growing and is now used in a number of high schools and colleges across the world (Jones et al., 2008).

This study drew from two different theories, namely Kolb's (1984) *experiential learning theory as a dimensional approach*, and Dewey's (2001) *experiential learning as inductive and deductive reasoning*. I used these theories to create a new outlook on experiential learning by developing an experiential skills model. This experiential skills model assisted me in theorising the findings of this study.

2.3.1 Experiential learning

Different perspectives were brought together to unite a theory set by the worldviews of fundamentally disparate narratives and phenomena (Bates, 2015). In my master's, I focused on an experiential learning model. Throughout the study it was observed that experiential learning or rather, the activation of experiential learning modes during skills development occurs unconsciously. I used the knowledge gained from my observations of skills that are developed throughout experiential learning in the different modes together with extensive literature to develop a conceptual framework. The aim was to use the experiential learning model to assist in compiling specific components needed in experiential skills lessons.

2.3.2 The modes of developing experiential skills

In this study, I made use of the following experiential skills model (Figure 2.5) by incorporating both Kolb's (1984) and Dewey's (2001) experiential learning models. The conceptual framework's key modes are concrete experiences, observing and reflection, formation of abstract concepts, and testing the implications of concepts (Figure 2.5). I made use of this experiential skills model to act as a unit of analysis where each mode was dependent on or independent of another, forming different relationships for research (Bates, 2015). Each mode of the model contains a certain aspect that adds value to the research for developing experiential skills. The four modes of experiential learning in developing experiential skills are:

- *Concrete experiences*

Concrete experiences are the first phase of learning, according to Kolb (1984). This mode builds learning experiences into the topics covered in the lecture syllabus, allowing learners to explore the relevance and meaning of the knowledge obtained. Learners are normally placed into a situation where higher cognitive levels are developed through recalling basic information.

- *Observations and reflection*

Experiences and practical skills in the Life Sciences classroom are developed through processing how learners 'do' things. This is achieved by relying on the observations made in the first mode. The focus is on the use of practical skills, allowing the learner to reflect through a series of considerations as they form new knowledge. This mode focuses on turning concrete experiences into observed knowledge. Kolb focuses on experiential learning as a dimensional process, improving experiential learning and building on prior knowledge to address the skills that should be inherited (Kolb, 1984).

- *Formation of abstract concepts*

Abstract concepts focus on the relation of discoveries and how logically theories are presented. The application of experiences gained through the first mode (concrete experience) and the second mode (observation and reflection) are used to create a new understanding of knowledge or a new set of skills, and to apply this understanding to a known theory. The focused outcome in this mode is that learners should apply their knowledge and analytic skills to the theory they have learned. This mode aims to promote analytic skills such as research, communication, and efficient problem solving.

- *Testing implications of concepts*

Active experimentation connects what the learner has learnt with reality. Experiences should be formulated by the learners. In this mode, learners must be able to use the theories explored in the previous modes to make decisions and solve problems.

2.3.3 The experiential skills model

Aristotle said in his Nicomachean Ethics Book (Beqiri, 2021:1):

> *"For things, we have to learn before we can do them,*
> *we learn by doing them."*

The expectation of designing this experiential skills model (Figure 2.5) is to guide the teacher in their lesson plans, assist them in time management, conduct cross-theme teaching, and ensure the development of a skilled and proficient learner. Research supports that the recollection of information is higher when skills are continuously applied to practice (Beqiri, 2021). Even with the rapid development of knowledge, changes in curriculum and the type of learner in the classroom, one aspect of learning remains the same: acquiring skills through experiences (Kolb & Kolb, 2017). After the literature review, I summarised the concepts relevant to this study. Using the established modes of experiential learning, I formulated specific skills and outcomes that should be achieved in the overall conceptual framework of the study that is presented in the experiential skills model (Figure 2.5). The model was developed in a manner of connecting rings which allows a skill that has been adopted and the understanding of its value is present, the skill can be applied to many different situations creating a proficient learner. The proficient learner can apply the skill across both lower and higher cognitive levels as required, irrespective of the difficulty. The following experiential skills model (Figure 2.5) may be implemented to reach the desired outcome of a skilled learner in the Life Sciences classroom.

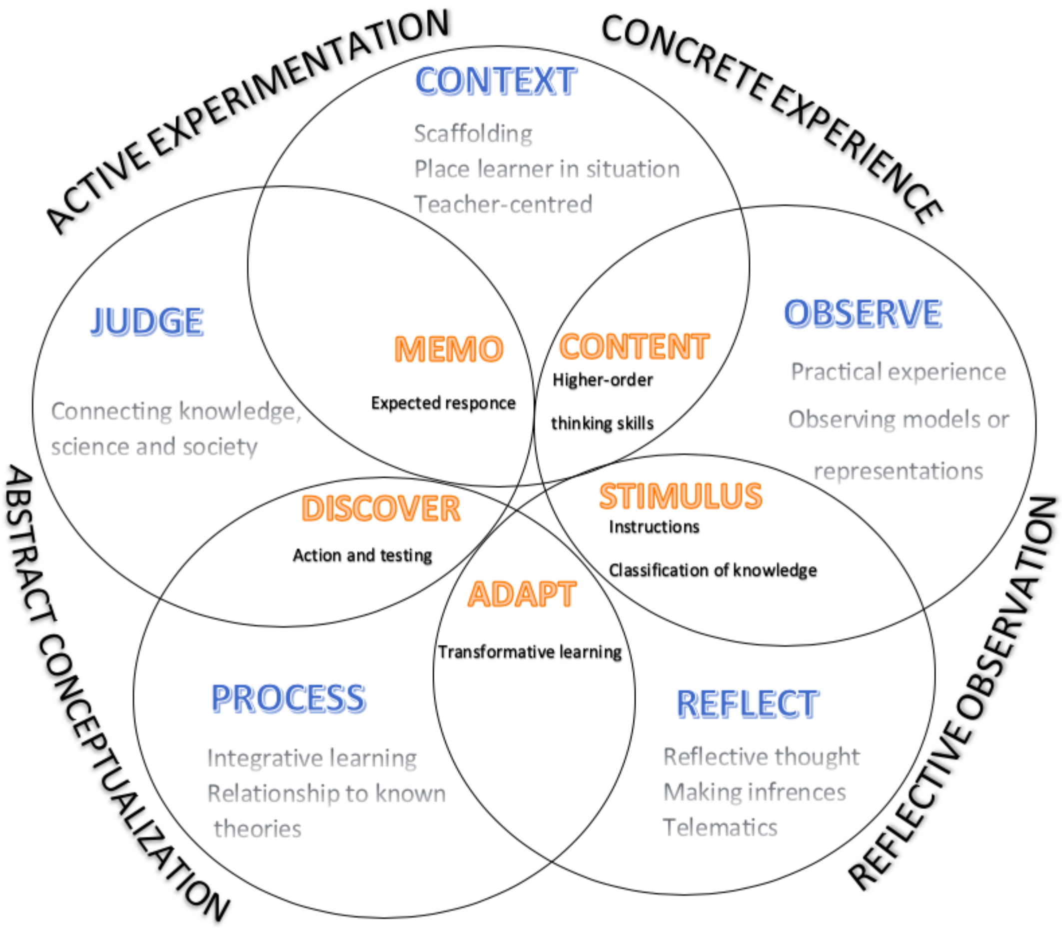


Figure 2.4 Experiential skills model (own)

I have designed my own cyclic experiential skills model, which comprises four modes of experiential learning, five experiential skills, and five outcomes. The four modes are concrete experiences, reflective observations, abstract conceptualisation, and active experimentation. The five skills are to interpret in context, observe, reflect, process, and judge. The outcomes are to understand content, reflect on a stimulus, adapt to situations, discover new theories, and be able to answer in line with a memorandum. A learner's experiential skills can be developed by starting from any mode, skill or outcome in the model, but it is expected that all four modes be completed by the end of a theme for learning to be successful. This model identifies steps that define partial capabilities until the model has been completed as an all-inclusive learning process. The modes will have a clear description as a whole to expand to the next mode.

The modes in developing experiential skills are:

CONCRETE EXPERIENCES

Context: Mostly teacher-centred, this is where the learner receives an initiation into the theme. By listening and taking notes, the learner is placed in the situation where shallow learning takes place.

Content: The outcome of this mode is to ensure that the learner internalises the information and is able to answer higher-cognitive, content-based questions.

REFLECTIVE OBSERVATION

Observe: This skill defines the hands-on, practical section of Life Sciences. Learners should be deeply involved and able to handle tools or chemicals.

Stimulus: The outcome of this skill is to react to a stimulus by following instructions, or to clarify what knowledge is needed from the context and be able to apply it.

Reflect: Learners reflect on an experience by making inferences or by using telematics, which include tables or graphs, to form conclusions from the context of the problem.

Adapt: Learners commit to a single course of action to solve the problem, and generalise to transform learning and apply the knowledge to known theories.

ABSTRACT CONCEPTUALISATION

Process: This skill is an integrative learning aspect where the use of content and the adaption thereof leads to the processing of relationships between experiences and known theories.

Discover: This outcome is where assertive action takes place while testing the probability of the theory and balancing dynamics as the situation demands.

ACTIVE EXPERIMENTATION:

Judge: This skill allows the learner to focus on results as a goal. The goal is to connect knowledge, science, and society to use experiences outside the norm.

Memo: This outcome allows the learner to give the expected answer as prescribed by the teacher when all steps are completed.

When these modes of the experiential skills development model are followed throughout a theme, a learner should be able to transform their experiences inside or outside the classroom as a proficient Life Sciences learner. This study looks at how experiential skills can be development using a series of lessons. Linking with the conceptual framework, this study follows the use of experiential learning and the modes in lessons targeted to develop knowledge and understanding of experiential skills and how these skills can be adopted in similar situations to create a proficient Life Sciences learner.

2.4 Chapter Summary

This chapter focused on the in-depth discussion on developing experiential skills, and on the experts who developed these methods of learning, such as David Kolb and John Dewey. The chapter highlighted, in a summative fashion, some key conceptual difficulties for learners concerning the manner in which the development of skills is tested. The conceptual framework was implemented during this investigation into the development of experiential skills through research design and methodology.

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

In Chapter 3, the research methodology and processes used to answer the research questions of this study are examined. This methodology is based on my assumptions, research skills, and practices, all of which together influenced the way I collected the data for this study (Maree, 2020). All research instruments were designed based on the literature and adopted from existing materials, and were modified to fulfil the purpose of this study. The results from these instruments determined how developing experiential skills influences the proficiency of a learner in the Life Sciences classroom.

3.2 Research Paradigm

This study shows the interconnection between the interpretivist and positivist paradigm when applied in a mixed method approach, which contains both qualitative and quantitative approaches.

In the qualitative methodology, interpretivism was used. In this instance, interpretivism was underpinned by the interpretation of data through the understanding of experiences constructed specifically in the scholarly learning areas of education. Intgrty (2016) describes the use of interpretivism as a way to understand a particular context. This paradigm allowed me to immerse myself in the observation of learners, their interactions, and the activities they completed. Moreover, in this study, knowledge gained by learners was experiential, personal, and subjective (Bates, 2015). The goal of this qualitative approach allowed for an insider's view of the learners as they engaged in this particular learning process (Cresswell, 2012).

In contrast, the quantitative methodology was strengthened by the positivist research paradigm. This allowed for objectivity, specifically where the emphasis was on measuring variables that were linked to general causal explanations (Chenail, 2010; Marghiloman, 2015). When I focused on gathering raw data in numerical form, the research formed part of positivist research paradigm (Antwi & Hamza, 2015). The adoption of these paradigms ensured that the analysis of the development of experiential skills and their influence on learner proficiency in the Life Sciences through a mixed method approach could be studied in-depth and objectively.

3.3 Research Design

The research design focused on the conceptual framework that carved the pathway for collecting and analysing data by utilising different methods and procedures (Iacobucci & Churchill, 2010). According to Zikmund and Babin (2013) and Malhotra (2010), the drive for research design includes determining possible answers to the research problems. The credibility and legitimacy of the replies received in answer to the research questions would enforce the research design (Johnson & Onwuegbuzie, 2004).

This study made use of a multi-instrumental case study design (Guba & Lincoln, 2005; Creswell, 2008; Simons, 2009), concerned as it was with the examination of a particular case to provide insight into an issue, rather than a case itself (Arseven, 2018; Denzin & Lincoln, 2000). The multi-instrumental case study refers to the three different instruments that were used in this study, lesson plans, tests and questionnaires that were used to establish the extent of which experiential skills were developed to create a proficient Life Sciences learner through lesson preparation. Saunders, Lewis and Thornhill (2012) refer to the research design as a study that addresses problems and can only be done in relation to the design elements. When describing the layers of research, Saunders, Lewis and Thornhill (2012) use the analogy of an onion (see Figure 3.1). When peeled away, each layer shows the blueprint of the underlying context and boundaries of the given research.

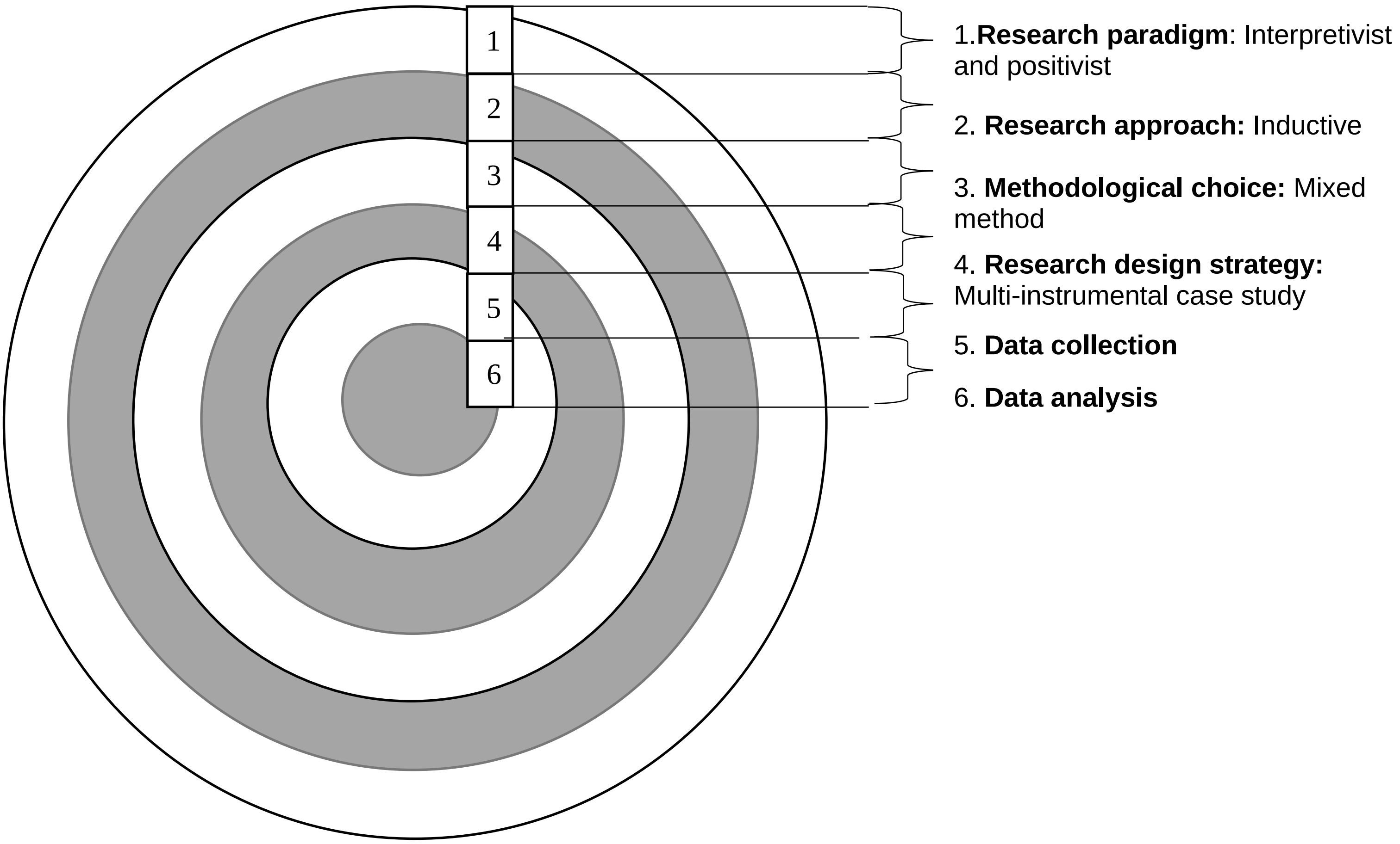


Figure 3.1 Research onion procedure (modified from Saunders et al., 2012)

This approach focused on an inductive approach, which allowed specific observations to form part of a sequence of patterns. These patterns assisted with a tentative hypothesis on experiential skills development and the related critical logic, which supported the theories of experiential learning. Case studies can be very effective, as they create the possibility to give a voice to the process and the people involved. The purpose of a case study is for fact-finding, and collecting data centred upon discovering, describing, and encapsulating the picture, or perhaps a combination of these (Hamilton & Corbett-Whittier, 2013). In this study, a narrative approach was adopted. I argue that the case in this study was concerned with developing experiential skills in Life Sciences learners. The case study strategy has been used in various studies specifically aimed at experiential learning. The case study strategy was one of my major driving forces behind the phenomenon of developing experiential skills (Arseven, 2018; Green & Farazmand, 2012; Tuulos & Kirjavainen, 2016).

3.4 Methodological Choice

This mixed method approach addressed the development of experiential skills and its influences on the proficiency of the Life Sciences learner. A triangulation of a qualitative and quantitative approach was used. In this research type, data was collected from different instruments which were complemented by the focus on answering research questions concerning experiential skills development (Cresswell 2013). In this study, quantitative pre, during, and post-testing explored the extent to which the experiential skills developed influenced proficiency in Life Sciences learners. Questionnaires were used to investigate the theory of how learners perceived practicals as aligned with content. Concurrent with this data collection (Babbie & Mouton, 2012), qualitative descriptive case studies on lesson plans determined which aspects were needed to develop experiential skills. Using the conceptual framework to form lessons and tests in correlation to the modes, skills, and outcomes in the field should lead to the development of experiential skills. The reason for collecting data with both a narrative as well as a statistical aspect was to bring together the strengths of this convergent parallel study, thereby ensuring that the study took place in one phase, where quantitative and qualitative data each were gathered in the same timeframe despite being conducted separately. The results and interpretations of these three different instruments were merged at the end of the data collection phase to reflect on the research problem as a whole.

3.5 Qualitative Research Approach

A qualitative research approach is naturalistic, interpretative, and mostly concerned with describing, interpreting, verifying, exploring, and evaluating social actions from the inside (Ritchie et al., 2013; Njie & Asimiran, 2014). Qualitative research as referenced by Welman et al. (2005) covers an array of interpretive techniques which describe and translate into a naturally occurring phenomenon. This study was strengthened by its ability to present complex word-based descriptions of how participants experienced the research problem, which supplemented information on the human side of the problem. Qualitative data included a descriptive case study on lesson plans and the factors required when developing experiential skills.

3.5.1 Lesson plans

While there is no standardised lesson plan format, Yuldashevna (2019) argues that all lesson plans should consist of five basic aspects, namely: goals, objectives, activities, media, and assessments. I made use of these aspects together with my knowledge on experiential skills development to create a lesson plan (see Appendix A) designed to influence the proficiency of the Life Sciences learner. All experiential skills development lesson plans were developed by me and validated by my Head of Department of Life Sciences and my supervisor as the experts Observations were made from the lesson plans through a descriptive study, and from the setting of an actual classroom (Bogdan and Biklen, 2006). A series of four lessons on the diversity of plants was conducted for the development of experiential skills. This theme meant an array of lessons were available to me, each of which could easily move from theoretical to practical. This gave me the options, if needed, to create multiple opportunities for the development of experiential skills. The first lesson was an introductory lesson which allowed the learners to engage with the theme of plant diversity. This lesson made use of concrete experiences as a mode to develop skills of scaffolding knowledge through instructional support. A second lesson explored the theme through practical analysis. This lesson made use of reflective observations as a mode to develop skills of observing, identifying and discussing structure, functions and habitat through reflection in the classroom. The third lesson explained the importance of the structures within the theme's adaptation for survival. This lesson made use of abstract conceptualisation as a mode to develop skills through scientific investigation to draw conclusions and discover new knowledge. The final lesson extended the learners' focus on the use of the theme in society. This lesson made use of active experimentation as a mode to develop skills that can be utilised in different situation through informed judgement. Each lesson plan was formatted to suit the experience the learners would have in the class after each lesson, and to meet the needs identified for successful skills development in the next lesson.

3.6 Quantitative Research Approach

Quantitative research addresses research objectives through empirical assessments that include analytical approaches and numerical measurement (Zikmund & Babin, 2013). In this study, quantitative data was gathered through pre, during, and post-tests, as well as through questionnaires.

3.6.1 Pre, during, and post-tests

Pre, during, and post-tests on the theme of plant diversity were held at key stages throughout the research. This theme could easily be tested on both theoretical and practical aspects, and gave me the opportunity if needed to conduct multiple tests in order to develop experiential skills. Learners formed basic knowledge on the diversity of plants in the introductory lesson, and a pre-test (see Appendix B) was completed by the learners in the second lesson, which was a practical lesson. The pre-test informed me of the baseline of skills possessed by learners with lower cognitive development. This test made use of concrete experiences as a mode to develop skills of scaffolding knowledge and testing whether learners could recall lower cognitive facts on the theme. I administered a during-test (see Appendix C) after the third lesson, specifically aimed at developing experiential skills and higher cognitive thinking. This test made use of reflective observations as a mode to develop skills of observing, identifying and discussing structure, functions and habitat through reflection from concrete experience in the previous lessons and producing new knowledge analytically. The post-test (see Appendix D) extended the learners' focus to society, by tasking them with identifying how the current theme could apply to their daily lives. This test made use of abstract conceptualisation and active experimentation as a mode to develop skills that can be utilised to draw conclusions from the previous tests and discover new knowledge in different situation through informed judgement. The pre, during, and post-tests measured changes and improvements, if any, in different experiential skills. These tests allowed me to understand the learners' basic thought processes, by testing the same type of question but measuring different skills that were developed through experiential learning which were require from lower to higher cognitive levels in these lessons.

This ensured that I could identify the extent to which the implementation of experiential-based lessons influenced the learners' performance between the pre, during, and post-test stages, or whether the learners' experiential skills had evolved. Thereafter, aspects which I determined should be included in an experiential skills development lesson were highlighted in order to further develop the learners' skills. The aim was to utilise different thought processes and teaching skills, as well as to stimulate different cognitive levels in the Life Sciences classroom, and use these results to aid in the development of an accessible teaching method which can be directed through a tool. The post-test allowed me not only to measure the extent of the development of experiential skills, but also to gauge how the lessons optimised the learners' abilities to harness new skills in a specific task, and how the lessons influenced proficiency among the learners. The pre, during, and post-tests were each designed and set by me, in accordance with the set of modes, skills and outcomes developed in the conceptual framework (Figure 2.5).

3.6.2 Questionnaires

A questionnaire is a "set of printed questions with a choice of answers, devised for the purpose of a statistical study" (Roopa & Rani, 2012:273). These questionnaires (see Appendix E) were completed by the learners at the end of their lessons. Questionnaires allowed the learners to give their voice and opinion on developing experiential skills in the classroom, and to describe their perceptions of experiential-based practicals aligned with content. Since no standardised questionnaires were available which could be used within the context of this study, this research instrument was designed from literature and existing questionnaires. This research instrument was constructed to meet the objectives of the study, and experts such as my Head of Department at the school and my supervisor in the field of Life Sciences were involved to ensure the objectivity of the data collection and interpretation. I analysed each individual statement of the questionnaire manually and created three themes, namely, benefits of experiential lessons, experiential skills development and improved proficiency. These three themes were used to answer the third research question to determine the significance of each statement through the mean. This instrument captured a snapshot of the participants and their experiences when using experiential skills inside and outside the classroom.

3.7 Research Sample

A target population comprises the number of cases which conform to selected characteristics relevant to the study (Iacobucci & Churchill, 2010). My target population was my Grade 11 Life Sciences learners in Tshwane West, Gauteng Province. This research did not disrupt the natural course of learning in the classroom, due to the fact that these learners should, according to CAPS, be taught of the diversity of plants and develop experiential skills in order to successfully complete assessments on the specific theme. This sample was considered eligible, as the learners were conveniently and purposely selected to partake in this study. The learners' involvement in this study was voluntary. My research took place without breaking any COVID-19 protocol, and allowed my learners to gain knowledge and skills through experiential learning.

3.7.1 Research participants

The target population for both the qualitative and quantitative data collection methods of this study were selected using convenience and purposive sampling. Convenience sampling is a type of non-probability sampling in which participants are sampled simply due to the accessibility of data for researchers (Lavrakas, 2008). For this study, this meant that participants included all the learners in my two Grade 11 Life Sciences classes. My classes were of 28 and 38 learners each, making a total of 66 learners (N=66). The purposive sampling aspect of this study restricted the study to the generalisation of the results to the target population. The results can therefore not be generalised to the total population of Grade 11 Life Sciences learners, as is the case with probability sampling (Gelo et al., 2008).

3.7.2 Pilot study

While the reactions participants have to specific questions can be monitored through the use of a pilot study (McDaniel & Gates, 2013), this was not needed with the two Grade 11 Life Sciences classes taking part in this study. The study took place at the school where I worked. There was no need to correct any misinterpretations or to clarify any areas of uncertainty in terms of the reliability of the data collection methods, as the lessons were conducted by myself, the tests were completed according to the guidelines of the Department of Education, and the questionnaires were developed on a standard language level which the learners would understand. I ensured that all learners were clear on what was expected of them by going through the objectives with them at the beginning of each lesson. It is important to state that all instruments were thoroughly checked by experts for errors, lack of clarity, or any ambiguity.

3.8 Data Analysis

Data from the pre, during, and post-tests, the lesson plans, and the questionnaires was analysed. This study was driven by the claim that underdeveloped skills in Life Sciences learners hinder learner proficiency. The unit of analysis defines what the multi-instrumental case study focuses on at an individual level—specifically, the learners. Results from the various research instruments were analysed by myself, my supervisor, and Dr Solomon—who has knowledge of the statistical data analysis at the University of Witwatersrand—for accurate data analysis and quality purposes. Quantitative analysis occurred through descriptive and inferential analysis of the pre, during, and post-tests. A Rasch analysis, using WinSteps software for the questionnaires, was performed. This study subsequently reported on the results obtained, and analysed them within the frame of the research objectives of this study. Qualitative data analysis was conducted using a hermeneutical approach. This approach ensured that the descriptive analysis and the focus on key aspects of the lesson plans were set from an interpretivist's perspective, unveiling any effects through real-world experience (Kafle, 2011). The approach can be expressed as given in Figure 3.2.

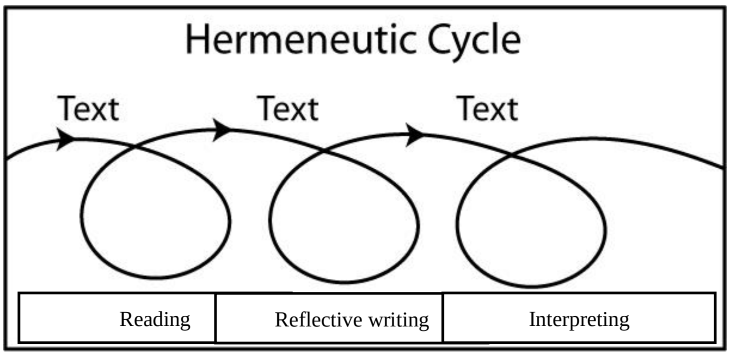


Figure 3.2 Hermeneutic cycle (Laverty, 2003)

After the data was collected from all the participants in the sample, data analysis was conducted to summarise the information obtained from each instrument (Saldana, 2009). Table 3.1 summarises the data procedures followed throughout the study.

Table 3.1 Summarised data procedures followed throughout the study

Research	Research questions	Data collection	Data analysis	Participants	Quality assurance
Qualitative research	What aspects are considered when creating experiential skills development lesson plans? To what extent does the development of experiential skills influence the proficiency of Life Sciences learners?	June-July 2020: Presentation of data procedures August 2021: Consent from school principals and learners (participants) September-October 2021: Plant diversity lessons Descriptive study on lesson plans	Manual analysis of data from lesson plans through a descriptive study, allowing the data to be explored, reduced, and interpreted	Learners (66)	Trustworthiness was verified by using strategies such as truth, applicability, consistency, and neutrality (Korstjens & Moser, 2018).
Quantitative research	How do the series of lessons through experiential-based practicals aligned with content help develop experiential skills in learners? How do learners perceive experiential based practicals aligned with content?	September-October 2021: Pre-, during- and post-test Questionnaires	Marked by using inferential statistics together with descriptive analysis Evaluated by the Rasch model	Learners (66)	Combining instruments, and consulting experts in the field.

3.8.1 Qualitative analysis of lesson plans

The analysis of the four different lesson plans stretched from the engaging introductory lesson to the practical exploration lesson, to the explanation of adaptation, and finally to applying knowledge in society. A descriptive case study of all the lesson plans was undertaken throughout the research to identify and explain the various aspects necessary to the development of experiential skills. Lesson plan analysis was based on descriptive analysis, while considering the cognitive levels implicated (Armstrong, 2010). It was first ascertained if the lesson plans could be reflective of an instructional approach which teachers found effective in developing experiential skills.

3.8.2 Quantitative analysis

All experiential skills development tests, as well as the questionnaire, were developed with assistance from my Head of Department of Life Sciences, my supervisor, and an expert in statistical analysis from the University of Witwatersrand. The statistical analyst from the University of Witwatersrand assisted me in analysing the responses of the 66 learners by decoding learner responses into intelligible language, and creating key phrases and themes to ensure quality research. The main priority was summarising the data received from the participants during the pre, during, and post-tests (Cant, 2008). The quantitative analysis of the tests allowed me to report the quality of the learners' answers on a rubric designed according to a Likert scale. Dr Solomon, a statistical analyst from the University of Witwatersrand, used SSPS analysis software to ensure that my data was reliable and valid. This analysis software allocated specific code to each learner's test and questionnaire to ensure that the findings were easier to analyse, and also assisted in making the correct interpretations with accommodating telematics presentations. The quantitative analysis (explained in Chapter 5) aligned the objectives of this study with the findings.

As summarising these large amounts of data was the first priority, I made use of descriptive statistics as a powerful means to further analyse my statistics (Hair et al., 2013; Zikmund & Babin, 2013). Descriptive statistics are the best-organised source for summarising the characteristics of large data sets (McDaniel & Gates, 2013). The descriptive statistics allowed an opportunity to use the participants in my Life Sciences classroom, and to make inferences from there which could be generalised to all Life Sciences learners in Grade 11 (Zikmund & Babin, 2013). During analysis, experts in experiential skills development focused on the raw data and/or scores in order to summarise the results in the more manageable form of tables and graphs. This format provided a visually accessible overview of all the learners' responses (Gravetter & Wallnau, 2009). The descriptive statistical technique is presented in Table 3.2.

Table 3.2 Descriptive statistical techniques

Descriptive statistical technique	Definition
Means	"The mean can be defined as the average value within the distribution and the most commonly used measure of central tendency." (Hair et al., 2013:12)
Standard deviations	"Standard Deviation (Std. Dev.) indicates the average distance of the distribution values from the mean." (Hair et al., 2013:12)

- *Quantitative analysis of pre, during, and post-tests*

The learners completed pre, during, and post-tests on the diversity of plants as a measurement of their skills both before and after introducing experiential skills. The learners' written skills were graded on a separate assessment rubric (see Appendix F) developed from the literature (Chapter 2). The rubric used for assessing the quality of the learners' experiential skills focused on the modes of experiential skills development, and the learners' scientific literacy according to the conceptual framework. From the assessment of these tests, I graded the learners' writing levels on a four-point Likert scale rubric to gain descriptive inferential analysis and glean valuable insights into the research questions, from which I was able to draw conclusions.

Level 1: Not skilled (the learner shows no competency in the demonstration of this skill/cognitive level)

Level 2: Substandard (the learner shows basic competency of this skill/cognitive level)

Level 3: Fairly skilled (the learner shows satisfactory competency of this skill/cognitive level)

Level 4: Skilled (the learner shows excellent competency in demonstrating this skill/cognitive level)

As mentioned, when summarising data using descriptive and inferential statistics, all data from the learners' tests and questionnaires was presented as simple, manageable statistics (Hair et al., 2013; Zikmund & Babin, 2013). Using this summary technique, I made inferences regarding the learners' experiential skills development (Zikmund & Babin, 2013). In this study, the t-test, a statistical test that compares the means of two samples, used the raw data from the pre, during, and post-tests, and organised the data into a table which allowed for a view of the entire set of data (Gravetter & Wallnau, 2009). A paired t-test was employed to make comparisons between the same group's means in the three different tests. The paired t-test represented the learners, who were repeatedly tested before and after receiving a specific experiential skills-based lesson, meaning each learner was used as a control sample against themselves.

The formula for computing the t-test:

$$T = \frac{mean1 - mean2}{\frac{s(\text{diff})}{\sqrt{(n)}}}$$

- *T* is the effect size
- *mean 1 − mean 2* is the difference between the means of compared tests
- *s(diff)* is the standard deviation of the differences of the paired data values
- *n* is the sample size (the number of paired differences)
- *n−1* is the degrees of freedom

In the findings, the practical significance of the instruments given to the learners was identified by making use of this data analysis method. The raw data was then dissected to obtain answers to the research questions.

- *Quantitative analysis of questionnaires*

The growth in Further Education and Training (FET) in Life Sciences is important to developing a learner with scientific knowledge, but more so when developing a learner who can use their mastered experiential skills, as these learners are essential to meeting the challenges of the 21st century (Lee & Tan, 2003). For this preliminary study, the actual performance of these learners was tested, and questionnaires were set to follow the mindset of a learner participating in the development of experiential-based practicals aligned with the given content. The appropriacy and efficacy of the development of the experiential skills evaluation questions were tested under a Rasch analysis, using RUMM2030 software. The questions set in the questionnaire improved the gathering of useful information in analysing the learners' performances and their ability to adapt to experiential activities. Using RUM2030 allowed me to produce evidence that both my instruments and my findings were credible, valid, and could be applied to the evaluation of experiential skills lesson planning. This process began with the research questions, and I was directly involved in the Grade 11 Life Sciences classroom when the data was compiled and subsequently analysed (Saidfudin et al., 2007).

RUMM2030 is a recent alternate guideline of measurement. It creates a starting point that matches the norms of an SI unit, "where it acts as an instrument with a clear unit of measurement" (Saidfudin & Ghulman 2009). I analysed the measurements collected from the questionnaires using pragmatic data gathered directly from the learners, and then converted the results to a logic measurement with a similar interval. The results could then be evaluated in a linear relationship. RUMM2030 enabled me to define the data as reliable and valid from the "most compatible data line", and therefore create figures that were trustworthy (Bond & Fox, 2007). Consequently, the results produced were a real-life representation of the questions designed in the pre, during, and post-tests to aid the development of experiential skills as a measuring point, consequently allowing for generalised conclusions.

3.9 Limitations of Study

This study only reflected the current extent of experiential skills development in the Grade 11 Life Sciences classroom. It is possible to create a body of knowledge that would generate new research questions, which would challenge further research on experiential skills development. Other limitations included the lesson time spent on a single topic that was later tested. A wider scope and different FET phases could have identified more aspects of the issues surrounding the development of experiential skills.

3.10 Quality Assurance of Study

Crystallisation—reflecting on the experiences in the study—walks hand-in-hand with triangulation, using different data sources to develop a comprehensive understanding (Cresswell, 2014). Triangulation was considered important in this study, and was therefore ensured by collecting three different sets of data for analysis (Hamilton & Corbett-Whittier, 2013). This study also required methodological triangulation involving mixed method procedures for data analysis (Guion et al., 2013), considering the data from various angles. Validity and trustworthiness are two parallel concepts mostly aligned to improve data collection through various research methods. In this study, trustworthiness was established when evidence from the results was reported to create sound arguments based on strong results (Agerfolk, 2013; Cresswell, 2014). In a mixed method study, high reliability as suggested by Korstjens & Moser (2018) ensures the valid interpretation of data through four criteria: truth, applicability, consistency, and neutrality. The validity of qualitative data is not statistically governed and requires more attention due to its subjective nature. Thus, quantitative data filled the gaps—namely, subjectivity—foreseen in this study's quality assurance. Qualitative data was collected as a holistic source of rich data by which the phenomenon of experiential skills development could be explained.

- *Lesson plans*

Content validity was used to sift through the analysis of the lesson plans. This type of validity evaluated the analysis performed on the lesson plans, ensuring that the qualitative data was representative of the specific construct. My subject advisor (HoD) and I determined the validity of the content in the lesson plans. The objective was to evaluate each part of the modes of experiential skills development, as well as the skills needed in each mode, and determine whether the lesson plan "looked" accurate. All particulars related to the lesson plans were obtained from the literature study.

- *Pre, during, and post-tests*

Content validity was enhanced by the credibility of the research (Agerfolk, 2013; Cresswell, 2014). In this study, credibility was attained through my own comprehensive and varied involvement in the field (Korstjens & Moser, 2018). The use of various researchers, data generation, contexts, and data sources aided the breadth and depth of the data to provide a more comprehensive image (Imenda, 2014). Although this research study was performed by one researcher, the input of study supervisors, experts in the field, and other advisors was acknowledged. Consistency referred to the credibility of the data, while external consistency referred to the confirmation of the data—"crosschecking"—through other researchers (Neuman, 2007).

- *Questionnaires*

For this study, there was no pre-existing questionnaire available which could relate to the objectives. Therefore, I made use of the conceptual framework, various researchers, and data sources (Jokonya, 2016; Korstjens & Moser, 2018) to develop a questionnaire which would provide a more comprehensive image of the data collected (Imenda, 2013). When I preformed the research study, I made use of my supervisor's input, experts in the field of experiential learning, and other advisors, to ensure that this image of quantitative data was acknowledged. Procedures such as anonymity were set in place to allow the learners to feel comfortable to give honest answers as voluntary participants. Participation took place under the following conditions: at the learner's convenience (during their free time), and in an environment where they felt safe (at school). I conveyed an open and friendly attitude, and it was made clear to all participating learners that there was no right or wrong answer (Korstjens & Moser, 2018).

3.10.1 Assessing validity and reliability

Assessing the validity and reliability of information is important, as it naturally allows for inquiry into corresponding criterion and for establishing trustworthiness (Agerfolk, 2013; Cresswell, 2014; Lehman, 2003). This study used a mixed method approach to ensure validity and reliability when presenting new knowledge. By converging the data from a multi-method approach in this study, the validity and reliability was strengthened. This study assessed validity and reliability by means of SPSS for the t-tests and for the tests and questionnaires, together with calculating Cronbach's alpha coefficients and conducting a Rasch analysis (RUMM2030).

- *Trustworthiness of qualitative data*

Validity and trustworthiness are two parallel concepts aligned to improve data collection through various research methods (Spencer et al., 2003). In the qualitative data, trustworthiness is linked to the quantitative data as a "demonstration that the evidence for the results reported are sound and the arguments made based on the results are strong" (Shenton, 2004). Korstjens & Moser (2018) suggest maintaining high trustworthiness through four criteria, used to ensure the valid interpretation of data: "truth, applicability, consistency, and neutrality". The validity of data is subjective, but can be improved objectively through statistically governed data in the mixed method approach.

The solidification of validity was implemented through confidentiality, credibility, and the validation. I made use of my own Grade 11 Life Sciences classroom to implement the lesson plans, which were structured according to the conceptual framework. I was confident in the research when I analysed the findings and reflected on the classroom environment and the learners (Neuman, 2007). The names of the participants were known only to me, to ensure a certain level of confidentiality and to keep record of each learner's participation in the study, especially when comparing the different tests that were administered over the series of lessons. Gathering the credibility of the study was achieved through a detailed description of the actions, assumptions, and procedures of the instrument.

Neuman (2007) states that the reliability of observations is determined through the internal consistency of the occurrences observed. Consistency from an internal perspective was gathered through the cross-checking of instruments, data, and the conclusions developed from the literature.

- *Trustworthiness of quantitative data*

The determination to follow the principles of trustworthiness ensured the reliability and validity of the quantitative data analysis (Malakoff, 2012). To determine the trustworthiness of the data, its credibility, consistency and validation had to be described, as mentioned by Bezuidenhout (2005) and Malakoff (2012).

Throughout the research process, experts in the field together with myself ensured the trustworthiness of the data. In my case, the credibility of my assurance rested on my degree in B.Ed. Senior and FET, which focuses on Life Sciences as an ongoing working experience; my honours and master's degrees in Life Sciences; and my role as an active practitioner in the Life Sciences classroom. Credibility is further enforced by combining the questionnaires with the pre, during, and post-tests given to the learners. When combining these instruments, the study was seen as a collective which was statistically analysed and evaluated by an analysist at the University of Witwatersrand, accompanied by myself.

Procedures were set in place to stimulate the integrity of the learners, i.e. through voluntary participation. The repetition of certain questions or explanations was evident in the audio recordings, confirming participants' answers and ensuring that the meaning of the answer was accurately interpreted. Data analysis and conclusions were also sent back to the experts in the field of quantitative analysis to confirm the accuracy of the data.

Dependability contributed to the reliability of research (O'Leary, 2004) and emphasised the consistency of the study (Agerfolk, 2013; Cresswell, 2014). In this study, the steps concerning verification and accuracy enhanced the dependability of the study. All decisions from literature were verified, especially sources on research methodology. Since accuracy is one of the important aspects of reliability, the pre, during, and post-tests as well as the questionnaire were given to experts involved in the development and analysis of tests and questionnaires to be evaluated on the relevance of the items/themes in each instrument. The statistical analyst assessed the adequacy of each instrument based on the objectives of the study. They also focused on whether the language was at an appropriate level for the learners. Using Cronbach's alpha to produce reliable coefficients ranging from 0.70 to 0.85 showed that the tests and questionnaires were reliable. For Cronbach's alpha to be classified as reliable, the coefficient normally ranges between 0 and 1. According to George and Mallery (2003), internal consistency is certified when the Cronbach's alpha coefficient is closer to 1.0. To further the internal validity, different themes were chosen to discuss similar findings from the pre, during, and post-tests, as well as the questionnaires

(Kruger & Gericke, 2004). As mentioned earlier, Malakoff (2012) states that the validity and reliability of quantitative data has to be determined through consistency. To establish the trustworthiness of the data, three criteria had to be described, namely credibility, consistency and validation. Firstly, validation ensured the objectivity of the research (Korstjens & Moser, 2018). Secondly, the literature study in Chapter 2 was used to confirm consistency. To ensure consistency, I marked the pre, during, and post-tests myself. Integrity was established by the learners during the pre, during, and post-tests, as well as in the questionnaires, by using a code number for anonymity. The quantitative instruments were coded using a class list numbered from 1 to 66, and a number was assigned to each learner during this study. Finally, the credibility verified the data as the data was evaluated by myself, the data analyst, the study supervisor and the participants (learners) (Korstjens & Moser, 2018; Malakoff, 2012).

- *Trustworthiness of qualitative and quantitative data*

The trustworthiness was taken into consideration when developing, assessing and analysing the instruments to increase the validity and reliability in this study: firstly, I used simple and clear technical terms that would be understood by any teachers in the lesson plans, and which would be understood by any learners in the tests and questionnaires. Secondly, I standardised the administration procedure as much as possible, ensuring that both Grade 11 classes as well as all 66 learners were placed in the same environment, heard the same series of lessons, and took the same tests. Thirdly, I ensured the scoring procedures were standardised using a rubric for the test scores and themes for the questionnaires. Fourthly, to avoid ambiguity I confirmed that each item of the instruments focused on the same outcome. Finally, I focused on the appropriate level of difficulty by incorporating both the experiential skills needed and Bloom's Taxonomy.

3.11 Ethical Considerations

According to Pillay (2014), there are three objectives in research ethics:

- To protect the human participants
- To ensure that research is conducted in a way that serves the interests of individuals, groups and/or society as a whole

- To examine specific research activities and projects for their ethical trustworthiness, management of risk, protection of confidentiality, and informed consent

In this study, I applied for ethical clearance and used the following ethical strategies as moral and responsible behaviour towards participants: obtain permission from the Gauteng Department of Education (GDE) (Appendix K) and the school principal (Appendix L-M); secure the informed consent of the parents (Appendix N-O); confirm assent from the learners (Appendix P-Q). Other strategies that were used included confidentiality and anonymity. The volunteers and I provided relevant data concerning the nature and aim of the research. If learners declined to assent, or the parents declined to consent, learners were not forced to participate verbally throughout the audio recording, they did not receive a pre-test, during-test or a post-test during the lessons, and they did not receive a questionnaire. When the study took place, all learners indicated that they would take part in the study. This secured the protection of participants, and ensured that no participants were negatively affected as outlined in the ethical procedures listed above. Ethical clearance was also received from the Ethics Committee at the University of Witwatersrand before any research was conducted. Lastly, the data from this study will be stored in the Division of Science at the WSoE.

3.12 Chapter Summary

This chapter focused on the research methodology used in the study, where both qualitative and quantitative research approaches were utilised. Regarding the qualitative methods, pre, during, and post-tests were used, whereas the quantitative methods were applied to the lesson plans and questionnaires. Convenient purposive sampling of Grade 11 Life Sciences learners was utilised in order to establish trustworthiness. Lastly, the critical importance of ethics and all it encompasses was also considered.

CHAPTER 4
QUALITATIVE FINDINGS AND DISCUSSIONS

4.1 Introduction

The previous chapter discussed the methodology used in this study, which lead to the investigation of the topic at hand. The next two chapters, 4 and 5, deal with data retrieved from the classroom, and the findings drawn from quantitative and qualitative data are presented and discussed. This chapter consists of the empirical results and the narrative description of the qualitative data. The chapter firstly focuses on the nature of the school (section 4.2), followed by a discussion on the qualitative data analysis (section 4.3), including the themes derived from the lesson plans designed for developing experiential skills. Conclusions made from the data analysis are provided throughout this chapter.

4.2 Nature of School

The study was conducted at a public school in Tshwane West, Pretoria, Gauteng Province. All schools in South Africa are ranked according to the school community's level of resource availability (DoE, 2015). Schools are placed between a one (mostly funded by government) and a five (funded by the learners' school fees) quintile system. The public school in question was part of the quintile five system, though the learners come from varying socio-economic backgrounds. This urban school is an Afrikaans-speaking high school, and Life Sciences lessons were conducted only in Afrikaans. Many learners were also part of school fee exemptions. The learners had access to Life Sciences equipment specifically needed for this study. They also had projectors, blackboards and whiteboards.

4.3 Qualitative Analysis

The qualitative approach in this chapter allows for a discussion of the findings drawn from the lesson plans. Lesson plans were used to direct the development of experiential skills qualitatively in the Life Sciences classroom. After implementing the qualitative instrument, I familiarised myself with a theme-based system in order to best observe the patterns created by the lesson plans in the classroom setting. I used these themes to summarise observations which were affirmed by the audio recordings made from the lessons, as well as the lesson plans that were studied. I created seven themes to ensure a logical analysis method, and to extract the necessary findings to answer the secondary research questions. An audio recording was used to ensure that I would be able to return to the teacher and learner activities during the lessons and summarise the information into themes. The findings of the qualitative data were categorised and tabulated according to the lesson plans, which were developed using the conceptual framework.

The lessons were broken down into eight themes, as follows:

(1) Planning and preparing for instruction

(2) The lesson introduction by the teacher for concrete experiences

(3) Practical attributes and scientific investigation for reflective observation (the writing of the pre-test)

(4) The teaching method on adaptions and impact on environment for abstract conceptualisation (the writing of the during-test)

(5) The value of scientific knowledge for active experimentation (the writing of the post-test)

(6) The teacher-learner activities

(7) The logical structuring of a lesson

In this research, I manually coded and analysed all the gathered data while observing the lessons in person. Creating the themes and analysing the data was manageable as the instruments were developed in a way which would follow the structure of the conceptual framework. This framework was already present before the data was analysed.

4.3.1 Data from lesson plans and their recordings

The lesson plans for the four lessons on plant diversity specifically Bryophyta, and the writing of the pre-test, during-test, and post-test, were all recorded using, the Cloud-based, audio-conferencing service which allows participants to meet remotely in real time, and also record meetings, classes and events for sharing and later review. I used these audio recordings to revisit the lessons and capture information which could have been missed in real time. Aspects which may have been overlooked during the lessons, such as learner behaviour patterns and evidence of developed skills when answering questions, could be revisited by returning to the audio recordings. The lessons were carried out for both Grade 11 Life Sciences classes, with 66 learners in total participating in the study. For anonymity and confidentiality purposes, a coding number was assigned to each learner for each test during these lessons, numbered from 1 to 66. Qualitative data was gathered and depicted with a narrative design, which included referring to specific experiential skills development activities where participants contributed to strengthen their arguments. All the learners were guided by the same four lesson plans, which included a time allocation for each activity. Learners were also provided with resource materials during the lessons.

In observing the learners carrying out the lessons on Bryophyta, together with the pre-test, during-test and post-test, I focused on the research questions: (a) What aspects need to be considered in creating experiential skills development lesson plans? and (b) To what extent does the development of experiential skills influence the proficiency of Life Sciences learners?

4.3.2 Planning and preparing for instruction

A teacher's lesson planning plays a strong role in the classroom, as it directly impacts what and how learners learn. Consequently, the planning of these experiential skills development lessons was very important to the outcome of the study. My planning was important both for educational research and for the development of experiential skills in my own classroom for the following reasons:

1) My planning decisions and chosen activities would be a major factor affecting the quality, quantity, and nature of classroom instruction.
2) The effects of planning decisions and activities upon instruction could be assessed.
3) Alterations and adjustments to planning decisions could be taken into account for future lessons, and thus planning represents a potentially powerful tool for the improvement of instruction.

Understanding the lesson planning process and how it influences the process of improving instruction is helpful for teachers. Understanding lesson planning can be done through the pre-active or planning phase of a lesson. It is important to understand the relationship between the planning process and effective instruction; until this relationship is understood, administrators and supervisors cannot help teachers plan effectively.

The themes were set in place before preparing for the four lessons, as follows:

Lesson 1: Bryophyta – structure, function, habitat and water dependence
(concrete experiences)

Lesson 2: Bryophyta – practical attributes and scientific investigation
(reflective observation)

Lesson 3: Bryophyta – adaptions and impact on environments or society
(abstract conceptualisation)

Lesson 4: Bryophyta – value on scientific knowledge
(active experimentation)

The lesson and related activity addressed the theme of Bryophyta. The audio recording and the analysis of the experiential skills lesson began when the learners walked into the classroom, or as they settled and prepared for their lesson to begin. Table 4.1 below tabulates the teacher's activities when preparing each lesson, and the teacher's observations of different aspects that arose as the lesson progressed, and which led to patterns in developing experiential skills in the participating learners' behaviours.

Table 4.1 Classroom preparation activities before the lesson commenced

Lesson	**Comments**
Lesson 1: *(concrete experiences)*	
Teacher	• Prepare introduction lesson • Prepare PowerPoint as resource material (See Appendix G) • Scaffolding knowledge on moss through instructional support • Explaining the aim of the pre-test
Learner	• Take notes

	• Questions and answers • Pre-test to be completed in following period
Lesson 2: *(reflective observation)*	
Teacher	• Prepare laboratory with microscopes and moss for lesson • Prepare PowerPoint as resource material (see Appendix H) • Set video as resource material
Learner	• Use microscopes to observe moss for the first time • Clearly identify and discuss the structure, function, habitat, and water dependence of moss • Complete pre-test
Lesson 3: *(abstract conceptualisation)*	
Teacher	• Prepare laboratory with microscopes and moss for lesson • Prepare PowerPoint as resource material (See Appendix I) • Give feedback on pre-test • Complete during-test at the end of period
Learner	• Use microscopes to observe moss • Use practical attributes and scientific investigation from previous lesson to draw conclusions • Take notes
Lesson 4: *(active experimentation)*	
Teacher	• Prepare laboratory for drainage system of moss • Prepare PowerPoint as resource material • Complete post-test in following period
Learner	• Take notes

	• Identify adaptions and the impact on the environment or society utilising moss • Develop a sense of value in the scientific system of moss as a drainage system (see Appendix J)

For the purposes of classroom observation, the audio recordings worked alongside a basic journal of notes, and together these allowed for detailed analysis. Learners came to their normal assigned Life Sciences period, and quickly settled. One class took a little longer than the others to begin due to having a higher number of learners. The recording began immediately as the lesson started. The atmosphere in the first lesson was tense, but the learners' natural, casual attitude soon returned as subsequent lessons took place and learners felt more comfortable with the theme and with being audio recorded. Once ready, learners showed attentiveness as they received each lesson, and also in the feedback and test phases. Each lesson was 50 minutes long, and pre-tests, during-tests and post-tests formed part of the four lessons. Each test counted a total of 15 marks and took more or less 20 minutes, and these were completed at the end of the lesson. The tests were developed together with the lesson plans to ensure that each test not only assessed the new experiential skills developed after the lesson, but also progressively introduced higher-order thinking skills. When the tests answer scripts were collected, learners were focused and waited for their next instructions. Since the laboratory work took place over the height of Covid-19 when social distancing rules were still in place, only a few microscopes could be made available, and learners had to wait for a station to open. When learners were selecting their own groups for the post-test, they briefly milled around before choosing a group. The learners were told beforehand that lessons would take place during their participation in this study, as this was explained in the consent letter they had signed. Even before the lesson was introduced, learners were eager and excited as they waited to start.

4.3.3 The lesson introduction by the teacher for concrete experience

As with any other lesson, I briefly introduced the lesson with an accompanying PowerPoint. The first part of the lesson focused on explaining the lesson outline that would be followed throughout the theme, as well as providing a brief explanation of the desired outcomes when concluding the lesson, to ensure that the learners were proficient in this particular theme. Learners listened and actively came together, which enabled the lesson to swiftly and smoothly move to the next activity or mode of experiential skills development. As the teacher, I made use of this mainly teacher-focused introductory lesson to develop the learners' concrete experiences, and to lay a basic foundation of knowledge on Bryophyta. The activities started with an introduction to the different types of plant diversity, and the necessity of starting with a primitive plant such as moss. I focused on teaching the basic meanings of terms, and the characteristics that form part of Bryophyta, namely:

- Vascular structures such as xylem and phloem
- Thallus plants
- Reproduction structures: seeds/spores
- Fruit/Flowers
- Water dependence for reproduction
- Life cycle: sporophyte (diploid) and gametophyte (haploid)

I asked learners to write down their responses on the table provided in learners' books as a method of direction when taking notes. The table makes provision for:

- Plant diversity from primitive to evolutionary
- Characteristics of moss
- Structure of moss

Throughout the lesson, basic knowledge scaffolding was established while continuous questions varied across lower cognitive questioning and answering. While completing the lesson, I frequently revisited the work done in previous lessons in Grade 10.

4.3.4 Practical attributes and scientific investigation for reflective observation (the writing of the pre-test)

As with any other lesson, I began with an introduction. The learners wrote the pre-test, which was mostly learner-centred. Due to Covid-19 restrictions, learners were instructed to use stations alone. The answer scripts were collected. The pre-test took place in a controlled environment where each learner was responsible for his or her own test. No questions were asked, and it was assumed that the learners understood the theme after the introductory lesson. Due to time constraints (because of school activities) the lesson was divided into two parts.

The lesson continued to focus on what is expected of the learner in reflective observation. This lesson took time to start and get learners settled. As the teacher, I supplied the learners with moss samples and the equipment, namely microscopes, that would be used in the during-test. In this lesson, the core method to develop experiential skills was through the means of feedback. This feedback allowed the learners to observe what was answered and reflect on their skills, the acquired skills would transform learning while the learners applied the new knowledge. Using the results of the pre-test, questions that showed a lack in knowledge or skills were revisited and clarified whilst demonstrating the scientific method. An explanation of necessary telematics' skills, such as graphs, tables and measurements, were also revisited in this lesson. As the teacher, I could see the learners' understanding of the question develop once they had received an explanation, and as the questions were again redirected to the learners.

This lesson focused on concrete experiences, and once concluded—together with the necessary feedback—it was expected that the learners should be able to carry out the practical part of their lesson using microscopes and completing a worksheet. Here I observed and made key point summaries, and reflected on observations that would be made in the during-test. Learners also were required to identify variables, ask questions, hypothesise, follow instructions, record information, and interpret and conclude on present findings. The lesson finished by summarising the knowledge and skills that should be produced at the end of the two lessons. It was clear that the learners were tired after this lesson. The lesson ended with a few minutes to spare, allowing learners time to reflect.

4.3.5 The teaching method on adaptations and impact on environment for abstract conceptualisation (the writing of the during-test)

As with any other lesson, I began with an introduction. The participants made use of laboratory stations to complete the during-test. The test was completed by each learner in a controlled environment. The expectation was to find a direct link between each learner's pre-test and during-test, as these tests were designed to help determine to what extent the learner had developed experiential skills on the same theme and manner of questioning. This link was determined by asking the same type of question in the pre-test and the during-test, but with an increased mark allocation per question, or by combining different questions in order to develop a higher-order thinking skill.

The lesson feedback on reflecting and observing guided the focus of abstract conceptualisation, bringing together the knowledge that had been acquired throughout the lessons. The lesson on abstract conceptualisation was more learner-centred. Teaching in this lesson focused on the main process and function of the systems in Bryophyta, pointing out the relationship between structure and adaptation for survival. It was the learners' responsibility to practically observe the structure and functions throughout the during-test, and later make key point summaries in the tables developed in the first lesson. This was a form of learner research, where learners collected information, analysed what was known, and synthesised the information. For this outcome, learners were expected to narrate their experiences and explain their opinions based on acquired scientific knowledge.

4.3.6 The value of scientific knowledge for active experimentation (the writing of the post-test)

Just like any other lesson, I began with an introduction. Of the series, this was the first lesson where the learners worked independently. I set out to only be a source of instruction, guiding the learners as they completed this practical lesson. I gave the learners an information sheet with clear diagrammatic illustrations of moss and its uses in water filtrations. I explained how water filtration takes place in nature versus through impervious surfaces. The learners divided into small groups, waiting for me to give instructions and facilitate the activity while they actively took part in discussions. Due to the size of the classroom, the learners were able to maintain social distancing as required. I was a facilitator and mentor, giving learners a set of questions to consolidate the information that was on the post-test, and aiding them where needed. I allowed learners to explore the practical system and real-life models themselves.

It was the learners' responsibility throughout the post-test to write down key facts and respond to questions. The learners had to explore filtration through moss and its relationship to real model systems. Certain groups completed the experiment much faster than others, and even decided to re-do the experiment and see whether they would receive the same results. The learners who worked fast set up the control and concluded their experiments with the same results. Learners could freely express their opinions, listen to the views of others, and reshape their ideas independently.

4.3.7 The teacher-learner activities

The relationship between teachers and their learners while interacting is critical in the success of teaching and learning activities. I focused on the activities that related best to the objective at hand, and which had been set at the start of the lessons for the learners to achieve.

The relationship between the teacher (myself) and activities set for the learners (the study participants) involved the following:

- The teacher was highly involved throughout the lessons
- The teacher assisted learners when they struggled with their instruments (e.g. microscopes)
- The teacher maintained discipline among the learners throughout each lesson; learners knew that the lessons not only benefited the research, but that they would also be tested on the content in their November examinations
- Learner participation was encouraged throughout the series of lessons to ensure self-discovery
- The teacher made use of artificial Bryophyta as alternatives to real moss, to ensure that the lessons could also be conducted without the microscopes if needed. This would be a cost-effective alternative for government-funded schools.
- The teacher tried to involve learner participation. Learners were attentive and engaged when they were able to use the microscopes or when building the drainage systems, but some of the learners struggled to find motivation to complete the written tests. I reminded them that their engagement in the current activities would benefit them in the November examinations. Most learners

understood the benefit of writing and finishing their tests in the allocated time, and most of them finished on time.

4.3.8 Logically structured lesson

The success of every lesson depends on how the teacher delivers the lesson. Taking this into consideration, I recorded the different methods which I had applied in the four different lessons. My methods are recorded in Table 4.2.

Table 4.2 Teaching methods

Lesson	Teacher or learner-centred	Experiential skill development	Outcome
1	Teacher-centred	Context	Content knowledge
2	Teacher and learner-centred	Observation and reflection	Stimulation of knowledge
3	Progressively more learner-centred	Process	Adapt and discover knowledge
4	Learner-centred	Judging	Memorandum expected answers

Before the lessons started, the learners were instructed on the series of lessons that would be taught on the subject of Bryophyta. Across all four lessons, the participants knew what was expected from them either during the lesson or in the test, and instructions were given at each new phase. I asked the learners to read these instructions carefully. As the learners received instructions to move around to the laboratory station, some learners could not see the moss under the microscope and had to be assisted. I always instructed the learners to observe first, and therefore make their own discovery. When giving the learners feedback in the lessons that followed, I demonstrated the activity or process to each learner in my Grade 11 class. The participants focused during the demonstrations. Throughout the four lessons, I gradually moved from a teacher-centred approach to a learner-centred approach. The learners were guided to identify the importance of certain drainage points of moss in real life, and the objective was to allow the learners to internalise their scientific knowledge on moss and apply the functions in answering the post-test, and to do so within the allotted time. I facilitated the practicals and the discussions during the post-test. The learners identified and discussed their work among themselves without much guidance. In most instances, the learners started to assist one other in building the drainage systems effectively, both timing and recording information. Both classes were instructed to carry out their pre and during-tests individually, and the post-test was held in groups of four to six learners. The number of learners in the different Life Sciences classes varied, thus affecting the size of the practical groups.

All learners were encouraged to discuss what they had learned or observed when using their practical instruments. I asked a range of cognitive questions, due to constructive arguments and discussions in the lesson, which led the learners through their own thinking process by engaging them more deeply with the Bryophyta theme as they solved the problems presented to them. The learner discussions were very enthusiastic. The pre-test was judged against the during-test written by the learners before a follow-up lesson was given to develop experiential skills. The pre-test was compared to the post-test to see whether the series of lessons equipped learners with greater proficiency in understanding a theme and then in applying the knowledge with the needed experientials skills, thereby arriving at a memorandum-expected answer and collecting the maximum number of marks. The same time allotment of 50 minutes was given to answer the pre, during, and post-tests. There was the possibility of some discrepancy between the class sizes, which could influence the final test performances. Additionally, the larger groups had the advantage of more contributions from learners, but also had the disadvantage of minimised hands-on participation. By contrast, the smaller groups had maximum hands-on participation with the disadvantage of fewer contributions from learners. Both situations showed clear advantages and disadvantages for the learners.

4.4 Conclusion of Qualitative Data

This chapter explained the implementation of experiential skills lesson plans into two Life Sciences classrooms with a total of 66 learners, and in which a series of lessons was carried out on the theme of Bryophyta. Throughout the series of lessons, pre, during, and the post-tests were all completed. The data from the lessons highlighted the development of experiential skills using the modes as set by the conceptual framework in order to develop a proficient learner. I also observed that the planning, preparation and logical structure of the lessons allowed the learners time to internalise the information and discover new knowledge in the lesson which followed. From my point of view, all four modes of experiential skills development were fulfilled across the series of lessons. The tests guided the learners to engage more deeply throughout the lessons, in order to discuss or engage with the presented questions from lower to higher-order skills. Generally, the attitude of the learners towards the lessons was positive, and with a bit of persuasion, the learners used the knowledge of further testing in the future as an incentive.

In Chapter 5, the presentation and discussion of the quantitative data from the pre-test, during-test and post-test, as well as the questionnaires, is given. The presentation of both quantitative and qualitative data is provided in the hope of deepening the understanding of the influence of experiential skills on the proficiency of the learner. Chapter 6 will report on possible reasons for the findings of the study and the synthesis of both Chapter 4 and Chapter 5.

CHAPTER 5
QUANTITATIVE RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter details the statistical analysis of the quantitative data by reporting, explaining and interpreting the empirical results and the narrative description of the qualitative data. The chapter begins by describing the participants used in the quantitative analysis (section 5.2), after which the quantitative data analysis (section 5.3) of the pre-test —a test written by the learners following the first experiential skills lesson, which assessed their basic knowledge of the moss, its structure and its function—is discussed. This section also explains the during-test, a test which assessed the learners' higher-order experiential skills following the third lesson. This section concludes with the post-test, a test which assessed the learners' proficiency in Bryophyta when combining all the modes of experiential skills development (section 5.3.1). This discussion is carried by the data presentation of the pre-test, during-test and post-test using the t-test (section 5.3.2). Thereafter, the quantitative data analysis of the questionnaire (section 5.3.3) and the data analysis conducted using RUMM2030 are both analysed. Conclusions derived from the data are provided throughout this chapter.

5.2 Participants

In this quantitative research, the study participants were discussed in order to identify a part of a population which could be generalised.

5.2.1 Participants in the quantitative research

In this study, participants were all Grade 11 Life Sciences learners selected from a public school in Tshwane West, Pretoria, Gauteng Province (N=66). These participants formed part of the quantitative analysis of the pre, during, and post-tests, as well the questionnaire analysis.

5.3 Quantitative Analysis

The quantitative instruments in this study focused on pre, during, and post-tests as well as questionnaires.

5.3.1 Results of raw data from the pre, during, and post-tests

Table 5.1 lists each question number and gives the question asked, providing the question's mark allocation as presented to the participating learners in the pre, during and post-tests (Appendix B-D).

Table 5.1 Questions presented in the pre, during, and post-test

PRE-TEST		
Question number	**Question**	**Mark allocation**
1.1.1	Describe the physical structure that can be observed from the moss: "Rhizoids"	1
1.1.2	Describe the physical structure that can be observed from the moss: "Leaves" and "Stem"	1
1.1.3	Describe the physical structure that can be observed from the moss: "Shoot"	1
1.2	Identify the presence of the structures in the moss-plant by using a tick **(√)** in the correct block. (A table was given with different characteristics for all the plant diversities.)	($^1/_2$ x 6 =3)
2	Give labels for structure 1-4. Write the label next to the correct number. (A diagram of a moss plant was given with four structures labelled 1 to 4.)	4
3.1	Draw a line graph that displays the relationship between the moss plant and the filtrate paper over the course of five days. (A scenario with data was given in table format.)	5
DURING-TEST		
Question number	**Question number**	**Mark allocation**
1.1	Describe concisely the type of habitat.	1
1.2	Evaluate how the leaves are arranged. State its importance.	2
1.3	Judge the general function of the rhizoids.	2
2.1	Labelled drawing of a moss plant. (Learners made use of microscopes to see, draw, and label a real moss plant.)	3
2.2	Calculate the average water that has been drained through the moss plant over the course of five days. (A scenario with data was given in table format.)	2

2.3	Draw a conclusion on a drainage system of moss that can be used in your garden. (A scenario with data was given in table format.)	2
3.1	From the description given above, explain the importance of water in the different structures in the life cycle of the moss plant.	3
POST-TEST		
Question number	**Question number**	**Mark allocation**
1.1	Why are non-vascular plants small? What does the size of a plant have to do with how water is transported?	2
1.2	Consider the differences between the two funnels. Tabulate the differences between the two funnels in terms of the time it took to filtrate and the turbid of the water after filtration. (Learners completed a practical where they built their own moss drainage system and recorded the results.)	6
1.3	Compare the water from the impervious surface bottle to that the soil-packed bottle.	3
1.4	Evaluate how the experiment models a real system.	4

Table 5.2 gives the raw data of each question in the pre, during, and post-tests for each participant. This table allowed me to analyse the raw data and observe emerging patterns found in the learners' performance.

Table 5.2 Raw data of each participant during the pre, during, and post-tests

PRE-TEST								**DURING-TEST**								**POST-TEST**				
QUESTION	**1.1.1**	**1.1.2**	**1.1.3**	**1.2**	**2**	**3.1**	**TOTAL**	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**	**3.**	**TOTAL**	**1.1**	**1.2**	**1.3**	**1.4**	**TOTAL**
LEARNER																				
1	0	0	0	1,5	2	4	**8**	1	0	0	2	1	1	0	**5**	1	6	3	2	**12**
2	1	1	0	2	2	5	**11**	1	2	1	2	0	2	1	**9**	2	6	0	0	**8**
3	0	0	0	1,5	4	3	**9**	1	0	1	3	0	0	0	**5**	2	6	3	2	**13**
4	0	0	0	1	0	3	**4**	1	2	0	2	1	1	0	**7**	1	6	1	1	**9**
5	0	1	0	1,5	1	5	**9**	1	2	2	3	2	2	2	**14**	0	6	2	1	**9**
6	0	0	0	2,5	2	4	**9**	1	2	0	3	2	0	0	**8**	0	6	2	2	**10**
7	0	1	0	2	2	5	**10**	1	2	2	3	2	2	3	**15**	2	6	3	3	**14**
8	1	1	1	2,5	2	3	**11**	1	0	0	3	2	2	1	**9**	1	6	3	3	**13**
9	0	0	0	2,5	2	5	**10**	1	2	1	3	2	2	1	**12**	2	6	3	3	**14**
10	1	1	1	3	1	0	**7**	1	2	0	2	2	0	0	**7**	0	6	3	2	**11**
11	0	0	0	2	0	5	**7**	1	0	1	2	0	0	1	**5**	2	6	2	1	**11**
12	0	0	0	2,5	2	0	**5**	1	2	1	3	2	2	3	**14**	1	6	3	2	**12**
13	0	0	0	2,5	2	5	**10**	1	1	0	3	1	2	0	**8**	0	6	0	2	**8**
14	0	0	0	2,5	2	4	**9**	1	0	0	3	2	0	0	**6**	1	6	3	0	**10**
15	0	0	0	2,5	0	4	**7**	1	2	2	3	0	0	1	**9**	2	6	2	1	**11**
16	0	0	1	3	3	5	**12**	1	0	1	3	1	1	0	**7**	0	6	0	1	**7**
17	0	0	0	3	4	4	**11**	1	2	1	3	2	2	3	**14**	2	6	3	4	**15**
18	0	0	0	2	0	5	**7**	1	1	0	0	2	2	0	**6**	0	3	0	0	**3**
19	0	0	0	2,5	4	1	**8**	1	0	0	2	2	1	1	**7**	0	1	0	1	**2**
20	1	0	0	2,5	1	5	**10**	1	1	0	3	1	2	3	**11**	2	6	3	2	**13**
21	1	0	1	3	3	5	**13**	1	2	1	2	2	1	1	**10**	2	6	2	2	**12**

22	0	0	0	3	2	5	**10**	1	2	0	3	1	2	1	**10**	1	5	0	3	**9**
23	0	0	0	2	1	3	**6**	1	0	0	1	0	0	0	**2**	1	3	2	2	**8**
24	1	0	0	2	3	5	**11**	1	0	0	2	2	2	2	**9**	2	6	3	3	**14**
25	0	0	0	2	2	5	**9**	1	0	0	2	0	0	1	**4**	0	3	0	0	**3**
26	1	0	0	3	2	3	**9**	1	2	1	3	1	2	2	**12**	2	6	3	3	**14**
27	0	0	0	2,5	0	4	**7**	1	0	0	2	2	0	1	**6**	1	3	2	0	**6**
28	1	0	1	2	3	1	**8**	1	2	0	0	0	0	0	**3**	1	3	0	0	**4**
29	1	0	0	2	1	4	**8**	1	1	1	3	2	1	1	**10**	1	6	3	2	**12**
30	1	0	1	3	3	5	**13**	1	0	1	3	1	2	0	**8**	2	6	2	2	**12**
31	0	0	0	2	2	5	**9**	1	2	1	3	1	2	1	**11**	2	6	3	4	**15**
32	1	1	0	2,5	3	5	**13**	1	1	0	3	1	0	1	**7**	2	6	2	2	**12**
33	0	0	0	3	3	5	**11**	1	2	0	2	2	2	1	**10**	2	6	2	2	**12**
34	1	0	0	3	1	5	**10**	1	2	2	2	1	2	3	**13**	2	6	3	2	**13**
35	0	0	0	2	1	2	**5**	1	0	0	1	0	1	2	**5**	0	3	0	0	**3**
36	0	0	0	2,5	1	2	**6**	1	1	0	3	2	1	0	**8**	2	0	2	1	**5**
37	1	1	1	2	3	3	**11**	1	0	0	3	0	0	0	**4**	0	5	2	1	**8**
38	0	0	1	2	3	5	**11**	1	1	0	2	1	2	1	**8**	0	6	2	3	**11**
39	1	0	0	3	3	5	**12**	1	2	2	3	0	0	3	**11**	0	6	3	1	**10**
40	0	0	0	2	1	4	**7**	1	2	2	0	2	1	2	**10**	2	6	2	3	**13**
41	1	0	1	2,5	3	5	**13**	1	2	1	2	2	0	1	**9**	2	6	2	2	**12**
42	1	0	0	2,5	3	4	**11**	1	2	1	1	1	2	2	**10**	2	5	2	1	**10**
43	0	1	0	2	1	5	**9**	1	2	0	3	0	0	0	**6**	2	6	2	2	**12**
44	1	0	0	2	2	5	**10**	1	1	1	3	1	1	1	**9**	2	3	1	0	**6**
45	0	1	0	2,5	1	5	**10**	1	2	2	3	2	2	3	**15**	1	3	2	2	**8**
46	1	1	1	2	2	5	**12**	1	0	1	3	0	2	2	**9**	2	5	1	1	**9**
47	1	0	0	3	1	1	**6**	1	2	1	2	1	2	1	**10**	1	6	1	1	**9**
48	1	0	0	2,5	1	0	**5**	1	2	0	2	2	2	1	**10**	1	6	1	1	**9**

49	0	0	0	2,5	1	4	**8**	1	2	2	0	1	2	2	**10**	2	6	2	3	**13**
50	1	0	0	2,5	1	5	**10**	1	2	1	3	2	2	2	**13**	2	3	1	3	**9**
51	0	0	0	2	0	1	**3**	1	0	2	2	0	2	1	**8**	1	6	0	1	**8**
52	1	0	1	3	4	5	**14**	1	2	2	3	2	1	2	**13**	2	6	1	1	**10**
53	1	0	1	2,5	4	4	**13**	1	0	0	2	0	0	0	**3**	1	6	1	1	**9**
54	1	0	0	1,5	2	3	**8**	1	2	0	3	2	0	2	**10**	0	6	0	0	**6**
55	0	0	0	2	2	4	**8**	1	0	2	3	2	1	1	**10**	0	3	1	2	**6**
56	1	0	0	2,5	3	4	**11**	1	2	1	3	2	2	3	**14**	0	6	1	1	**8**
57	1	0	0	1,5	2	1	**6**	1	1	0	2	1	0	0	**5**	2	0	1	2	**5**
58	1	1	0	3	1	5	**11**	1	2	1	3	2	2	2	**13**	2	6	3	1	**12**
59	0	0	0	2	1	3	**6**	0	0	0	2	0	1	1	**4**	2	6	2	4	**14**
60	1	0	0	2,5	2	4	**10**	1	2	0	3	0	0	0	**6**	0	4	0	0	**4**
61	1	1	1	2,5	3	1	**10**	1	2	1	3	2	2	3	**14**	2	6	2	1	**11**
62	0	0	0	3	3	5	**11**	1	2	2	3	2	2	3	**15**	2	6	2	3	**13**
63	1	0	0	3	1	4	**9**	1	0	1	3	0	1	0	**6**	2	3	0	1	**6**
64	1	1	1	2	2	4	**11**	1	0	1	3	0	2	2	**9**	0	0	2	1	**3**
65	1	0	1	1,5	4	3	**11**	1	0	1	3	0	2	2	**9**	2	6	2	2	**12**
66	1	0	1	1,5	3	3	**10**	1	2	1	3	2	2	2	**13**	2	6	3	3	**14**

5.3.2 Pre, during, and post-test question analysis

Schools name improvement efforts as a key component in assessing whether learners are meeting the desired academic needs (Park et al*.,* 2012). In many cases, as a practitioner, it is beneficial to start with an approach that includes a baseline test. This identifies the benchmark of knowledge at the outset, and helps identify learners' academic needs so that supplemental interventions can be provided where needed in order to meet the standards set out by the South African Department of Education. In this study, a series of tests (pre, during, and post-tests) were administered to determine and monitor the progress and development of learners while using a certain set of experiential skills in order to aid and establish their proficiency in a given topic, namely Bryophyta. The aim of these tests was to evaluate the efficacy of the lesson, where lesson plans directed the teacher to develop experiential skills in the learners. When progress reports reached a "flat line" (Park et al*.,* 2012), this showed that there was a need for intervention, as the learners struggled to develop experiential skills from this point. I used this information to help make instructional modifications, with the aim of finding an intervention or combination of instructional approaches in the lesson plans which would enable the majority of learners to make adequate progress toward achieving grade-level proficiency on content standards. In this study, the measures were valid and reliable, which was critical when assessing the target content. These measures were also sensitive enough to detect improvements in experiential skills over a short period of four lessons.

The number of modes of experiential learning and their outcomes were constructed prior to designing the tests, and this construction was done according to the experiential skills development model measured in the tests. These modes and outcome measures are fundamental tools both within this research and the progression of experiential skills development going forward. Most importantly, the validity of the tests ensured that they measured the development of experiential skills as intended. These processes cannot be assigned validity if the tests did not display a high quality of precision and proved reliability. Reliability focused on a Retest and an Alternate form of reliability (Middleton, 2022). This allowed me to administer three different tests which covered varying levels of cognitive skills development, but which still required a development of question-and-answer.

- ***Pre-test analysis***

The pre-test was conducted after a basic introductory lesson of 50 minutes. The pre-test allowed the teacher to determine the grade-level of proficiency in the learners' basic knowledge, through experiential skills development in the mode of concrete experiences. Concrete experience allows for context and is an initiation into the theme. Learners can master the skills of listening and making notes. Bartle (2015) explains that experiential learning used in education is about connections and collaborations. My philosophy aligns with Bartle, as the learners' experiences play a vital role in how they understand and assimilate new knowledge. The first lesson developed their concrete experiences, leading to the introduction of the reflective observation mode, which defines the hands-on, practical section of Life Sciences. Table 5.3 shows questions 1.1.1 to 1.1.3 and 1.2, which required basic understanding of the theme based on recollection.

Table 5.3 Pre-test table analysis (Question 1.1.1 to 1.1.3 and 1.2)

QUESTIONS	**1.1.1**	**1.1.2**	**1.1.3**
MARK ALLOCATION			
0	33	53	50
1	33	13	16
TOTAL	**66**	**66**	**66**

QUESTION	**1.2**
MARK ALLOCATION	
0	0
1	1
1.5	7
2	20
2.5	24
3	15
TOTAL	**66**

Table 5.4 shows questions 2 and 3, which required basic observations and telematics and which included an analysis as well as the skill to draw a graph. These questions were designed to ensure that the learners were provided with context within the content.

Table 5.4 Pre-test table analysis (Question 2 and 3)

QUESTION	2
MARK ALLOCATION	
0	6
1	18
2	20
3	16
4	6
TOTAL	66

QUESTION	3
MARK ALLOCATION	
0	3
1	6
2	2
3	10
4	16
5	29
TOTAL	66

From the information in Table 5.3, it is clear that Question 1.1.1-1.1.3 as well as Question 1.2 (where learners were asked to describe the physical structures of Bryophyta, namely the rhizoids, the leaves or stem and shoot) showed an apparent division in skills and not in knowledge. A lack of knowledge would have shown itself in an inability to answer the question, or would have revealed a misunderstanding. However, the lack shown in the skill lies in the manner in which the question was answered. When asked to describe something, a learner should not only recall the required knowledge, but also show comprehension of the skill by making use of the knowledge being communicated. As practitioners, we tend to assume that learners will accumulate sufficient knowledge to answer lower cognitive questions of the type used in the pre-test. However, the results to the pre-test's lower cognitive questions clearly indicated that this was not the case. Only 50% of learners in Question 1.1.1, 20% in Question 1.1.2, and 24% in Question 1.1.3 were able to answer the question and receive a single mark. Question 1.2 was a collection of characteristics which supported the claim that Bryophyta is a thallus plant. Learners had to correctly identify these characteristics from a list given by the teacher. Surprisingly, learners struggled to identify these characteristics even when answers were given. The majority of learners could not grasp these basic skills in only one lesson.

Questions 2 and 3 each focused on reflective observation, which allows the learner to get deeply involved with the topic. Question 2 was designed to take learners from their paper, prescribed book, or PowerPoint presentation, to a hands-on presentation involving the clarification of knowledge while using abstractions and concrete situations. Staggeringly, only six learners out of a classroom of 66 were able to correctly identify four labels on a diagram after being introduced to the topic of moss. Question 3 was designed to focus on using basic stimuli to clarify what knowledge is needed from the context and to apply that knowledge, allowing learners to reflect on an experience by making inferences or by using telematics, in this case including a graph. The majority of learners were able to draw a double-line graph. Feedback was given after the results were obtained from the pre-test.

- ***During-test analysis***

The during test was conducted after a second lesson of 50 minutes. In this lesson, learners used microscopes to observe moss and clearly identify and discuss the structure, function, habitat, and water dependence of the moss. A part of the lesson allowed for feedback from the teacher. The second lesson ensured that the practical attributes and scientific investigation allowed the learner to move from reflective observation to abstract conceptualisation. The objective for this lesson included abstract conceptualisation and allowed for knowledge of classifications and categories, knowledge of principles and generalisations, and knowledge of theories, models, and structures. The tables below show Questions 1 to 3, which required the development of abstract conceptualisation.

Table 5.5 During-test table analysis (Question 1.1)

QUESTION	**1.1**
MARK ALLOCATION	
0	1
1	65
TOTAL	**66**

These results indicate that the majority of learners could process lower cognitive skills. Learners could recall or remember basic information, but were attentive to the manner in which the question was formulated. The question prompted the learner to describe the environment and the habitat in which a person may find a moss plant. It is clear that learners were successful in answering this question.

Question 1.2 engendered judgments regarding the value of the arrangement of leaves for given, pre-described purposes. It is clear from the analysis in Table 5.6 that learners made use of the feedback given from the previous lesson.

Table 5.6 During-test table analysis (Question 1.2)

QUESTION	**1.2**
MARK ALLOCATION	
0	22
1	9
2	35
TOTAL	**66**

The pre-test only required the learners to describe the physical structure of a plant's leaves, whereas the during-test asked the learners to evaluate how the leaves are arranged for the plant's specific purpose. Learners used the feedback from the previous lesson to utilise their experiential skills gained from the pre-test, which required only recalling the leaf structure and developing a new experiential skill, and which now required the learner to make inferences on the importance of said structure. The learners moved from a 24% success rate to a 53% success rate in a question which not only required more information, but which tested a higher cognitive level.

The results in Table 5.7 focus on Question 1.3. Here learners were expected to judge the function of the rhizoids. To 'judge' in this context means that a learner should be able to form an opinion after carefully sifting through the facts.

Table 5.7 During-test table analysis (Question 1.3)

QUESTION	1.3
MARK ALLOCATION	
0	29
1	25
2	12
TOTAL	**66**

In comparison to Question 1.2, Question 1.3 showed that learners continued to struggle with higher cognitive questions. It can be assumed that Question 1.2 required learners to employ their evaluation skills, with a primary focus on facts given, whereas Question 1.3 required the learners to judge. Judging focuses on the opinion the learners hold, and this requires insight. I can conclude that after exposing learners to a fact more than once, they were able to internalise the idea. However, learners struggled in certain questions to place the fact they had learned in a real-life situation. The information as seen in Table 5.8 shows the results on observing as an experiential skill. This skill also required the learner to recall knowledge in the mode of reflective observation. In this question, learners could interpret any picture of moss in a workbook and link the picture in the workbook to a practical, hands-on approach by observing the Bryophyta (moss) under a microscope. The Bryophyta was not only illustrated, but learners made use of their telematic scientific skills (drawing skills), which were successfully represented in the answer to Question 2.1.

Table 5.8 During-test table analysis (Question 2.1)

QUESTION	2.1
MARK ALLOCATION	
0	4
1	3
2	20
3	39
TOTAL	**66**

The results in Table 5.9 and in Table 5.10 appear to validate the theory that exposing learners to pre-visited ideas—in this case, a drainage system using the moss plant in the pre-test—allows them to draw conclusions using data as well as whatever facts they have themselves gathered. Question 2.3 asked learners to draw a conclusion on the usage of a drainage system in their own gardens. Out of a class of 66 learners, 71% of the learners could formulate an answer or successfully conclude the correct answer.

Table 5.9 During-test table analysis (Question 2.2)

QUESTION	**2.2**
MARK ALLOCATION	
0	19
1	17
2	30
TOTAL	**66**

Table 5.10 During-test table analysis (Question 2.3)

QUESTION	**2.3**
MARK ALLOCATION	
0	19
1	14
2	33
TOTAL	**66**

By observing the previous tables, we can deduce that the majority of learners were able to develop experiential skills related to the mode of reflective observations. The findings in Table 5.11 cover one of the first questions, which focused on abstract conceptualisation. The mode of abstract conceptualisation, according to our conceptual framework, is to balance experiences and known theories. The desired outcome of this is to process the experiential skill of reflection, and move towards a skill which allows for discovery. Theories are seen as an organised body of facts that are systematically interconnected to explain a phenomenon (Leedy and Ormrod, 2005; Johnson and Christensen, 2007). McMillan and Schumacher (2000) explain that utilising experiential skills and experiences can further be expressed through a theory, which can develop scientific knowledge in a specific situation. Question 3.1 asked learners to use their knowledge of the physical structures of moss, having judged and evaluated the importance of its different structures, and discover how the importance of water in these different structures may contribute to the life cycle of the moss plant.

Table 5.11 During-test table analysis (Question 3.1)

QUESTION	**3.1**
MARK ALLOCATION	
0	19
1	22
2	15
3	10
TOTAL	**66**

The information in Table 5.11 shows that 47 learners out of a classroom of 66 were able to acquire a mark for this question by using the experiential skills they had now mastered. This indicates that 71% of the learners were able to answer a higher cognitive question by utilising skills from previous lessons. The results also indicate that 38% of the learners had already shown promise in moving to the mode of active experimentation, which allows for learners to give a memorandum-based answer. This type of an answer is expected in a formal assessment, and is an indication of a proficient learner.

- ***Post-test analysis***

The pre and during-tests were focused on experiential skills that were classroom-oriented and related to knowledge that was assimilated. The post-test motivated the learner to use their experiences in a practical frame, and to move from an isolated mindset to one that would be effective outside the classroom. As stated in Chapter 2, real-life experience should connect to active experimentation. These experiences, initially extracted by the teacher as a facilitator, should ultimately be formulated independently by the learners. In this mode, learners must be able to use the theories explored in the previous modes to make decisions and solve problems. The table below shows the results of questions where learners had to recreate a drainage system with a moss plant, using its physical structures, adaptions and needs to ensure not only the life cycle of the Bryophyta but also the filtration of water as a drinkable source in nature.

Table 5.12 Post-test table analysis (Question 1.1)

QUESTION	**1.1**
MARK ALLOCATION	
0	17
1	15
2	34
TOTAL	**66**

The information in Table 5.12 suggests that of the 66 learners, 49 of them (74%) were able to successfully answer a question on a higher cognitive level using terminology they were briefly introduced to in Grade 10. As a teacher continuously monitoring progress and giving feedback, this indicates that while 38% of learners struggled to answer a similar question (Question 3.1) in the during-test, the success rate had now increased to 51%.

Table 5.13 Post-test table analysis (Question 1.2)

QUESTION	**1.2**
MARK ALLOCATION	
0	3
1	1
2	0
3	11
4	1
5	4

6	46
TOTAL	**66**

The results in Table 5.13 determined that 94% of learners were able to follow instructions, successfully construct two funnels that represented a drainage system with moss plants, and tabulate differences in the time and filtrate that was produced. The hands-on component of experiential skills development was very successful. The purpose of Question 1.3 was to make use of the data the learners had collected in Question 1.2, and compare which surface would be functional as a drainage system.

Table 5.14 Post-test table analysis (Question 1.3)

QUESTION	**1.3**
MARK ALLOCATION	
0	13
1	11
2	24
3	18
TOTAL	**66**

The analysis of Question 1.3 in Table 5.14 showed that 80% of learners could at least secure one or more marks in this question, indicating that learners could produce the required knowledge in this area. A further 64% of the learners could successfully relate the knowledge to the process, and 27% of the learners could achieve the maximum marks for this question by relating their knowledge to the process using scientific literacy and experiential skills. One of the secondary research questions posed in this study was to identify the specific experiential skills needed by learners in the Life Sciences classroom. This question could be further developed by asking, *How adept are our learners in scientific literacy?* Scientific literacy is seen as the body of knowledge which should be apparent to all Life Sciences learners as it pertains to the appreciation of the nature of science (Ajayi, 2018). Life Sciences in layman's terms can be seen as a body of knowledge and the processes of an existing and ongoing phenomenon which combines living things and their interactions with their surroundings (ArtiFacts, 2019). ‘Scientific literacy’ refers to the concept of knowledge and the implementation and application of knowledge, principles, and skills through the use of scientific ideas. Without the knowledge and the know-how of Life Sciences skills, the application thereof would not be possible. Successful integration of these skills into the Life Sciences classroom ensures a richer learning experience for the student.

In the table below, Table 5.15, the learners were asked to evaluate how well the experiment modelled a real drainage system. This required that learners come full circle in the experiential skills development process by focusing on basic facts and by considering the physical structures of the moss plant, using these points to generate an opinion on the experiment, how it sustains the Bryophyta’s life cycle, and how it works to produce filtrated water.

Table 5.15 Post-test table analysis (Question 1.4)

QUESTION	**1.4**
MARK ALLOCATION	
0	10
1	21
2	20
3	12
4	3
TOTAL	**66**

The results of Question 1.4 as given in Table 5.15 show that the majority of learners, at 85%, were able to attain one or more marks for this question. 53% of learners attained more than half of the question’s allocated marks, indicating in their accepted answers that water was indeed cleaner by referring to the physical structures of the moss. This was the first time any of these learners were exposed to such a higher-cognitive question, which is commonly used in Grade 12 end-of-year assessments. Superficial knowledge only for assessment purposes is not of any benefit, and the preferred goal is to enhance long-term knowledge in order to produce skilled learners who are able to demonstrate a deep understanding (Mathew et al., 2021). Of the learners in this study, 23% were able to harness all the experiential skills introduced to them throughout these lessons, and produced successful, memorandum-based answers, which in this case identifies a proficient learner in the theme of plant diversity: Bryophyta. The development of experiential skills can lead learners to engage with the subject and come forth with imaginative answers, indicating the stimulation of logical thinking as an added characteristic to the overall performance of the learner (Omatseye, 2007).

5.3.3 Data presentation and discussion of the pre, during, and post-tests

This section presents and describes data from the pre-tests, during-tests and post-tests, which were written by 66 Grade 11 Life Sciences learners. The purpose of these tests was to answer the secondary research question:

- *To what extent does the development of experiential skills influence the proficiency of Life Sciences learners?*

As introduced in Chapter 3, a series of four lessons on Bryophyta were developed following lesson plans that followed the structure of the conceptual framework. Table 5.16 shows the sequence of lessons and the writing of the tests.

Table 5.16 Sequence of lessons when writing the tests

Lesson	Mode of experiential skills	Test
1	Concrete experiences	
2	Reflective observation	Pre-test
3	Abstract conceptualisation	During-test
4	Active experimentation	Post-test

Each lesson focused on a specific mode of experiential learning to develop an experiential skill. After a lesson was concluded, a test was written. The pre-test and during-test each focused on the same type of questions, progressively moving from a lower-order cognitive skill to a higher-order cognitive skill. The pre-test and the during-test can be directly compared. A type of intervention lesson took place between the two tests in order to develop more experiential skills. The feedback on the pre-test allowed for learners to improve on the skills they had not yet mastered. By directly comparing the pre-test and the post-test results, the difference in skills development from the beginning of the lessons to the end of the lessons is readily apparent.

Each of the tests was based on Bloom’s Taxonomy, and included learning questions which predominantly focused on the modes of experiential learning. The first mode, concrete experiences, focused on lower-order questions which only required a demonstration of basic understanding. The second mode, reflective observation, focused on discussions with insight, telematics, and data analysis. The third mode, abstract conceptualisation, focused on discovering new knowledge while referring to known theories. The final mode, active experimentation, focused on linking science to society while answering higher-order questions, allowing the learner to receive the maximum number of marks in an assessment. All four modes of experiential learning were based on the conceptual framework as well as the lesson plans, which focused on the theme Bryophyta as stated by the Curriculum Assessment Policy Statement of the Department of Basic Education.

As explained in Chapter 3, descriptive inferential analyses were conducted to reduce data and validate the instruments. This was done using various scales which measure different experiential skills in the pre, during, and post-tests. I again made use of the audio recordings in order to draw inferences from the experiential skills developed by the participants (Zikmund & Babin, 2013). Using a t-test, the raw scores were used and then summarised into a table, which made the analysis of the entire set of final scores for each learner more manageable (Gravetter & Wallnau, 2009). The paired, one-tailed t-test, which focused on results from an alternative test which would decrease or increase significance, was used to make comparisons between the Life Sciences learners (N=66) experiential skills development in my classroom after specific lessons on Bryophyta had concluded. I assessed all of the 15-mark tests using a rubric with a Linkert scale to ensure consistency. The pre-test, during-test and post-test scores were presented in three different forms, namely the effectiveness of the test based on learners’ experiential skills development, the learner-to-question analysis, and the means of the pre-test, during-test and post-test. These three representations were score summary statistics, which were used to compare the pre-test, during-test and post-test scores.

5.3.3.1 Effectiveness of the test based on learners' experiential skills development

I measured the effectiveness of the tests based on the model fitting the information concerning the learners' experiential skills development in the tests through the Chi-square-test. The Chi-square-test showed statistical significance between the tests and the development of experiential skills as shown in Table 5.17.

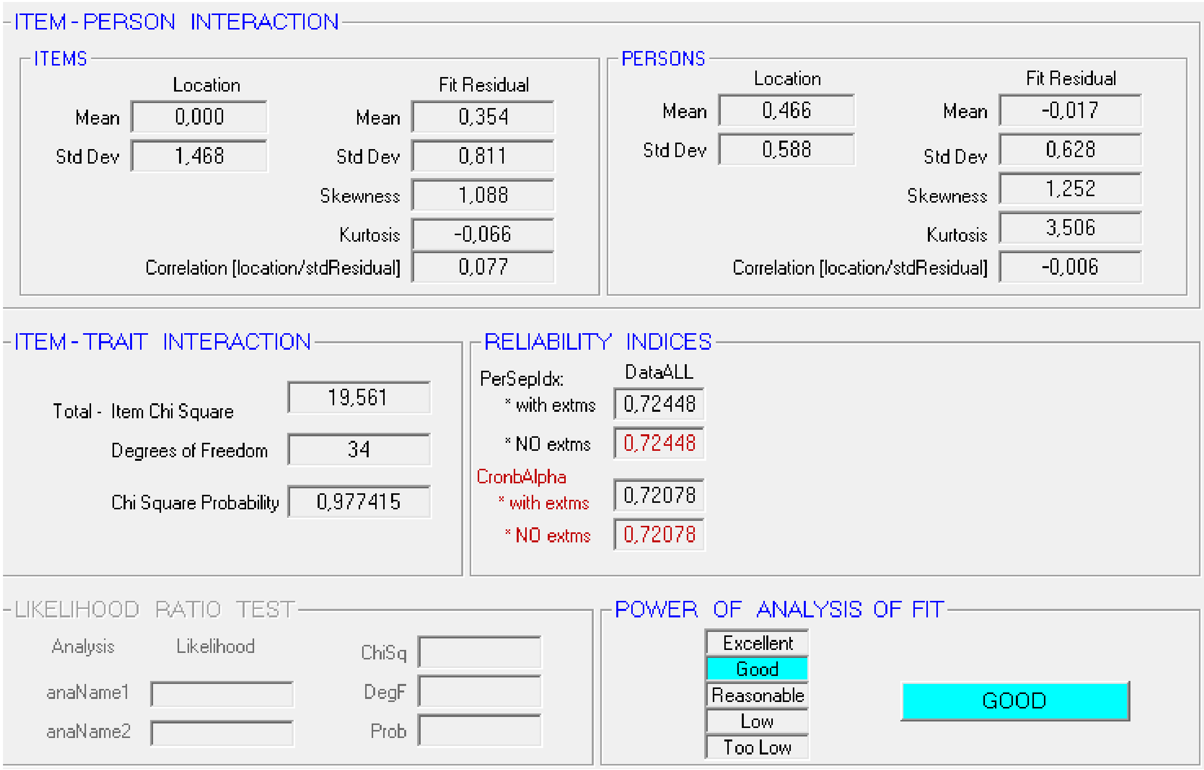
Table 5.17 Effectiveness of the test based on learners' experiential skills development

Model Fitting Information				
Model	**-2 Log Likelihood**	**Chi-Square**	**df**	**Sig.**
Intercept Only	290.701			
Final	229.912	60.789	2	<,001
Goodness-of-Fit				
	Chi-Square	**df**		**Sig.**
Pearson	605.898	642		.843
Deviance	212.853	642		1.000

The Cronbach's alpha reliability coefficient normally range between 0 and 1. The closer the coefficient is to 1.0, the greater the internal consistency in the scale. As a result of this the significant Cronbach's alpha coefficient in the Table 5.17 increases as the number of tests increases, indicating to what extent the learners' experiential skills developed as the tests' effectiveness increased.

The combined data for the pre, during, and post-tests shows that the power of analysis is significant when analysing the influence of experiential skills in learner proficiency. The data showed a clear link between the performance of the participants through their ability to answer the questions as set by the modes in the conceptual framework. Throughout the analysis, the RUMM2030 identified the persons as the participants and the items as the questions in each test. Figure 5.1 presents the summary statistics from RUMM 2030 of the pre, during, and post-tests.

Figure 5.1 Summary statistics from RUMM2030 of pre, during, and post-tests



The summarised analysis covered the results of three tests (pre, during and post) which were administered to measure the participants' ability to perform at different levels of experiential skills. Once the pre-test was assessed, an intervention lesson took place before the during-test could be completed and assessed, followed by another intervention lesson before the post-test could be carried out. Table 5.18 explains the statistics from RUMM2030 as seen in Figure 5.1.

Table 5.18 The summarised statistics from RUMM2030 as seen in Figure 5.1

Summary statistics: **Pre, during, and post-test**	**ITEMS** **(Questions)**	**Persons** **(Participants: N=66)**
Mean	0.354	-0.017
Std Dev	0.811	0.628
Power of analysis of fit	Good	Good

Table 5.18 depicts the descriptive statistics (means and standard deviations) obtained from the three tests. Based on the information in this table, it is evident that questions-participant relationship indicates a mean of (mean=0.354) and (mean=-0.017). The means of the pre, during, and post-tests show significant differences. The different questions and their effectiveness in each test were successful as an intervention to develop experiential skills in learners. Triangulation is covered in Chapter 6.

5.3.3.2 The learner to question RUMM2030 analysis of the pre, during, and post-tests

When I completed the marking of the pre, during, and post-tests, I calculated the relationship between the learners' ability to use the relevant experiential skill in the tests (the instrument) with specifically designed questions that correlate with the modes of experiential learning in the conceptual framework as a base to start a summary. When looking at the learners (persons) in the RUMM2030 analysis, it indicated that the more positive the measure, the higher the portrayed ability of the learner to successfully master an experiential skill. When a learner was measured more negatively on the scale, this showed a lower ability to master the experiential skill. When looking at the question (item) in the RUMM2030 analysis, it indicated that the more positive the measure on the scale the easier the question was for the learner to complete. The more negative the measure on the scale, the more the learners struggled to answer the question and, by correlation, master the relevant experiential skill. Figure 5.2 shows the difference between the pre-test and the during-test.

Figure 5.2 Difference between the pre-test and the during-test

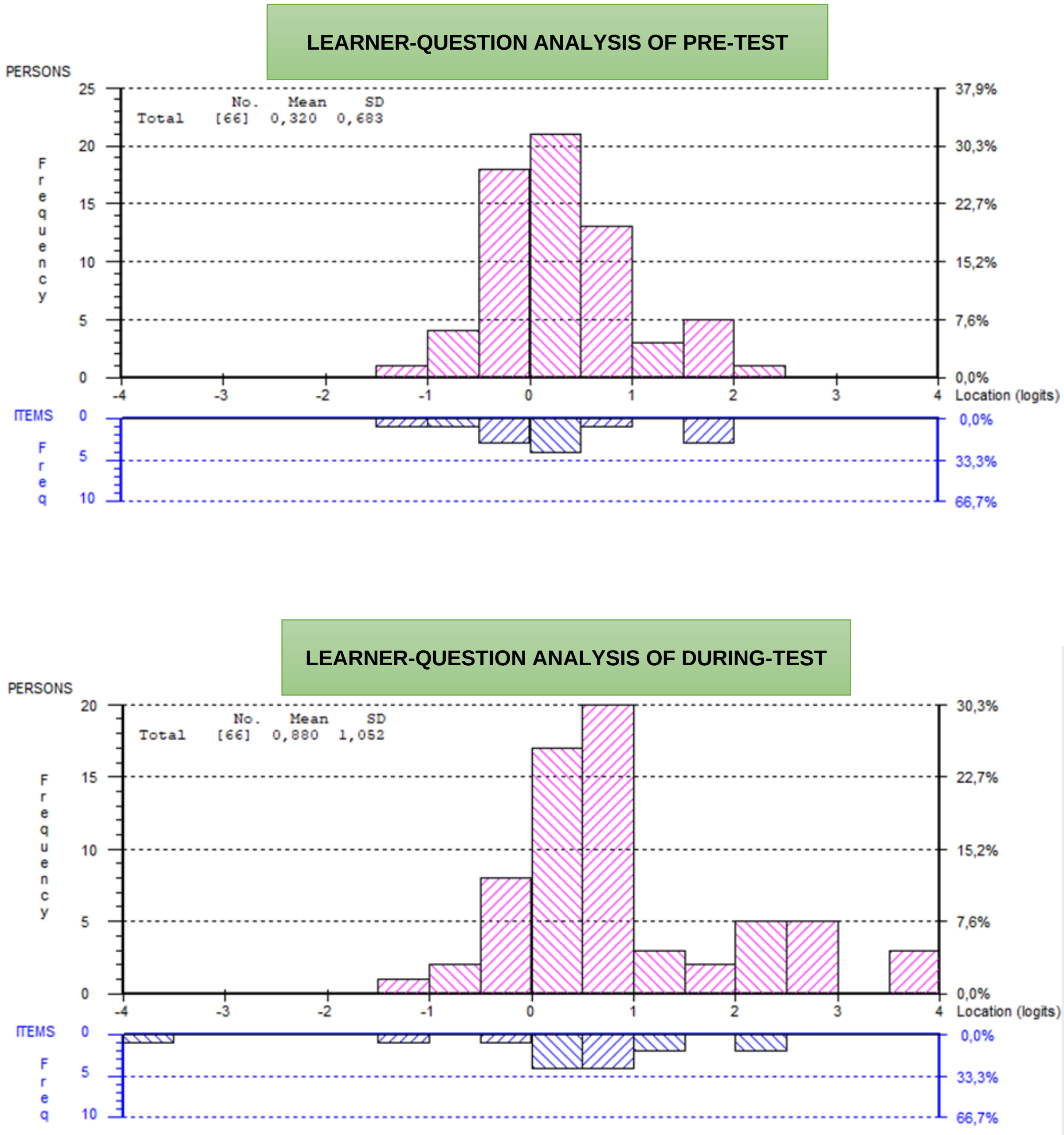
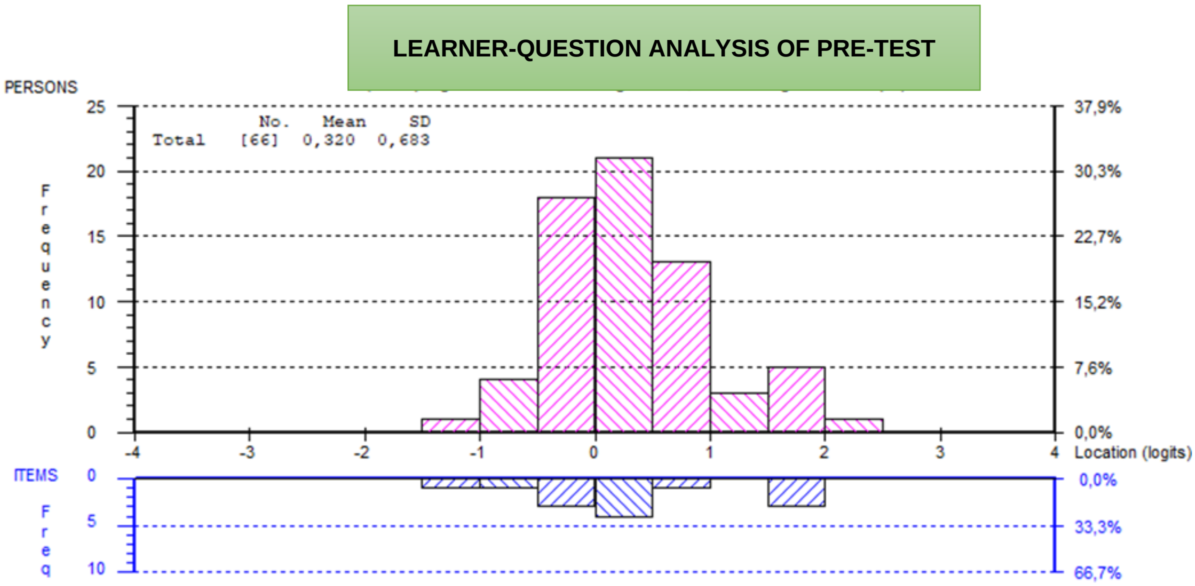


Figure 5.2 shows that the during-test's statistical analysis of the learners' understanding and development of basic skills was relatively higher than in the pre-test. The majority of learners mastered the set experiential skills, which had to be developed during the first two lessons. It is clear that even though some learners struggled with higher-order questions in the during-test, the greatest impact was on the questions and the learners' ability to show proficiency when answering specific questions. It is evident that most learners found the questions in the during-test easier than in the pre-test. A greater understanding on the application of the experiential skills

was developed. Based on the information in Figure 5.2, it is evident that the relationship of learner-question analysis between the pre and during-test indicate a mean of (mean=0.320) and (mean=0.880). The means of the pre and during-tests show significant differences.

Figure 5.3 The difference between the pre-test and the post-test



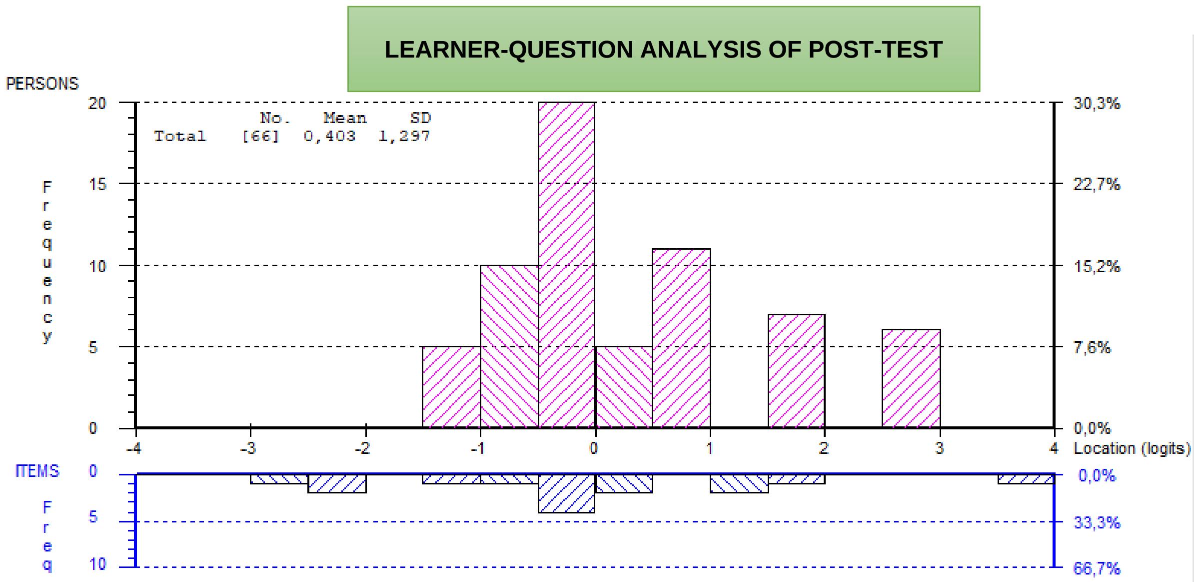


Figure 5.3 shows that the post-test's statistical analysis of the learners' understanding of the development of the skills needed to be proficient in the theme of Bryophyta was relatively higher than in the pre-test, when observing the frequency of learner to item

analysis. Even though there is a clear spread in the data, it can nevertheless be concluded that the majority of learners mastered the experiential skills on a higher cognitive level, as the post-test assessed higher-order skills than that of the pre-test, allowing learners to store the information and use the acquired experiential skills in future assessments. With the positive projectile of the learners' abilities, we can conclude that more lessons will further enhance these abilities, or will assist the learners who still need to master the needed skills. It is evident in the spread of the bars of the graph that learners struggled with different types of questions, as I cannot clearly identify a specific question type which would need more attention than the others. The greatest impact shows that even though the experiential skills required by the questions were of a higher cognitive order, the majority of the learners still showed proficiency when answering specific questions. It can be concluded that even though questions were of a higher cognitive demand, more than 25% of learners exhibited the ability to answer the questions in the post-test which they could not answer in the pre-test. Based on the information in Figure 5.3, it is evident that the relationship of learner-question analysis between the pre and post-test indicates a mean of (mean=0.320) and (mean=0.403). The means of the pre and post-tests show significant differences. A greater understanding on the application of experiential skills was developed.

5.3.3.3 The result of significant differences between the pre-test, during-test and post-test

As mentioned in the introduction, the total mark was 15 per test and all tests were marked by myself for consistency. The pre-test, during-test and post-test scores were presented in the form of significant differences. The significant differences were used as score summary statistics, which compared the pre-test against the during-test scores, and the pre-test against the post-test scores. Significant differences found between the pre, during, and post-tests are represented in the table below.

Table 5.19 Results of each participant significant difference in the pre, during, and post-tests

LEARNER	PRE-TEST	DURING-TEST	POST-TEST
1	-0,08	-0,187	0,859
2	0,718	0,719	-0,493
3	0,095	-0,187	1,521

4	-0,794	0,256	-0,29
5	0,095	2,661	-0,29
6	0,095	0,481	-0,002
7	0,342	3,507	2,606
8	0,718	0,719	1,521
9	0,342	1,617	2,606
10	-0,234	0,256	0,377
11	-0,234	-0,187	0,377
12	-0,559	2,661	0,859
13	0,342	0,481	-0,493
14	0,095	0,035	-0,002
15	-0,234	0,719	0,377
16	1,178	0,256	-0,644
17	0,718	2,661	4,383
18	-0,234	0,035	-1,119
19	-0,08	0,256	-1,271
20	0,342	1,269	1,521
21	1,707	0,977	0,859
22	0,342	0,977	-0,29
23	-0,389	-1,047	-0,493
24	0,718	0,719	2,606
25	0,095	-0,421	-1,119
26	0,095	1,617	2,606
27	-0,234	0,035	-0,77
28	-0,08	-0,688	-0,998
29	-0,08	0,977	0,859
30	1,707	0,481	0,859
31	0,095	1,269	4,383
32	1,707	0,256	0,859
33	0,718	0,977	0,859
34	0,342	2,054	1,521
35	-0,559	-0,187	-1,119
36	-0,389	0,481	-0,883
37	0,718	-0,421	-0,493
38	0,718	0,481	0,377
39	1,178	1,269	-0,002
40	-0,234	0,977	1,521
41	1,707	0,719	0,859
42	0,718	0,977	-0,002
43	0,095	0,035	0,859
44	0,342	0,719	-0,77
45	0,342	3,507	-0,493
46	1,178	0,719	-0,29
47	-0,389	0,977	-0,29

48	-0,559	0,977	-0,29
49	-0,08	0,977	1,521
50	0,342	2,054	-0,29
51	-1,295	0,481	-0,493
52	2,408	2,054	-0,002
53	1,707	-0,688	-0,29
54	-0,08	0,977	-0,77
55	-0,08	0,977	-0,77
56	0,718	2,661	-0,493
57	-0,389	-0,187	-0,883
58	0,718	2,054	0,859
59	-0,389	-0,421	2,606
60	0,342	0,035	-0,998
61	0,342	2,661	0,377
62	0,718	3,507	1,521
63	0,095	0,035	-0,77
64	0,718	0,719	-1,119
65	0,718	0,719	0,859
66	0,342	2,054	2,606

Comparing the means of the pre, during, and post-tests using the t-test

Significant differences between the means of the pre-test and during-test, as well as the pre-test and post-test, were established. Almost all participants in the table showed a measurable difference between the different tests. This helped to determine if the series of lessons had any effect on the results as pertaining to the development of experiential skills. The null hypothesis, −H0 in the process of a t-test, stated that the pre-test was equal to the means of the during-test (A = B). Alternatively, the hypothesis −H1 stated that the means of the pre-test was not equal to that of the during-test (A ≠ B) (Kavai, 2013). If the p-value was smaller than p=0.05, the study accepted the null hypothesis. Consequently, the t-test of the pre-test and post-test were also hypothesised. The pre-test was equal to the means of the post-test (A = B), alternatively the hypothesis −H1 stated that the means of the pre-test was not equal to the post-test (A ≠ B) (Kavai, 2013).

Data presentation for the pre-test, during-test and post-test means and the t-test for the overall marks

It was considered essential to analyse the development of experiential skills or the knowledge gained (during-test mean – pre-test mean, and post-test mean – pre-test mean) of the total marks for the entire group of Grade 11 Life Sciences learners before looking at the t-test results, which then established if the development for each variable was significant. Table 5.20 shows significant differences between the during-test and the pre-test.

Table 5.20 Significant differences between the during-test and the pre-test

	DURING-TEST	PRE-TEST
Mean	0,880454545	0,403015152
Variance	1,106441667	1,683065954
Observations	66	66
Pearson Correlation	0,379134544	
Hypothesized Mean Difference	0	
df	65	
t Stat	2,928076767	
P(T<=t) one-tail	0,002348713	
t Critical one-tail	1,668635976	
P(T<=t) two-tail	0,004697426	
t Critical two-tail	1,997137908	

Here we can report P (T<=t) two-tail. In this case, p = 0.0046. This figure is smaller than 0.05, meaning that there is a significance in the performance between learners' performances in the pre-test and in the during test. Table 5.21 shows the significant differences between the during-test and the post-test results.

Table 5.21 Significant difference between the during-test and the post-test

	DURING-TEST	POST-TEST
Mean	0,880454545	0,403015152
Variance	1,106441667	1,683065954
Observations	66	66
Pearson Correlation	0,379134544	
Hypothesized Mean Difference	0	
df	65	
t Stat	2,928076767	
P(T<=t) one-tail	0,002348713	
t Critical one-tail	1,668635976	
P(T<=t) two-tail	0,004697426	
t Critical two-tail	1,997137908	

Here we can report P (T<=t) two-tail. In this case, p = 0.0046. This smaller than 0.05. This means that there is significance performance between learners' performances in the post-test and during test. Table 5.22 shows the significant difference between the pre-test and the post-test.

Table 5.22 Significant differences between the pre-test and the post-test

	POST-TEST	PRE-TEST
Mean	0,403015152	0,319621212
Variance	1,683065954	0,466920024
Observations	66	66
Pearson Correlation	0,132314129	
Hypothesized Mean Difference	0	
df	65	
t Stat	0,489527487	
P(T<=t) one-tail	0,313058162	
t Critical one-tail	1,668635976	
P(T<=t) two-tail	0,626116324	
t Critical two-tail	1,997137908	

Here we can report P (T<=t) two-tail. In this case, p = 0.626116324. This is larger than 0.05, so we fail to reject the null hypothesis. This means that while learners performed better in the post-test than in the pre-test, there was no significant difference between these performances. The learners wrote the pre-test as a means of measuring their basic understanding, as well as to gauge the development of their experiential skills following the introductory lesson. Comparing the pre and post-tests scores, the scores following the lessons were relatively higher, as a type of intervention had been completed. The greatest impacts from the lessons were evident in the during-test, as these tested similar types of questions while requiring a higher development of experiential skills, and this directed the learning which was lacking in the learners. The participants completed the tests with improved skills over the series of lessons. This may be interpreted to mean that the series of lessons which focused on developing experiential skills possibly enhanced the learners’ overall proficiency in completing assessments.

5.3.4 Questionnaire analysis

This section presents and discusses data from 66 questionnaires completed by Grade 11 Life Sciences learners from the same school in Pretoria. The purpose of this questionnaire was to answer research sub-question three:

- *How do learners perceive experiential-based practicals aligned with content?*

As mentioned in Chapter 3, the questionnaires were given to the Grade 11 learners soon after carrying out a series of lessons, and only after they had completed the pre-test, during-test and post-test. The data gathered from the questionnaire answers was coded and summarised logically. Coding is the process of converting questionnaire data into meaningful categories in order to facilitate analysis (Korstjens & Moser, 2018; Malakoff, 2012). The coding on the closed-ended questions was done using the Likert scale.

5.3.4.1 Data presentation and discussion of the questionnaire

The questionnaire consisted of 23 statements, and learners were required to tick the relevant box on a Likert scale to indicate the extent of their agreement or disagreement with each statement (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree). The statements were developed to determine the attitudes and opinions of the participants on the series of lessons, and their ability to apply the experientials skills they had mastered as a result of their attendance and participation in the class. It would also indicate their attitude and opinions on whether these experiential-based lessons aligned with the content they would be assessed on in the November examinations. The data gathered was subjected to measures of central tendency—specifically frequency, cumulative frequency, percentage, and cumulative percentage—to determine the frequency of occurrence of a particular response. The summary was presented in tabular form as a frequency. Table 5.23 shows the frequency distribution of responses for the 23 statements.

Table 5.23 Frequency distribution of the responses on questionnaire

STATEMENT	LEVEL OF AGREEMENT									
	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
I find having specific objectives beneficial in directing what I should achieve at the end of a lesson.	0	0	0	0	14	21.2	30	45.5	22	33.3
Most times I believe the way in which a lesson is conducted justifies the knowledge applicable in real-life.	0	0	4	6.1	18	27.3	23	34.8	21	31.8
I am keen on exploring the basic techniques supporting practicals with content.	0	0	0	0	6	9.1	27	40.9	33	50.0
I feel that the introductory lesson gave me enough basic knowledge on the diversity of plants.	1	1.5	15	22.7	25	37.9	17	25.8	8	12.1
I feel that the teacher improved my ability to answer questions that require basic understanding.	0	0	1	1.5	6	9.1	32	48.5	27	40.9
I enjoy being exposed to/doing hands-on work in the classroom.	1	1.5	1	1.5	7	10.6	10	15.2	47	71.2
I am open to change my attitude to practicals to improve my skills.	0	0	0	0	16	24.2	19	28.8	31	47.0
I feel that my previous knowledge from the introductory lesson helped establish my thought process in the answering of the practical lesson.	0	0	3	4.5	19	28.8	30	45.5	14	21.2
I feel I can use my observation skills because of the introductory lesson in order to reflect successfully on questions that require more advanced interpretation skills.	0	0	1	1.5	27	40.9	32	48.5	6	9.1
I feel that different skills are important for answering different types of questions.	0	0	2	3.0	6	9.1	28	42.4	30	45.5
I feel after the experiential lessons that I can answer questions which require understanding or identification.	0	0	7	10.6	15	22.7	26	39.4	18	27.3

I feel after the experiential lessons that I can answer questions which require explanations.	7	10.6	2	3.0	16	24.2	23	34.8	18	27.3
I feel after the experiential lessons that I can answer questions which require me to demonstrate my knowledge.	7	10.6	0	0	15	22.7	33	50.0	11	16.7
I feel after the experiential lessons that I can answer questions which require me to analyse data.	0	0	0	0	5	7.6	37	56.1	24	36.4
I feel after the experiential lessons that I can answer questions which require me to judge whether a topic is relevant.	0	0	1	1.5	28	42.2	29	43.9	8	12.1
I feel after the experiential lessons that I can answer questions which require me to create new knowledge and apply it to known theories.	0	0	4	6.1	29	43.9	24	36.4	9	13.6
I think I now possess ALL of the skills needed to complete a Life Sciences task which could be content-based.	0	0	12	18.2	21	31.8	25	37.9	8	12.1
I feel the manner in which the lesson was conducted allowed me to discover my own knowledge on the topic.	0	0	6	9.1	19	28.8	32	48.5	9	13.6
With my new skills, I think carefully before answering certain questions or contributing to discussions.	0	0	1	1.5	10	15.2	31	47.0	24	36.4
When things went wrong in practicals or when answering content-based questions, I was happy to shrug it off and 'put it down to experience'.	0	0	1	1.5	21	31.8	23	34.8	21	31.8
I will be able to relate my current actions and skills development to the longer-term, bigger picture such as in tests or in real-life.	0	0	1	1.5	26	39.4	28	42.4	11	16.7
If I have to write a report, I will now be able to relay the knowledge with the skills I know and answer the questions according to marks allocated.	0	0	6	9.1	26	39.4	28	42.4	6	9.1
I can now see inconsistencies and weaknesses in other people's arguments.	0	0	3	4.5	22	33.3	23	34.8	18	27.3

Firstly, I wanted to establish the benefit of providing specific objectives or plans before the lesson started in order to direct what should be achieved by the end of the lesson. A cumulative percentage of over 78% of the learners who completed the survey agreed or strongly agreed that knowing the objectives prior to the lesson allowed them to work towards the necessary knowledge or skills required to successfully complete future assessments. The majority of the learners indicated a belief that the way a lesson is conducted aligns with the knowledge in terms of how a skill can be applied in real life. This is likely due to the fact that learners had an opportunity to test this theory in the classroom as, following the series of lessons on Bryophyta, the teacher allowed the learners to physically use moss and apply their new knowledge on the topic of Bryophyta to build a drainage system. I continuously referred to Bear Grylls—the famous British outdoor adventurer and wilderness survival expert—as a motivator in how to understand the characteristics of a plant when judging the true scope of the Bryophyta's usefulness.

The learners were asked, in correlation with the third secondary research question, whether they were keen on exploring the basic techniques needed to complete practicals with the support of the subject content. The learners indicated, on a cumulative percentage of over 90%, that this was a major factor in Life Sciences. When conducting practicals, basic knowledge is usually introduced with the expectation that it be applied with insight. Even though only 25 of the sample of 66 learners agreed or strongly agreed that the introductory lesson gave them enough basic knowledge on the diversity of plants, a total of 59 learners out of the sample of 66 indicated that the lessons improved their ability in basic understanding of the theme. I can conclude that this is a very important find, as all assessments—according to Section 4 of the Curriculum Assessment Policy statement—are required to have a minimum total of 40% of lower cognitive skills and basic knowledge (DoE, 2019). By looking at the data, most learners should successfully achieve the minimum requirement to pass an assessment.

When asked whether the learners enjoyed hands-on, learner-centred work, a cumulative percentage of more than 86% agreed or strongly agreed with this statement. When asked to report whether they were open to improving their practical skills, a cumulative percentage of over 75% of the leaners still believed they could do better. When faced with statements on the questionnaire which referred to the introductory lesson, learners clearly believed that covering a theme such as Bryophyta in one lesson was not enough to successfully develop an experiential skill. When learners were asked if they felt that the introductory lesson helped establish their thought process when answering questions in the practical lessons, 44 from the sample of 66 agreed or strongly agreed. In correlation, 38 of the 66 learners agreed or strongly agreed that the introductory lesson allowed them the necessary skills to observe and reflect on questions requiring more advanced interpretation skills. These findings show that learners do not feel confident in their knowledge or skills after only one lesson on a theme. Before reporting on all the experiential skills learners may need in a theme in order to be proficient Life Sciences learners, I wanted to establish whether the learners understood that when completing assessments—be they content-based or requiring a practical aspect—it is important to answer different questions using different skills. A cumulative percentage of more than 87% of the learners agreed or strongly agreed that different skills are important when attempting to answer different types of questions. Exposing learners to different types of questions throughout the curriculum, be they summative or formative, allows learners to be mindful of the skill they need to use or develop in order to become proficient in a theme. Table 5.24 depicts the experientials skills the learners develop over the series of lessons, in association with the conceptual framework and lesson plans (Bates, 2015).

Table 5.24 Experiential skills learners develop after the series of lessons

Experiential skill	**Cumulative percentage of sample**
Understanding or identification	66.7 %
Explanations	66.1 %
Demonstrating knowledge	66.7 %
Analysing data	92.5 %
Judging	56 %
Creating new knowledge and applying it to known theories	53.6 %
I think I now possess ALL of the skills needed to complete a Life Sciences task which could be content based.	50 %

Table 5.24 shows that 66.7% (more than two-thirds) of the learners felt that they had sufficient knowledge and had developed the skills needed to receive a mark which they are satisfied with in an assessment. As previously stated, this indicates that the majority of the learners should be able to pass an assessment. The findings on the questionnaire also indicated that 66.1% of the sample felt confident in producing explanations that would receive full marks in an assessment. Both of the experiential skills—namely understanding, or identification and explanation—demonstrate knowledge. When learners were required to report on this skill, a cumulative percentage of 66.7% of learners indicated that the agreed or strongly agreed that they were confident in the experiential skill they had developed.

In the conceptual framework, it was indicated that the lessons should also cover an aspect which would allow the Life Sciences teacher to demonstrate how to develop the learners' telematics skills, such as drawing graphs and analysing the data. As a practitioner, I can say that the experiential skill of telematics is a major part of examinations, and as such should not be taken lightly. A staggering 92.5% of the learners felt that they were confident in this skill, and should earn a mark of distinction in an assessment. When looking back at the pre-test, during-test and post-test, all tests assessed an aspect of the telematics skill, and learners did in fact achieve their goal.

When assessing whether the learners were able to develop experiential skills on a higher cognitive level, which required the learners to answer advanced questions such as judging or creating new knowledge from known theories, more than half of the sample indicated that they were confident in these skills. A cumulative percentage of 56% indicated that they should be able to judge whether a topic is relevant, while 53.6% indicated that they should be able to create new knowledge from known theories. Both these experiential skills were tested in the during-test and the post-test. Finally, the learners were asked whether they thought that they possessed all the skills needed to complete a Life Sciences task. A cumulative percentage of 50% felt confident that they possessed all the skills as set out by the conceptual framework in creating a proficient Life Sciences learner. It is also necessary to mention that a cumulative percentage of 31.8% of the sample felt neutral. It can be concluded that if these learners had another lesson to strengthen their skills, then an even higher percentage of learners would possess all the experiential skills covered over the series of lessons.

Learners were questioned on their mind-set as related to the issue of developing an array of experiential skills. The question focused on whether the learners would think more carefully before answering different types of questions requiring different types of skills. A total of 41 out of 66 learners revealed that they felt they did think carefully, and that they would continue to think carefully in future. A total of 19 learners were neutral on this matter. It is fair to deduce that these learners are likely the same learners who felt that they had not yet developed all the experiential skills covered over the lessons. If these skills could be developed in future lessons, the total number of learners who feel confident in their judgement in answering questions would also be higher. The majority of learners, at 44, acknowledged the realisation that when given feedback on the tests (instruments) used to assess the experiential skill, and found that they had answered the questions incorrectly or did not receive the maximum number of marks, they could put this down as a learning curve. From this finding, I can conclude that learners do indeed learn through doing. When completing a task, learners develop experiential skills that can be tested during other assessments in other themes. A cumulative percentage of 59.1% agreed or strongly agreed that the development of these skills would be effective in the long-term. Even though 39.4% of learners were neutral on this matter, I can conclude that learners held a positive attitude towards the development of these experiential skills, and that if the opportunity did present itself, the learners who indicated a neutral stance would likewise later agree to the long-term effectiveness of their skills development. In harnessing these experiential skills—which the majority of the learners indicated were effective—a cumulative percentage of 62.1% of learners realised that they had not only developed experiential skills, but were now able to identify consistencies and weaknesses in other learners' arguments, especially when placed in a group setting in the post-test.

- ***The means for the learners in correlation with the questionnaire***

As explained in the introduction to the questionnaires, the questionnaire consisted of 23 statements requiring learners to tick the relevant box (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree) on a Likert scale to indicate the extent of their agreement or disagreement with each statement. During the reduction phase, I looked at three different themes, together with their key phrases and colour codes, and logically summarised the key phrases not only as they related to the secondary research questions, but also how they addressed the conceptual framework. As an example of how I went about this, I made sure while individually analysing each statement that they could all be grouped into one or more of three themes, namely:

1. Benefits of experiential lessons
2. Experiential skills development
3. Improved proficiency

These three themes were selected to ascertain the extent of significance in the mean of each statement, while also giving me the opportunity to provide a conclusion on the findings as a whole. The summary was presented in tabular form in order to identify whether the majority of learners agreed or strongly agreed with the statements. These statements focused on whether learners developed the required experiential skills needed to become proficient learners. Each statement was colour-coded to the specific theme in order to give an overview of the questionnaire. The questionnaire consisted of 23 statements. Ten of these statements were grouped under the theme 'Benefits of experiential lessons'; six statements were grouped under the theme 'Experiential skill development', and; seven statements were grouped under the theme 'Improved proficiency'. Table 5.25 shows the process of colour-coding in relation to the statements and themes.

Table 5.25 Colour-coding in relation to the statements and themes

Theme	**Colour-coded statements**
Benefits of experiential lessons	10
Experiential skills development	6
Improved proficiency	7

To produce the means distribution of each statement, key phrases were developed for use in the SSPS program, which would generate the necessary data. Table 5.26 shows the statements with the corresponding key phrase. The table also indicates which statements and phrases would be grouped under the three themes as displayed in Table 5.25.

Table 5.26 Key phrases describing each statement in the questionnaire

	Statement	Key phrase
1	I find having specific objectives and plans beneficial in directing what I should achieve at the end of a lesson.	Benefits of lesson objectives
2	Most times I believe the way in which a lesson is conducted justifies the knowledge applicable in real-life.	Real-life application
3	I am keen on exploring the basic techniques supporting practicals with content.	Techniques supporting practicals with content
4	I feel that the introductory lesson gave me enough basic knowledge on the diversity of plants.	Introductory lesson
5	I feel that the teacher improved my ability to answer questions that require basic understanding.	Ability to answer questions
6	I enjoy being exposed to/doing hands-on work in the classroom.	Hans-on activities
7	I am open to changing my attitude to practicals to improve my skills.	Attitude towards practicals
8	I feel that my previous knowledge from the introductory lesson helped establish my thought process in the answering of the practical lesson.	Thought process in practical lessons
9	I feel I can use my observation skills because of the introductory lesson in order to reflect successfully on questions that require more advanced interpretation skills.	Reflecting using observation skills
10	I feel that different skills are important for answering different types of questions.	Skills needed for different types of questions
11	I feel after the experiential lessons that I can answer questions which require understanding or identification.	Answering with understanding
12	I feel after the experiential lessons that I can answer questions which require explanations.	Answering with detailed explanation
13	I feel after the experiential lessons that I can answer questions which require me to demonstrate my knowledge.	Answering while demonstrating knowledge
14	I feel after the experiential lessons that I can answer questions which require me to analyse data.	Answering with insight on detailed analysis
15	I feel after the experiential lessons that I can answer questions which require me to judge whether a topic is relevant.	Answering using my own judgement
16	I feel after the experiential lessons that I can answer questions which require me to create new knowledge and apply it to known theories.	Applying new knowledge
17	I think I now possess ALL of the skills needed to complete a Life Sciences task which could be content-based.	Life Sciences skill set
18	I feel the manner in which the lesson was conducted allowed me to discover my own knowledge on the topic.	Discovering own knowledge
19	With my new skills I think carefully before taking action in certain questions or discussions.	Thought process in discussions
20	When things went wrong in practicals or answering content-based questions, I was happy to shrug it off and 'put it down to experience'.	Experience through learning

21	I will be able to relate my current actions and skills development to the longer-term bigger picture such as tests or real-life.	Relating current actions to assessment
22	If I had to write a report, I would now be able to write the knowledge with the skills I know and answer the question according to marks allocated.	Answering according to mark allocation
23	I can now see inconsistencies and weaknesses in other people's arguments.	Identifying flawed arguments

When processing the three themes with the corresponding 23 key phrases in the SSPS program, the means distribution was used to ensure that objective and neutral conclusions could be made to ensure reliability. Furthermore, the reliability of the questionnaire was assessed using the Cronbach's Alpha, since the Likert scale was applicable to all the questions given in the questionnaire. The Cronbach's Alpha allowed the study to be unbiased on my part. The questionnaires were processed using statistical objectivity. It would give me an opportunity in Chapter 6, in the quantitative approach to triangulate the data that will ensure convergence. Triangulation will allow for a multi-dimensional approach to the quantitative data where questionnaire, the pre-test, during-test and the post-test results can be compared.

The scale used in the Cronbach's Alpha reliability test ranges from 0–1. The closer the reliability level is to 1, the higher the reliability of the key phrases. According to Maree (2020), a reliable estimate of 0.80 is required for internal reliability. When an instrument shows a range of lower than 0.60, it is regarded as an unacceptable application and would compromise the internal reliability of the study. In the case of this study, the reliability coefficients which were considered acceptable ranged between 0.75 and 0.85. Table 5.27 shows the means distribution of responses for the 23 statements using key phrases with its Cronbach's Alpha coefficient.

Table 5.27 Means distribution of responses for the 23 statements using key phrases

Key phrases	Scale Mean	Cronbach's Alpha reliability coefficient	Standard deviation	N
Benefits of lesson objectives	4.12	.804	.734	66
Real-life application	3.92	.772	.917	66
Techniques supporting practicals with content	4.41	.784	.656	66
Introductory lesson	3.24	.809	.993	66
Ability to answer questions	4.29	.780	.696	66
Hands-on activities	4.52	.800	.932	66
Attitude towards practicals	4.23	.780	.819	66
Thought process in practical lessons	3.83	.797	.815	66
Reflecting using observation skills	3.65	.784	.668	66
Skills needed for different types of questions	4.30	.807	.764	66
Answering with understanding	3.83	.765	.954	66
Answering with detailed explanation	3.65	.759	1.222	66
Answering while demonstrating knowledge	3.62	.762	1.106	66
Answering with insight on detailed analysis	4.29	.780	.602	66
Answering using my own judgement	3.67	.781	.709	66
Applying new knowledge	3.58	.790	.805	66
Life Sciences skills set	3.44	.765	.930	66
Discovering own knowledge	3.67	.774	.829	66
Thought process in discussions	4.18	.799	.742	66
Experience through learning	3.97	.783	.841	66
Relating current actions to assessment	3.74	.763	.751	66
Answering according to mark allocation	3.52	.770	.789	66
Identifying flawed arguments	3.85	.771	.881	66

- ***Theme 1: Benefits of experiential lessons***

Theme one explains the participants' understanding of the benefits of experiential lessons. Bartle (2015) explains that experiential lessons used in education are about connections and collaborations. My philosophy aligns with that of Bartle, as learners' experiences play a vital role in how they understand new knowledge. The literature review (Chapter 2) explained that experiential lessons are the transformation of experiences. A cumulative percentage of over 90% of the leaners corroborated this transformation in learning when exploring the techniques of experiential skills development.

When working through the means, over 60% of the participants indicated that they agreed (Linkert scale = 4) that there are benefits in using experiential lessons.

Stabback (2011) and Ko (2016) claim that a stage constructed using a proper strategy with the objective of achieving a high quality of learning contributes to the factors which can reform educational knowledge. It is clear that the participants wanted to achieve the lesson objectives, where a cumulative percentage of over 78% of the learners strongly agreed that knowing and working towards these objectives would benefit them in developing experiential skills through experiential lessons. The Cronbach's Alpha reliability coefficient of the first theme in the questionnaire had an Alpha coefficient ranging from 0.78 to 0.81, showing that it was reliable.

- **Theme 2: Experiential skills development**

Theme two indicates the skills the participants should develop in a Life Sciences classroom. It is important that teachers develop a variety of strategies for use in their classrooms (McDonald, 2020). When utilising experiential learning, it is of utmost importance that learners keep in mind that one of the main goals is to establish a set of experiential skills. The set of skills, as confirmed by 59 learners out of the sample of 66, showed clear improvement. These skills can only be developed if learners are exposed to different teaching methodologies within the same lesson.

Change has become an enduring factor in the 21st century, and Life Sciences education is not immune to these movements (Wallace and Priestly, 2011). In experiential learning, the teacher is required to give lead-way to the learners and direct them to accomplish the task at hand, priming learners to utilise the modes of experiential learning as tools to develop experiential skills. One of the secondary research questions posed in this study was to identify the experiential skills needed by the learner in the Life Sciences classroom. Scientific literacy is seen as the body of knowledge which should be apparent to all Life Sciences learners, as to imply the appreciation of the nature of science (Ajayi, 2018). A cumulative percentage of more than 87% of the learners strongly agreed that scientific literacy through the utilisation of different experiential skills to answer questions is very important. Life Sciences in layman’s terms can be seen as a body of knowledge and processes of an existing and ongoing phenomenon which combines living things and their interactions with their surroundings. Scientific literacy refers to the concept knowledge, implementation and application through the use of scientific ideas, knowledge, principles and skills.

Without the knowledge and know-how of Life Sciences skills, the application thereof would be unescapable. Successful integration of these experiential skills in the Life Sciences classroom, as confirmed by a cumulative percentage of more than 50% of the learners, indicated that they had received a richer learning experience.

When working through the means on the theme of whether the participants felt confident in the development of their experiential skills, a staggering 92.5% of the participants indicated that they agreed (Linkert scale = 4) that there are benefits in using experiential lessons. The Cronbach's Alpha reliability coefficient of the fist theme in the questionnaire of the learners has an Alpha coefficient ranging from 0.76 to 0.79, which shows that it was reliable.

- **Theme 3: Improved proficiency**

The curriculum represents a foundational element to different knowledge areas. The Life Sciences curriculum itself values a selection of knowledge areas and skills in shaping the way learning takes place, along with the assessments addressing what, why and how learners should learn. The curriculum is a supporting tool for holistic development in the educational system.

There are challenges which may affect the development of the learners' knowledge and skills in the Life Sciences classroom. The heightening demands of content knowledge, skills development, and future plans that are placed on learners without support may be taken as disruptive transformation (Daggett, 2014). When implementing experiential skills development in the Life Sciences classroom, all these requirements may challenge the learner to progress, but the main goal of experiential skills development is to enhance the learning experience and create a proficient learner (McLeod, 2017). A cumulative percentage of 59.1% agreed or strongly agreed that the process of developing experiential skills enhanced their long-term memory. Enhancement not only focuses on the environment that is created in the classroom, but also considers long-term development in cognitive recognition. Experiential skills development allows experiences that have already been acquired outside the classroom to be implemented in assessments inside the Life Sciences classroom.

Participants confirmed that implementing experiential skills development across the series of lessons enhanced their learning on the Bryophyta theme.

The utilisation of experiential learning should boost learner performance in the Life Sciences classroom. As a teacher, the aim is not to offer a superficial understanding of Life Sciences, but rather to aid learners in retaining long-term knowledge, ultimately allowing learners' performance to continue to improve independently (Mathew et al., 2021). When working through the means on the theme of whether the participants felt confident, a cumulative percentage of 62.1% learners not only felt that they had improved, but could identify weaknesses in other participants' arguments and recognised that they had improved on their proficiency, with most showing a mean of 3.4 to 4.2. The Cronbach's Alpha reliability coefficient of the first theme in the questionnaire had an Alpha coefficient ranging from 0.76 to 0.80, showing that it was reliable.

The use of experiential skills development during lessons can inspire learners to engage with the theme and provide imaginative answers, and this indicates that the stimulation of logical thinking is present as an added characteristic to the skills development and overall performance of the learner (Omatseye, 2007).

5.4 Conclusion of the Quantitative Data

Quantitative data was shown and discussed throughout Chapter 5. It was clear that the Cronbach's Alpha reliability test from the pre, during, and post-tests displayed that all three tests were reliable as research instruments. Secondly, inferential statistics compared the performance of the learners in the pre-test, during-test, and post-test. The statistical significance was determined using inferences from a statistical point of view, which focused on the variance of means in the scores of the pre, during, and post-tests. Comparing the pre-test with the during-test, the during-test with the post-test, and the pre-test with the post-test, found highly significant p-values indicating a large relative between the participant scores. Thirdly, the descriptive data from the questionnaire completed by the 66 learners, reported on the frequencies and cumulative percentages from Table 5.23. From the questionnaire data, the majority of learners (over 50%) felt that this series of lessons boosted their proficiency in the theme of Bryophyta. This emphasises the unambiguous fact that the majority of the learners developed experiential skills to an adequate degree to successfully answer the pre-test, during-test and post-test questions.

It was clear that the results of the mixed method approach needed to be represented and discussed when the instruments were merged in Chapter 6. The following chapter does not repeat findings, but triangulates the conclusions made in order to address the research questions. Chapter 7, the final chapter, allows the research to draw conclusions and proposes the development of a tool which would assist teachers in developing experiential skills in their learners. Chapter 7 further makes recommendations for future research in the field of Life Sciences education.

CHAPTER 6
DISCUSSION OF FINDINGS AND RESULTS OF THE STUDY

6.1 Introduction

The main research question for this study aimed to investigate how the development of experiential skills influences the proficiency of the Life Sciences learner. The data for this study was collected using a mixed method approach, with the qualitative and quantitative data each being presented separately. The qualitative data collection was presented in Chapter 4, and the quantitative data collection was presented in Chapter 5. When comparing the data, the findings from Chapter 4 and Chapter 5 were triangulated for further analysis and discussion. Maree (2020) suggest that categorising data into themes reduces the problem of data overload, as a large amount of data is normally retrieved during mixed method research. This step is very important in research, as categorising data makes it possible to deduce the meanings and implications of the study's findings. Maree (2020) supports this statement, stating that a systematic data analysis is needed in order to communicate what has been learned and share it with a wider audience. In triangulating the data retrieved in Chapter 4 and Chapter 5, I divided the current chapter into sections. First, the collected data is organised according to the conceptual framework, indicating the relationship between the lesson plans and the pre, during, and post-tests (Section 6.2). Second, the patterns and themes that run between the questionnaire and the pre, during, and post-tests are identified (Section 6.3). Finally, a few assumptions are brought forward from the analysis, and these are considered and articulated into a conclusion (Section 6.4). This conclusion focuses on the results obtained, as it addresses the three secondary research questions, triangulating and converging the data with an in-depth understanding of the study.

6.2 The Relationship Between the Lesson Plans and the Pre-Test, During-Test, and Post-Test

Directed by the four secondary research questions, the main research question was addressed by means of the data gathered from the lesson plans and the pre, during, and post-tests.

- *(i)* *What are the aspects considered in creating experiential skills development lesson plans?*
- *(ii)* *To what extent does the development of experiential skills influence the proficiency of Life Sciences learners?*
- *(iii)* *How do the series of lessons through experiential-based practicals aligned with content help develop experiential skills in learners?*
- *(iv)* *How do learners perceive experiential-based practicals aligned with content?*

6.2.1 Learners' engagement during the series of lessons and usage of pre, during, and post-tests in the development of experiential skills

The triangulation took place by using the data from the pre-test, during-test and post-test, together with the lesson plans. Once the data was triangulated, I could conclude that learners generally understood how to implement experiential skills in a successful manner. By exploring the results of their concrete experiences in the pre-test, it is clear that learners mastered the basic 30% skills requirement needed to pass an assessment. Learners developed experiential skills such as understanding or identifying, which require lower cognitive skills in one lesson, but progressed to higher cognitive skills in another lesson when making inferences. These experiential skills in the mode of concrete experience, which focused on remembering, understanding context, listening and taking notes, improved from 24% to 53% in only one experiential lesson (Section 5.3.1). The 28% increase in the results for concrete experiences show that, by using the experiential skills development lessons, learners are not only using previously acquired skills but are able to improve their use of experiential skills on a higher cognitive level in another assessment. It is important to note that the manner in which the learners actively participated in the practicals involved using the skills that were developed over the series of lessons. It was clear that more than three quarters of the participants had hands-on experience with the theme Bryophyta. An author such as Maranan (2017) support the findings that learners learn more by effectively engaging with the practical activities where they have the opportunity to gain an in-depth knowledge. When observing how the learners engaged with the experiential skills lessons, the paired t-test results showed statistically significant skill development (Section 5.3.1, Table 5.17) of the means of the pre-test and during-test, as well as the means of the pre-test and the post-test. It may therefore be asserted that the learners' engagement with the lessons possibly resulted in the improvement of their marks in the tests overall. The distribution of data shown by the RUMM2030 statistics further supported this assertion, depicting an improved proficiency between each question in the tests and the learners' newly developed experiential skills.

The mean was 0.32 for the pre-test and 0.88 for the during-test, showing that the pre-test median more than doubled in the case of the total mark. These results may be used to argue that even though some questions became more difficult as the tests progressed across Bloom's cognitive levels, 63,6% of the learners still managed to improve their test performances. In conjunction, the mean was 0.32 for the pre-test and 0.40 for the post-test, showing that the pre-test mean was still improved in the case of the total mark. These results may also be used to argue that the post-test not only tested theory or hands-on skills, but also the learners' skills in judging other learners' answers. By conclusion from this, the degree in which the learners actively took part in the experiential skills development lessons could have improved their skills development and their marks in the tests overall. The pre-test mean was, however, significantly lower than the during-test, indicating a marked improvement in the learners after concluding two experiential lessons. This shows that their engagement with experiential skills development lessons influenced this improvement, and in turn had a positive impact on their proficiency in the theme.

6.3 The Relationship Between the Questionnaire and the Pre-Test, During-Test, and Post-Test

The following three secondary research questions were used to address the main research question using the data obtained from the pre, during, and post-tests, as well as from the questionnaires.

(i) *To what extent does the development of experiential skills influence the proficiency of Life Sciences learners?*

(ii) *How do the series of lessons through experiential-based practicals aligned with content help develop experiential skills in learners?*

(iii) *How do learners perceive experiential-based practicals aligned with content?*

6.3.1 Learners' opinions regarding experiential skills development

There were quite a few items in the questionnaire which I considered essential to establishing the attitudes and perceptions of the learners. In the questionnaire, the majority of the learners acknowledged the usefulness or importance of experiential skills. Responses in Table 5.18 reflect that 86.4% of the learners were of the opinion that hands-on work was useful in learning this theme, and 62.1% of the learners acknowledged that experiential skills development helped them to discover their own knowledge in the theme. The table also shows that 59,1% of the learners were of the opinion that experiential skills development helped them to relate current actions to longer-term, larger contexts, such as in tests and in real-life. An easy majority of 62,1% of the learners said they would be able to identify inconsistencies or weaknesses in other people's arguments. A cumulative percentage of 87% of the learners agreed or strongly agreed that different skills are important when answering different types of questions. When exposed to hands-on work, the responses of 86% of learners agreed that they were interested and engaged. I further explored if this positive attitude would be evident in experiential skills development, where these learners were involved in completing the pre, during, and post-tests. Here 66.6% of the learners noted that if their answers in the tests were wrong, they would simply shrug it off and put it down as experience. The majority of the learners also showed positive attitudes towards the experiential lessons which indicated that learners acknowledged the usefulness and importance of experiential skills development, recognising it as a process whereby they might comfortably develop new skills before an assessment should be completed. Authors like Marshall (2012) and Woodward (2001) also highlight this finding that lessons guiding more adaptive way of thinking ensures a positive response from learners.

In the questionnaires, the Life Sciences learners responses were coherent with the results of the pre, during, and post-tests, acknowledging that experiential skills produced not only scientific knowledge but also enhanced the acquisition of investigative skills, creative thinking, problem-solving skills, and many other experiential skills. When triangulating the pre, during, and post-tests paired with the questionnaires, it became clear that learners understood the expected outcome of the study. It was evident in the questionnaires that the learners realised that it was possible to develop specific experiential skills in one test and apply those same skills in another test, and further that they may use these skills not only when answering questions on the theme of Byrophyta, but also potentially apply these same skills in other assessments on other themes and in other subjects.

It is worth noting that the pre, during, and post-tests tests, and the questionnaire, lead learners to consider each question in the assessments from various angles before attempting to answer. It was gratifying to observe the learners as they employed the experiential skills that enabled them to improve their proficiency both in and out of the Life Sciences classroom. It is then imperative to highlight that, even though the participants were not yet using all experiential skills in the pre-test, the development of skills allowed the learners to improve throughout the tests. This in itself guided an experiential skills development teaching and learning style that has not yet been explored in South Africa.

6.4 Discussions of the Findings and Results of the Study

Analysing the findings from this study was centred around the secondary research questions:

(i) What are the aspects considered in creating experiential skills development lesson plans?

(ii) To what extent does the development of experiential skills influence the proficiency of Life Sciences learners?

(iii) How do the series of lessons through experiential-based practicals aligned with content help develop experiential skills in learners?

(iv) How do learners perceive experiential-based practicals aligned with content?

6.4.1 The aspects considered in creating experiential skills development lesson plans: The importance of teacher effectiveness in lesson planning

When planning lessons that focus on experiential skills development, there are different theories on how to effectively approach and interpret the aspects needed for skills development (Goldhaber, 2002; Hill, 2009; Milanowski, 2004; Odden et al., 2004; Sanders et. al, 2008). The findings showed that the series of experiential skills development lessons were effective, given the sizable improvement margin between the pre-tests and during-tests. Figure 2.5 confirms this statement as the learner-question analysis between the pre-tests and the during-tests indicate a mean of (mean=0.320) and (mean=0.880). The means show significant differences. Therefore, a link can be drawn between the developed experiential skills and the effect thereof on the learners' attitude (Hattie, 2009). As a mean of (mean=4.23) corroborated this statement as learners expressed in the questionnaires that they feel more confident and evidently more positive. In order to ensure that the effectiveness of the experiential skills development lesson planning is optimised, and to extract the most out of this study, it is valuable to highlight the learners' positive attitudes.

To make the best of the research, observing the created framework for experiential skills development is a vital step. While each lesson focused on developing a different mode of experiential learning (together with its experiential skill) to reach a specific outcome, the lesson planning demonstrated its legitimacy as a necessary instructional tool. However, the term 'lesson planning' can be interpreted in many ways. This study focused on the process of formal planning and skills development. Here the formal planning focused on structure and was task-oriented, while the skills development aspect focused on types of assessment that are required as part of proficiency in the subject of Life Sciences. There is no specific manner in which lesson planning can be assessed, therefore this challenge lies with the teachers putting in the hard work in this area which often goes unseen and unmentioned. Experiential skills development was most commonly achieved when multiple aspects of learning were considered and covered in the lesson plans, ranging from teacher-centred, basic scaffolding of learner knowledge to focused methods of engaging learners with the material, the environment, and the other learners in order to develop the necessary experiential skills. Although these lessons helped develop many different experiential skills over one theme, these skills could each be gained slowly over several themes. Learners were clear when they identified that, in only one theme, they had developed a Life Sciences skill set (mean=3.44) which could be used to answer different types of questions, with a staggering response of (mean=4.30). The response is very significant to this study as I am in search for ways to improve the lesson planning aspects for classroom instruction. I have based my planning of experiential skills development lessons on the prototype of effective planning in my own classroom practices, as well as the experiential skills needed by learners to be proficient in Life Sciences assessments. According to De Janasz, Wood, Dowd and Gottschalk (2009), effective planning of time and resources to achieve outcomes concerning lesson planning.

The research shows that for a teacher to be efficient and excel in lesson planning when preparing for experiential skills development lessons, the theme must be formed with instruction in mind (Marshall, 2012). The instruction method should reflect an understanding of the theme—the important concepts and principles present within the content, and how these elements relate to the relevant experiential skills. From the results shown across the pre, during, and post-tests indicating that the learners had developed the required skills. From the results in the pre-during/during-post-tests, a p-value of p=0.0046 reported that there was a significant difference in the performance, confirming that experiential skills improved as lessons progressed. From the results in the pre-post-tests, a p-value of p=0.626116324 reported that there was no significant difference, but question analysis still showed that learner performance in different questions was significant. In the post-test, 49 learners out of 66 were able to successfully answer higher cognitive level questions, but only 23% of learners were able to produce a memorandum-based answer. From this, I can conclude that with more exposure to experiential skills development in the post-test would allow improved experiential skills in the future. It is logical to conclude that the lesson planning was effective in this case. Using the lesson planning phase to plot the transitions from one mode of experiential learning to another made designing experiential skills lessons more logical. An additional attribute of effective teaching was the capability to design logical lesson plans and comprehensive assessments that correlated with the appropriate levels of Bloom’s Taxonomy, in order to develop the learners’ experiential skills more efficiently. In addition, I can state that effective lesson planning increases the clarity learners need in their lessons and related assessments. Ensuring a clear development of lessons and using logical instruction assisted the learners in this study as they linked the concepts, increased their understanding, and improved their ability and proficiency level.

I found that effective experiential lesson planning ensures that enrichment and remediation opportunities take place, allowing learners to use the familiarity of previous lessons, their prior knowledge, or the experiential skills they have developed to provide an effective vehicle of instruction (Stronge et al., 2007). By articulating the objective(s) of the series of experiential lessons to the learners, the learners formulated a knowledge and experiential link to prior lessons as well as to related lessons in the future. I considered the needs of the learners, and adjusted my teaching approach accordingly. The aspects of experiential lessons attracted the learners' interest and kept them engaged. They were able to mentally move through the series of lessons anticipating the need to apply their understanding or organise their knowledge and skills, as the lesson objectives were clearly explained at the beginning of each lesson. The teacher's experiential skills lesson planning must be undertaken bearing in mind that their teaching approach directly influences each learner in the Life Sciences classroom on a daily basis.

6.4.2 The aspects considered in creating experiential skills development lesson plans: The support for the modes of experiential skills development in lesson planning

This study provides evidence that supports lesson planning and the core role it plays in the modes of experiential skills development in the Life Sciences classroom. Daft and Marcic (2014) show that a teacher's perception of lesson planning while including the modes of experiential learning to develop certain skills can improve the learners' proficiency outcome. In Table 5.24, more than 50% of learners confirmed their improved experiential skills in understanding, explanation, analysis, and judgment, as well as discovery. This study suggests that a standard for effective experiential skills development lessons does exist. Such a standard for lesson planning may be reflected in the research backed by the conceptual framework, from which this study originated.

My ranking of the modes of experiential skills development in lesson planning shows a significant difference between tests which is relatively just as important as the learners' perception of achievement in each mode and its improvement of their skills. This finding was corroborated, as each mode identified with a skill required on a specific level of Bloom's Taxonomy. Authors like Kelly (2017) and Kolb and Kolb (2017) highlight this finding by concurring that linking the cognitive levels of Bloom's Taxonomy to experiential skills developed in a Life Sciences learner a clear interrelation can be drawn. By report, the majority of learners, 66.7%, felt they had successfully developed the desired experiential skill needed for each question. This suggests that the learners were aware of the different modes as well as the experiential skills needed in their assessments, as the research showed that the learners attempted to apply these skills in the Life Sciences class. The question as to whether these developed experiential skills will be implemented correctly in another theme is unknown, but from using the same approach in this lesson and implementing it in another theme, I can speculate that the same outcome should be achieved.

6.4.3 The extent experiential skills development influences the proficiency of Life Sciences learners: Utilising Bloom's Taxonomy in developing experiential skills

Researchers such as Stronge, Ward and Grant (2011) and Armstrong (2010) specify the need for formatting questions, declaring that when questions are formulated, they should be considered carefully and be prepared well in advance of a lesson. This not only ensures that the questioning leads to experiential skills development, but also that the questions included allocate different marks in an assessment per the level of Bloom's Taxonomy. Utilising Bloom's Taxonomy ensures that lessons support the development of experientials skills and emphasises the key points in a theme, along with maintaining an appropriate level of complexity and difficulty. However, the reality is that teachers have definitively different points of view regarding questioning and the specific ways of planning for the sequence of questions asked (Mc Pherson-Geyser et al., 2020). This research focused on the manner in which questions were developed in lesson planning, and how the questions might best be aligned with Bloom's Taxonomy. The sequence of questioning did not matter in this study, as the conceptual framework suggested that the modes of experiential skills development take place cyclically. In this model, as long as all four modes are completed with the correct level of difficulty, the learner would show improved proficiency in the developed experiential skills. This focus on how questioning sequences are ranked therefore becomes the least important aspect of experiential lesson planning. The study found the sequence of questioning to be significantly less important in regard to learner achievement. The focus was more on the level of difficulty the questions were asked on for the purpose of developing experiential skills. The approach of not focusing on the sequence of questioning and instead considering the manner in which the question is raised results in a classroom where not everything is prescribed which allows for new experiential skills to develop through experiences in the classroom. The movement of the Department of Education and its amendment to Section 4 ushered teachers into an era where they are told what to teach and learners are assessed using standardised, government-prescribed assessments. In some cases, the curriculum materials from the government or the district include questions a teacher should ask, thereby directing the learners. This might feel like another way in which teachers are told how to teach; the teacher only has the classroom activity or the assessment to showcase their art of teaching. When showcasing the results of the assessment, as a teacher I would like to show my authenticity in the classroom—my way of questioning is a natural skill. However, the idea of questioning as a natural teaching approach does not require planning. These questions are leading questions which focus on a review of previously read materials or materials presented, and normally are questions of a lower cognitive level. However, it became clear in the pre, during, and post-tests that a variety of questions are needed to ensure that the cognitive level of an assessment is met by the end of a theme. Therefore, in this study it was clear that the planning of questions according to Bloom's Taxonomy was a key aspect in the lesson outcome when developing experiential skills. This study found that not focusing on the sequence of questions, but rather considering each question's complexity and difficulty, improved the proficiency of the learner and gave the majority of learners a sense of achievement, which the research and literature of Armstrong (2010) affirms.

Questioning is an important skill for a teacher to know, and for a teacher to teach a learner. High quality questions ensure an experiential skill of the same quality. High quality questions ensure that a variety of experiential skills are unlocked by enabling a learner with clarity, purpose, usefulness, and orientation of thinking. The use of

Bloom's Taxonomy not only secures in-depth knowledge of a theme, but also ensures that teachers prepare their learners ahead of time for end-of-year examinations and the possible questions learners may face. Skill development is not only simple but also takes time. From my own experience and observation, a main factor for teachers not spending time on developing different skills is the limited time that is available in the curriculum. This issue can be bridged when planning an approach to questioning which makes use of Bloom's Taxonomy. Another reason for planning the types of questions in advance is not only to ensure quality, but also variety. According to Armstrong (2010), there are six levels or categories of questions that should be developed:

- Remembering
- Understanding
- Applying
- Analysing
- Evaluating
- Creating

These questions run parallel to the development of experiential skills, moving from a lower cognitive skill to a higher cognitive skill. This study made sure that the learners were exposed to these question types, and enabled the learners to apply their own mental initiative. Using different questioning allows the learners to think creatively, critically, and analytically, while developing the appropriate experiential skill. It also allows the learners to utilise an array of knowledge when answering the questions with the acquired skill, and this in turn improves their proficiency.

Finally, after formulating questions with quality and ensuring variety, experiential skills are developed, and learners are able to critically question others inside or outside the classroom. This ability to judge and question is in itself a lifelong skill. Effectively questioning (or judging) should fill gaps in knowledge and allow learners to solve the problems in their assessments. Therefore, utilising Bloom's Taxonomy in developing experiential skills allows learners to discover a valuable learning tool, organise their thinking to achieve a desired proficiency, and begin to develop new experiential skills.

6.4.4 The extent the development of experiential skills influences the proficiency of Life Sciences learners: Implications for improving learner proficiency

The support shown in this study for developing experiential skills provides insight where the learners' proficiency could be improved when properly implementing the modes of experiential skills development in lesson planning. The study shows that the development of experiential skills exists and is achievable, and that this development improves proficiency in learners. It is then necessary for teachers to improve on planning processes or to become more effective in developing experiential skills. The fact that there was a significant improvement in the proficiency of the learners shows that experiential skills development and planning experiential skills lessons are equally important, which is congruent with the literature (Daft & Marcic, 2014). In addition, the high number of learners (mean=3.67) who reported in the questionnaire that using the series of experiential lessons added to the development of experiential skills for memorandum-based answers are an important finding. Both these findings support the idea that in order to improve learner proficiency in the Life Sciences classroom, lessons may find a solution in focusing on the modes of experiential skills development. Giving planning discussions a degree of focus will help teachers pinpoint areas where learners can be more effective in improving proficiency. These planning discussions, and the information gleaned from examining how experiential skills developed in the lessons, all helped determine the outcome of the learners' proficiency. Additionally, the study can help in assessments and when evaluating learners on a more individualised basis to determine where their specific weaknesses may lie.

Finally, the study allowed for the teacher to identify the proficiency of the classroom as a whole, and to recognise ways to improve learner proficiency by focusing on the skills that need to be developed through other themes. Highlighting the experiential skills developed by the learners offers valuable information concerning their progress prior to completing their assessments, ensuring a standard quality. The study found that learners grasp the idea of moving from a teacher-centric approach to a learner-centric approach to complete assignments, and that this may be beneficial in promoting learner achievement. However, planning the appropriate assessments may be time consuming. Teachers can work with learners on the aspects that ensure proficiency to create quality assessments for the classroom, aiding learners in getting the biggest possible benefit from their engaged learning time. The relationship between the teacher with their planning and learners' goal for proficiency should align during assessments. Finally, the findings influenced the learners in practice by helping to create a culture of learning in the classroom as the need for learning in real-life, a (mean=3.92) was identified in the questionnaires confirming that learning through doing developed the learners' experiential skills individually. Authors such as Chan (2023) concurs with this finding and explains that in the classroom, helping to create this culture of learning that can relate to real-life experiences are important and therefore have very real practical implications for learners. By giving the learners a focal point to begin their experiential skills development, each learner was empowered to develop their experiential skills in a manner that was useful to them with their respective Life Sciences class, and as related to their self-efficiency with each of the modes of experiential skills development.

6.4.5 Alignment of experiential-based practicals with content: The impact of aligning the instruction of the Department of Education's Section 4 amended lesson plans and assessments

The learners in the questionnaire and myself as a practicing teacher ranked the learning objectives, the skills development, and the assessment as significantly important when it came to learner achievement of Life Sciences proficiency (see Section 5.3.4.1). The findings from the learners also showed that using the modes of experiential skills development as a slow but progressive guideline was beneficial. This echoes the findings of Dewey (2001) and Kolb (1984), who both state that cyclic, guided skills development allows for deep learning. The findings for the alignment of the Department of Education, the teacher's lesson plans, and the learners' assessments, all demonstrated that experiential skills development makes a difference in learner achievement. This belief is substantiated by the research, recognising how the modes of experiential skills development led to significant improvements in learners' results, from the pre-test to the during-test. This finding is important in understanding lesson coherency for learners, and proves the claims of Daggett (2014), who likewise states the importance of alignment between the modes in lessons and experiential skills. This is particularly relevant for future assessments, given the significant difference between the learners' performances in the pre-test and during test (p = 0.0046). By skilfully planning experiential skills development lessons together with the directive of the Department of Education, lesson plans ensured the use of varied approaches to the levels of skill development while maintaining focus on assessment coherency.

In this series of experiential skills development lessons, each lesson was aligned with the next and adjusted where needed to influence the development of proficiency among learners. The findings show that the learners understood this benefit of experiential skills development (mean=4.30), and they reported in the questionnaires that using experiential skills during the lessons improved their efficiency in their assessments (see Section 5.3.4.1). While it is clear that I as the teacher and the learners as the students understood that aligning experiential-based practicals with the content was important in this series of lessons, the question remains as to how effectively experiential skills might align with other themes. Most learners recognised the alignment between the goals of the teacher as set in the learning objectives and the grading criteria when receiving feedback from the pre, during, and post-tests. The result showed a staggering confirmation of a (mean=4.12). Therefore, when observing the results of the study, it is important to note that teacher objectives and grading criteria for planning and self-report. The relationship between the learning objectives, the Department of Education's directive and assessments merits a closer look. The relationship of learning objectives, the Department of Education's directive and assessments to the experiential skills development are linked to experiential skill lessons which highlights the first secondary research question. Based on the results from the first secondary research question, learners overall showed a neutral support for the increased effect of experiential skills development in lessons. Stabback (2011) and Ko (2016) support this claim, as the first mode of concrete experiences is normally constructed using a proper strategy with the objective to achieve a high quality of learning, and if this were implemented it would contribute to many of the factors that hold the potential to reform educational knowledge. This observation is also confirmed by Ali (2019) who identifies that Life Sciences subject matter relates to the material world, teachers should include acts of showing and telling in their lessons.

Regarding the third secondary research question, learners were united in the belief that the content taught was aligned with the practicals that were given to them from the pre, during, and post-tests, and that this alignment strongly influenced their proficiency in the theme of Bryophyta. This is interesting, as part of the Department of Education's amended Section 4 lesson plans and assessments removes the requirement to write a full scientific report—by far the most controversial change made to student assessments. Some concerns can then be raised as to the validity of the alignment between the Department of Education's directive, lesson plans, and assessments when developing experiential skills. The link between these two outcomes, experiential skills and increased proficiency in assessment, may be the result of the directive of the Department of Education's amended Section 4, as learners are no longer required to write a full scientific report covering all skills in one assessment, but instead are given standard questions that allow for certain skills to be assessed in different activities (DoE, 2011).

Confusion arises when teachers teach these experiential skills as a whole and not in staged steps, but as the findings in this study have demonstrated, this confusion can be bridged by clearly stating the learning objectives. When teachers align experiential-based practicals with the class content, they allow learners to understand the alignment between the Department of Education, the lesson plans, and the assessments through learning objectives. Learners therefore will fully understand the importance behind experiential skills development, and be clear on the intent when completing experiential skills development lessons (Maranan, 2017). If these aspects are aligned in the learning objectives, the content of a theme will complement the practicals and/or assessments, allowing learners greater clarity as well as higher proficiency in the theme.

6.5 Chapter Summary

Triangulation in Chapter 6 was important when presenting the convergence of the data, the analysis of the data, and the interpretation of the data in this mixed method study. The final chapter, Chapter 7, presents the conclusions made throughout this research.

CHAPTER 7
CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

The conclusions drawn in this chapter were first introduced in Chapter 6, together with the preceding literature review (Chapter 2). This chapter gives valuable insight into the overview of this study (section 7.2), followed by a synopsis of the findings initially analysed in Chapter 4 and Chapter 5 (section 7.3). The conclusions to the secondary research questions are presented (section 7.4), and the recommendations for future research (section 7.5) are then further discussed. This chapter concludes with a discussion on the significance (section 7.6) and limitations of the study (section 7.7).

7.2 Overview of the Study

The aim of this study was to investigate the development of experiential skills in Grade 11 Life Sciences learners. In order to achieve this aim, it was essential to determine the contribution of the development of lesson plans by the teacher and assess the influence thereof on the development of experiential skills in learner proficiency. The development of experiential skills was established by answering four secondary research questions (section 7.3).

In Chapter 1, this study stated the problem, explained the rationale, and presented the research questions. The research questions were then discussed by analysing the research data in Chapters 4, 5, and 6. In the literature review in Chapter 2, the intricacies of skills development in the Life Sciences classroom were investigated—particularly, the outlook of skills development in South Africa, Bloom's Taxonomy in the classroom, the use of lesson plans by teachers, time management, the differentiation between practical and experiential lessons, and the theories underpinning experiential learning. A literature study covering the aspects of experiential learning in the South African context in Life Sciences was initially conducted in order to place this study within the framework of that knowledge, only to find a death in the current literature. The experiences from a global view of experiential learning studies provided in the literature review were compared with the findings of this study to provide confirmation for existing findings regarding the development of experiential learning. Chapter 2 highlighted important aspects which distinguished the literature and described the possible effects of experiential skills development on the proficiency of the Life Sciences learner.

Chapter 3 focused on describing experiential skills development and on the methodology used to achieve it, which was necessary for the analysis of the study to draw conclusions of the research questions in Chapter 7. This methodology chapter integrated the use of the onion research design, purposive sampling methods, and the manner in which I collected data and developed the instruments utilised in this study, as well as the ethical procedures that were considered. Further, the chapter introduced the data analysis theory, followed by a description of the mixed method approach. In this study, a mixed method design was used with concurrent application of both quantitative and qualitative approaches. Lesson plans were developed by myself, my supervisor, and experts in the field of Life Sciences as a measure to collect the qualitative data for this study. While implementing the lesson plans over a series of four lessons, a pre-test, during-test, and post-test were written by learners, and a questionnaire was completed in order to collect the quantitative data used in this study.

Chapter 4 organised and discussed the findings from the qualitative data, including the lesson plans where learners completed pre, during, and post-tests exploring the theme of plant diversity. It was established that a logical structure of lessons, continuous feedback, and the progressive development of skills, together can influence the manner in which teaching and learning take place. Most learners have positive attitudes towards learning, especially when completing hands-on activities.

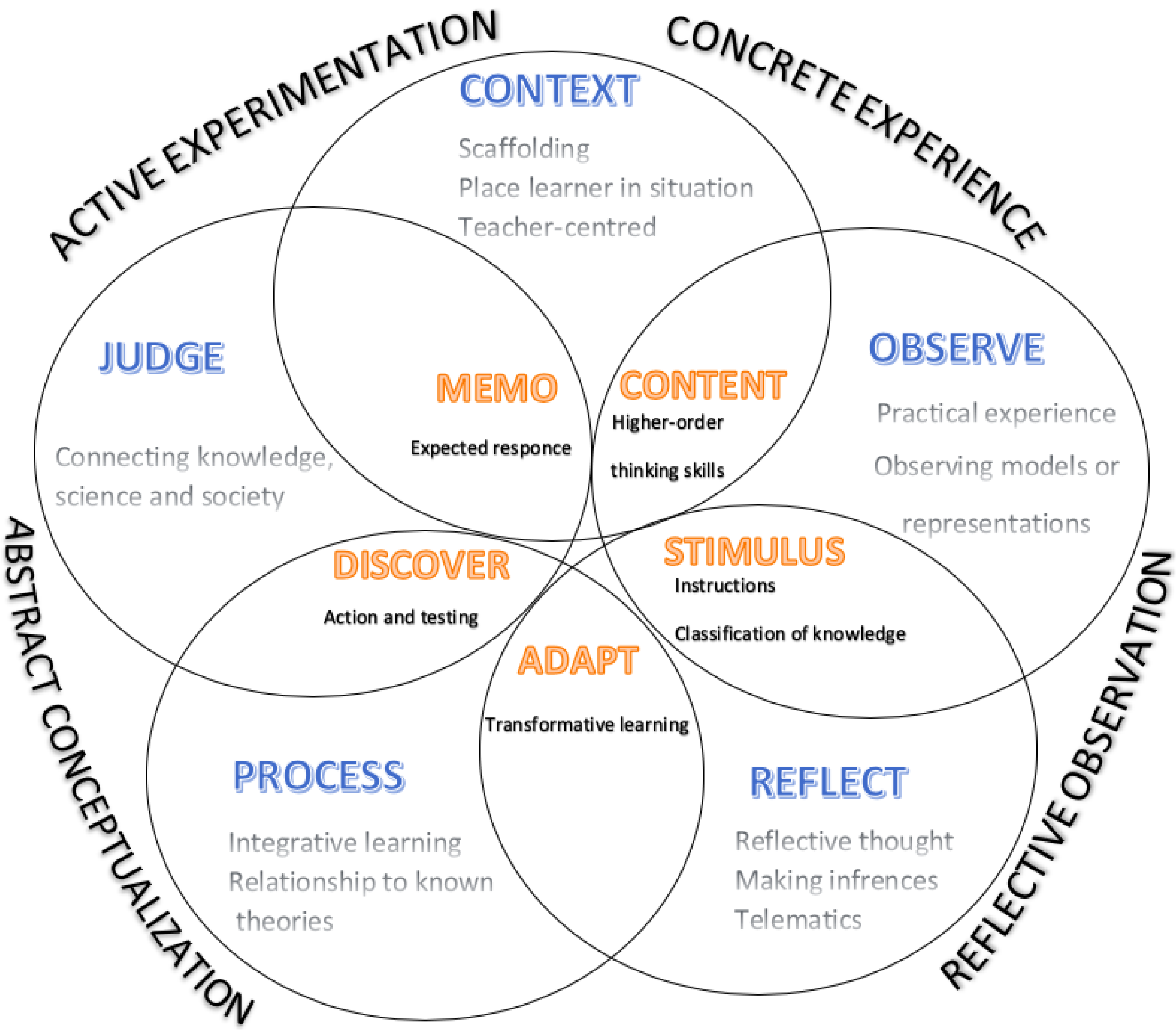
Chapter 5 presented and discussed the findings derived from the quantitative data. These findings originated from the pre-test, during-test and post-test, as well as from the questionnaire, which was completed by a total of 66 learners. It was established that the development of experiential skills during a plant diversity lesson on Bryophyta had indeed contributed to the proficiency of the learner. The significant differences between the pre-test and during-test, as well as the pre-test and the post-test means through the t-test and analysis of variance, confirmed the development of proficiency in the learners. The outcome of the questionnaires through RUMM 2030 further established that most of the learners had positive attitudes towards the implementation of the lessons and the manner in which experiential skills were developed, and that they understood the potential benefits toward completing their assessments with a proficient set of skills and knowledge.

Chapter 6 discussed the convergence and triangulation of findings from a mixed method approach, giving an in-depth understanding of the study. The mixed method data showed that the development of experiential skills in the Life Sciences classroom contributed to the development of a proficient learner. It also contributed to the manner in which learners perceived experiential-based practicals, and how those practicals aligned with the content the learners would be assessed on in formative assessments or in the end-of-year examinations. In their responses in the questionnaires, the learners acknowledged the usefulness of a series of lessons in developing experiential skills.

7.3 Contributions According to the Conceptual Framework

In Chapter 2, section 2.3.3, it was explained how experiential skills can be developed by focusing on the cyclic process of experiential learning and the possible modes in the conceptual framework. Kolb (1984) and Dewey (2001) provide a lens through which this theory of experiential skills development could be captured in the Life Sciences classroom. The magnification on the improvement of experiential skills development that could be implemented in South African schools was clear when the research was completed, as the results illustrated the learners' improved coherence and enhanced proficiency in Life Sciences. The conceptual framework shows that the modes, skills, and outcomes cannot work in isolation, but rather must extend from theory to practice. Consider Figure 7.1 as provided in Chapter 2, which summarises the experiential skills that were explored in this study.

Figure 7.1 Experiential skills model (own)



The framework provided in Figure 7.1 is well supported by the findings from this study. The framework was used to create experiential skills development lesson plans in the Life Sciences classroom, thereby achieving the development of experiential skills as shown in the findings. This research shows that implementing a series of lessons using the conceptual framework ensures that learning to some extent takes place in a progressive manner, in order to successfully reach the desired outcome of proficiency in learners in an assessment. The learners shared their subjective opinions on experiential skills development and the success of the strategy in their classroom.

Section 2.3.3 of the conceptual framework provided a platform to understand the modes of experiential learning and the outcomes that should be reached, as well as the experiential skills that are required in the amended Section 4 in the context of the curriculum. The learners' understanding, motivation, challenges and successes were addressed in the questionnaires, allowing the learners to renew their perspective of this strategy of experiential skills development once their understanding of the theme had been assessed in their pre, during, and post-tests. As discussed in Chapter 4, when using experiential skills with the major attribute of identifying experiences, learners quickly grasped a basic degree of understanding of the theme of Bryophyta, making the lesson a practical and stimulating discovery. This understanding formed the learners' point of introduction in the pre-test, which included the practice of using basic knowledge and utilising the flexibility of teacher-centred methods over the series of lessons. The post-test showed that one of the modes of experiential learning, namely concrete experiences, had been mastered to an exceptional degree. The results showed that the concrete experiences were successfully answered, as 74% of learners received the maximum marks and a further 94% of learners showed evidence of following instructions to receive the full mark. The challenges were included such as asking learners to produce a memorandum-based answers that could be bridge with further exposure to experiential skills development. Learners' attitudes having a major influence on the success of the strategy in the classroom. The unpredictability of the subject and the teachers' lack of experience in using the strategy may also inhibit experiential skills development, but with the correct tool these challenges can ultimately be bridged (Daft & Marcic, 2014).

One quintessential factor which emerged from the conceptual framework, when questions in the tests were developed and assessed, that even though all learners excelled in the concrete experiences, the learners progressively developed new skills-some faster than others-in observing and reflection, forming abstract concepts, and testing the implications of concepts. A series of four lessons contributed to the four modes and the development of experiential skills with the theme, Bryophyta, at hand. The lessons were seen as a mapping factor, identifying those learners can practice skills in a theme if they have a clear enough understanding of the topic at a level which the teacher would find acceptable in an assessment. It was clear that the learners were comfortable in being the source of information in this study, and depended on each other to discover certain facts or develop knowledge on the theme that would lead to higher-order thinking skills. This allowed learners to use the experiential skills they had developed to link other themes, override the challenge of learning different skills for different assessments, and bridge time constraints. It is worth mentioning that learners clearly achieved the first mode in the during-test, the learners moved from a 24% success rate to a 53% success rate in a question which not only required more information in the concrete mode, but which tested a higher cognitive level. As well as in the post-test, 74% of learners were successful in acquiring the skills of concrete experiences which is where learners either started or fully grasped the experiential skills in the other three modes as represented by the conceptual framework. The learners were not deprived of making their own discoveries, as their judgement was stimulated by the post-test. It could be concluded that the learners were left equipped to hold the necessary skills to lead their judgement or utilise their own experiences in successfully implementing the final mode of the conceptual framework.

The tools used by the teacher to facilitate experiential skills development in the Life Sciences classroom were well described in Chapter 4. These strategies in the lesson plans highly influenced the development of experiential skills by the learner. The teacher used strategies (tools) such as reading, writing, observing, technology, hands-on activities, and questioning to engage learners on the specific theme in the classroom. This allowed a specific set of skills to form, as it forced the learners to achieve the skills needed in an assessment and discover new skills in the formulation of new knowledge.

Finally, a very important finding from this study was the influence of experiential skills development in the Life Sciences classroom in specifically supporting the learners' understanding of the theme, the skills developed, and the overall discovery of other themes built on the current theme. The study found that the majority of the learners saw an immediate effect on their experiential skills after completing the series of lessons that supported the use of experiential skills development. The development of these skills allows for the long-term development of skilled learners who are able to apply the same skills to different topics, and ultimately discover new knowledge independent of their teacher. As already mentioned in Chapter 2, in identifying the gap in knowledge on experiential skills development in South African schools (Conway, 2017), I tested the strategy of experiential skills development in my own classrooms in order to learn from it as well as possibly incorporate aspects of it into my lessons.

7.4 Conclusions Based on the Findings of the Study

Following a process of data analysis and while reflecting on the study as a whole, I came to the following conclusions. Effective lesson planning by the teacher, when guided by the modes of experiential learning, has a significant influence on learner experiential skills development. By the same token, ineffective focus on lesson planning can negatively influence learner experiential skills development (Daft & Marcic, 2014). Therefore, understanding what aspects are needed in designing an effective experiential skills lesson plan is a necessity. Being a professional teacher, the fact remains that lesson planning is a vital part of preparing classroom lessons that focus on developing experiential skills in each theme in Life Sciences. Together with planning, the learners' attitudes and manner of thinking and how the teachers organise these lessons can lead to either successful or unproductive outcomes.

The development of an experiential-based lesson plan and the effective implementation thereof provides information of value on what aspects are seen as important when developing this particular type of lesson plan. The lesson plans, together with the pre, during, and post-tests, reported on classroom practices when developing experiential skills and also provided insight into the implementation of the strategy when it is used in the classroom. This combination gives an indication into the complexity of the experiential skills lesson planning process. Considering the modes inherent in experiential skills development, how much a teacher thinks and organises their thoughts during the planning process can be a powerful factor when preparing for developing experiential skills in the classroom. This idea was further supported by the fact that, in the questionnaire, learners expressed positive attitudes towards the skills development lessons. Other important findings surrounded the research on aspects of experiential skills development lessons. The learners indicated a significant improvement in their experiential skills, which in turn influenced their proficiency and achievement in their assessments. More specifically, learners perceived that progressively moving towards a more student-centric classroom assignment was most effective when it included the development of all four modes of the conceptual framework. Learners identified that the experiential lesson and the sequence thereof allowed for the development of a variety of experiential skills, all of which would be needed towards the post-test or end of an experiential skills lesson. These skills included:

- Making assessments that link to real-life situations
- Completing assessments with a deeper understanding
- Understanding the performance criterion or teacher's guide to successfully complete assessments
- Grasping an opportunity to control the outcome of the assignments

These results, where learners merely complete their assessments without experiential skills development and for the sake of complying with the Department of Education's requirements according to CAPS, is useless. Developing experiential skills that can be taught by teachers through the use of a tool developed under the conceptual framework and findings, can and does increase learner proficiency. If the tool is implemented and used effectively to develop experiential skills, learners can fulfil the requirement of the amended Section 4 of the Curriculum Assessment Policy Statement. A few themes in Life Sciences may be linked to experiential skills development and used to enhance the proficiency of learners in any assignment. I created an experiential skills model in Figure 7.2 which links the theme of a lesson with experiential skills development.

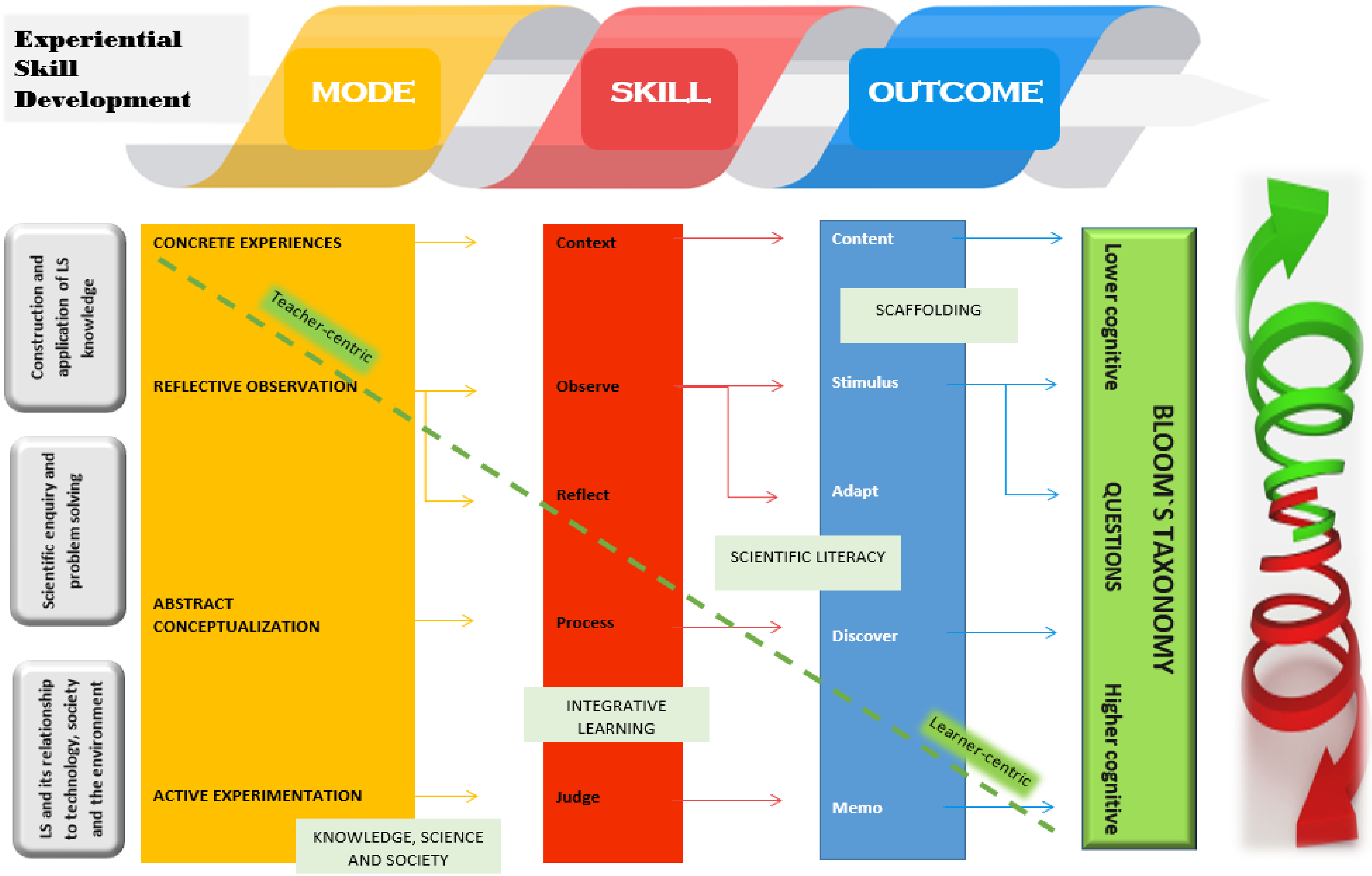


Figure 7.2 Experiential skills model (own tool)

The conceptual framework and the tool were designed by myself from the results to represent a cyclic experiential skills model consisting of four modes, five skills, and five outcomes. The four modes are concrete experiences, reflective observations, abstract conceptualisation, and active experimentation. The five skills are to interpret in context, observe, reflect, process, and judge. The outcomes are to understand content, reflect on a stimulus, adapt to situations, discover new theories, and be able to answer in line with a memorandum. Learners' experiential skills can be developed by starting from any mode, skill, or outcome in the model, but it is expected that all four modes be completed by the end of a theme for successful learning. This model identifies steps that define partial capabilities until the model has been completed as an all-inclusive learning process. The modes will have a clear description as a whole to expand to the next mode. However, there will be a need to train the teachers in how to interpret and implement the model effectively.

The modes in developing experiential skills are:

CONCRETE EXPERIENCES

Context: This is where the learner receives an initiation into the theme. By listening and taking notes, the learner is placed in the situation where shallow learning takes place. Mostly teacher-centred.

Content: The outcome of this mode is to ensure that the learner internalises the information and will be able to answer higher-cognitive, content-based questions.

REFLECTIVE OBSERVATION

Observe: This skill defines the hands-on, practical section of Life Sciences. Learners should be deeply involved and able to handle tools or chemicals.

Stimulus: The outcome of this skill is to be able to react to a stimulus by following instructions, or to clarify what knowledge is needed from the context and apply it.

Reflect: Learners reflect on an experience by making inferences or by using telematics, which include tables or graphs, to form conclusions from the context of the problem.

Adapt: Learners commit to a single course of action to solve the problem, and generalise to transform learning and apply it to known theories.

ABSTRACT CONCEPTUALISATION

Process: This skill is an integrative learning aspect where the use of content and the adaptation thereof leads to processing the relationships between experiences and known theories.

Discover: This outcome is where assertive action takes place while testing the probability of the theory and balancing dynamics when the situation demands it.

ACTIVE EXPERIMENTATION:

Judge: This skill allows the learner to focus on results as a goal. The goal is to connect knowledge, science, and society to use experiences outside the norm.

Memo: This outcome allows the learner to give the expected answer as prescribed by the teacher when all steps are completed.

When these modes of the experiential skills development model are followed throughout a theme, a learner should be able to transform their experiences inside or outside the classroom as a proficient Life Sciences learner. Additionally, it is known that the experiential skills development model requires the move from teacher-centric to learner-centric teaching modes. Teachers are allowed to use the CAPS document together with Department of Education planned assignments as a deviation. Experiential skills development may be a result of requirements set by the Department of Education for lesson planning, which regularly stipulates the use of government standards. Concerning lesson structure, the sequencing of the pre, during, and post-tests significantly influenced learner achievement. This finding was validated when the pre-test and during-test, as well as the pre-test and post-test, each reported that using all other aspects of experiential skills development lessons led to improved proficiency in the majority of the learners. Further research is required to corroborate these unsurprising findings, as the development of this lesson plan using the tool in Figure 7.2 can be applied to different themes in the Life Sciences classroom, which could have many benefits for teachers and learners alike.

In the experiential skills development model in Figure 7.2, understanding, making decisions, judging, and discovering, all are opportunities that should be created in a lesson when taking into account the various modes of a learning process. The objective for experiential skills development is to implement a more long-term process by learning actively in order for learners to personalise their learning experiences. In assessments, learners are continuously faced with problems that require different skillsets which could be connected to real life. Learners should make use of mastered experiential skills while referring to previously assimilated knowledge and experiences. Taking this into consideration, it is essential for the learners to be prepared for any assessment, such as the end-of-the-year examinations. This further includes scenarios pertaining to real-life problems that require specific experiential skills in the learners' learning environment. Learners need to be able to utilise experiential skills and approach questions or problems pragmatically and progressively, as demonstrated throughout the study. From my perspective, the most critical attribute to developing experiential skills is the teacher guidance of an experiential skills lesson, otherwise the whole process has little to no impact and the teacher will have lost time and valuable resources. A manner by which this outcome could be reached in developing an experiential skills lesson is shown in Figure 7.2.

7.5 Recommendations of the Study for Further Research

This study considered how the development of experiential skills influences the proficiency of the Life Sciences learner. Based on the secondary research questions and the various modes, skills and outcomes identified in the conceptual framework, a series of lessons was designed and tested.

7.5.1 Recommendations for tertiary institutions

Research pertaining to the instruction of experiential skills development as a skill at university level should be mastered before practical teaching experiences commence. Methodology subjects at different campuses can implement experiential skills development as a strategy in itself. When preparing teachers in using the CAPS documents, teachers should be exposed to other education professionals who are already seen as specialists in the development of experiential skills and who incorporate the guidelines and outcomes as set by the CAPS document in Chapter 4. Tertiary institutions should include as many practicals as possible so that new teachers can master hands-on experiential skills, while in turn lifting confidence levels when they are placed in a classroom which requires demonstrations. Tertiary institutions should include a teachers' guide which covers the numerous implementation strategies for experiential skills development. These methods should include the manner in which experiential skills development can be used in assessments which are not only practical but which also require critical thinking of a higher cognitive order.

Advanced programmes for growth in the use of experiential skills development which can be utilised by either tertiary professors or lecturers should be introduced to potential teachers in their final year of study. The feedback from universities needs to reproduce vital information on experiential skills to develop a teacher who is confident and informed in the process that will be followed, thereby ensuring quality teaching. Currently, the lack of a workable tool that ensures the development of all experiential skills in one theme leads to the lack in the development of experiential skills.

7.5.2 Recommendations for teachers

Teachers should consider their role in the development of experiential skills. Although participating in experiential skills development is learner-centred and positively affects the outcomes in the lesson, teachers should mull over experiential learning as an effective teaching and learning strategy. The learners participating in this study showed understanding in the process of developing experiential skills, and were stimulated to perform in assessments. If teachers could draw from all the modes of experiential skills development as set in the conceptual framework, this would help create long-learning Life Sciences learners who not only hold a wide range of knowledge, but who show skills in linking topics, judging importance, and who can substantiate their findings with proven facts, self-realisation, and exploration. It is important to educate teachers on the need to know how to develop experiential skills as a modern teaching strategy that shows traits of flexibility, sustainability, accessibility, efficiency, and innovation, all of which work together to accomplish outcomes and produce proficient learners.

7.5.3 Recommendations for future research

This area of study has been influenced directly by this study in the development of experiential skills and its influence on the proficiency of a Life Sciences learner. Future research can, by noting the limitations, include:

- Focusing on experiential skills in different assessments and themes relating to the Life Sciences using the CAPS document. The pre, during, and post-tests that were developed for the learners focused on gradually developing experiential skills, and the questionnaires together with the lesson plans enabled the research to use experiential skills not only in the Bryophyta theme but also in other topics.
- Making use of the experiential skills development tool in Fig 7.2 to assist in planning and organising lesson plans for teachers, and developing experiential skills for future classrooms.
- Developing experiential skills as a strategy in ensuring an outcome where students become life-long learners. The findings may have enhanced the experiential skills and experiences of the learners who took part in this study.
- Focusing on the teachers as a source of planning when implementing experiential skills development lessons.
- The use of experiential skills development and the teachers' willingness to implement this teaching strategy.
- Lead in the assistance of policy makers in the Department of Education (DoE), Life Sciences training and maximising the use of experiential skills development while structuring its outcomes in CAPS Chapter 4.

My opinion is that the findings in this research can serve as an eye-opener to any stakeholders involved in education. It is clear that the development of experiential skills in learners has the potential to positively affect their overall proficiency. The outcomes that have been reached can be used in future research, focusing on the use of the tool that was developed in this study. This would allow teachers to better plan, organise, and evaluate the experiential skills in a specific theme or in any practical classroom in a way which reaches all four modes of experiential skills development effectively, efficiently, and with a greater chance of developing a proficient learner.

7.6 Significance of the Study

Bearing in mind the intended research objective(s) and the intended audience(s), the value of this study can be understood (Hamilton & Corbett-Whittier, 2013). The descriptions and explanations in this study focused on how the development of experiential skills could influence proficiency among Life Sciences learners. As discussed in the problem statement in Chapter 1, once I formulated the problem, the research could be provided to supply pertinent information for this study (Icobucci & Churchill, 2010).

Taking into consideration the limited knowledge teachers have concerning experiential skills (Mc Pherson-Geyser et al., 2020), as well as the lack of training available for teachers to implement the amendment in Section 4, a gap soon became apparent—a gap between the development of experiential skills that should be aligned with the content taught in the Life Sciences classroom (Suryani & Widyastuti, 2015).

The gap also highlighted that the practicals done in order to meet the imposed amendment, which aimed to develop proficiency in learners, were lacking a clear tool for direction in developing experiential skills. By acknowledging the lack of experiential skills development and considering its positive effects on learner proficiency if implemented in the Life Sciences classroom, the findings can emphasise the direction or initiatives needed when presenting a specific theme. The findings can serve as a directive for policy makers, CAPS, or curriculum training opportunities when addressing concerns around learner proficiency in the end-of-year examinations and the skills that should be demonstrated by the learners. I developed the pre, during, and the post-tests for the learners who required experientials skills, and used the lesson plans as a tool of instruction to give a new approach to the lesson themes from a different perspective. Implementing experiential skills development enabled the learners to develop skills that not only benefited them in the Bryophyta theme, but which should enhance their proficiency in other themes. The learners who formed part of this study may have found an enhanced proficiency when assessed in the November examinations following the end of the research period. This study, therefore, considered experiential skills development as the means used to establish or improve the essential level of proficiency in learners.

If the necessary skills to facilitate Life Sciences lessons are not developed, the outcomes of these lessons will only resemble experiential skills development and will not hold any impact (Andrews et al., 2011). The significance of the development of experiential skills is self-driven. The lack of support in South African research allowed this study to provide valuable insight into the status of experiential skills development as a teaching approach in FET education. It soon became clear that experiential skills development can evolve a knowledgeable learner with an adaptable skill; one who is able to employ experiential learning in assessments with proficiency. This is the first study of this nature within Life Sciences in the South African context. The findings from this study would help to plan for better support for teachers concerning the use of experiential skills development and its effective implementation in the Life Sciences classrooms, displaying the possible attributes and shortcomings that would influence the effectiveness of experiential skills development as a teaching strategy (Mc Pherson-Geyser et al., 2020).

7.7 Limitations of the Study

The interpretivist perspective in this study seems to highlight the challenge of subjectivity and its tendency to generalise findings (Nieuwenhuis, 2012). The study made use of a post-positivist perspective to balance the subjectivity of findings with objective statistical analysis. This study only reflects the current development of experiential skills development in the Grade 11 Life Sciences classroom, as it stands at the time of writing. The conclusions that have been formulated in this study cannot be generalised, but rather should be used to formulate new research questions from a body of knowledge which will go on to confront research on experiential skills development in the future. Other limitations include that only a single teacher's class on a single theme was tested, and that a wider scope and different FET phases could have identified more aspects regarding experiential skills development and the manner of completing the modes in the Life Sciences classroom. The implementation of experiential skills development was largely focused on the learners and not the teachers. The lesson plans and the manner in which the teacher taught, as it was my own Life Sciences classroom, may to an unavoidable degree be unsettling as teachers sometimes struggle with change in order to adapt to challenges in the Life Sciences classroom. This is due to the fact that the lesson was recorded. To minimise this, the recording was focused on the PowerPoint and only made use of audio to ensure that the teaching atmosphere felt as normal as possible to the teacher and to the learners (Kavai, 2013).

7.8 Final concluding remarks

The benefits of experiential skills development and its influence on the learners' proficiency in the Life Sciences classroom were explored in this study. The study highlighted the research and implementation of lesson plans using the modes of experiential learning, the experiential skills needed by the learner, and its influences on learner competencies in assessments in the Life Sciences. The study showed the interconnection between the interpretivist and positivist paradigm when applied in a mixed method study, which contains both qualitative and quantitative approaches. Quantitative pre, during, and post-testing, together with questionnaires, explored the extent to which the experiential skills developed influenced the learners' proficiency.

Concurrently, qualitative descriptive case studies on lesson plans determined which modes are needed to develop experiential skills. Using the conceptual framework, lessons plans were created as an approach a teacher may use to develop experiential skills along with their modes, subskills, and outcomes. The aim is to inform the Department of Education (DoE) of the need to train teachers who are confident in applying experiential skills development to the various assessments which must be completed throughout the year. These findings could assist teachers in providing better support for learners when making use of experiential skills and gauging the effectiveness of the experiential skills in the classrooms and in assessments, showcasing attributes and shortcomings which would influence proficiency in learners. The findings of this study have confirmed that merely building on concrete experiences is not enough to develop a proficient learner who also requires knowledge through reflective observation, abstract conceptualisation, and active experimentation. A learner learns by doing, and it is this form of active, involved engagement which develops experiential skills.

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APPENDIX A: LESSON PLANS

TOPIC: BRYOPHYTA			**DURATION:** 6 HOURS
FOCUS LEARNING GOALS *(according to CAPS)*	**Scientific enquiry and problem solving skills**	**Construction and application of Life Sciences knowledge**	**Life Sciences and its relationship to technology, society and the environment**
INTEGRATED LIFE SCIENCES LEARNING OBJECTIVES	Learner identifies and questions phenomena and plans an investigation.	Learner access knowledge.	Learner explores and evaluates scientific ideas.
	Learner conducts an investigation by collecting and manipulating data.	Learner interprets and makes meaning of knowledge.	Learner compares and evaluates uses & development of resources and their products and the impact on the environment and society.
	Learner analyses, synthesises, evaluates data and communicates findings.	Learner shows understanding of how Life Sciences knowledge is applied in everyday life.	Learner compares the influence of different values on scientific knowledge.
Possible integration with other subjects.	English, Mathematics, Geography and Technology		
Knowledge area	Biodiversity of plants		
Prior knowledge	Phylogenetic tree, evolutionary pathways, plant tissue, water root system and diffusion		
Topics	Lesson 1: Bryophyta: structure, function, habitat and water dependence *(concrete experiences)* Lesson 2: Bryophyta: practical attributes and scientific investigation *(Reflective observation)* Lesson 3: Bryophyta: adaptions and impact on environments or society *(Abstract conceptualization)* Lesson 4: Bryophyta: value on scientific knowledge *(Active experimentation)*		
Links to next lesson	Pterophyte, gymnosperms and angiosperms		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	MEDIA	ASSESSMENTS
Lesson 1: Bryophyta: structure, function, habitat and water dependence *(concrete experiences)*			
Refer learners to textbook to ascertain the meanings of terms: - Vascular structure - Thallus plants - Reproduction structures: Seeds/spores - Fruit/flowers - Water dependence for reproduction - Life cycle: diploid/haploid Ask learners to write down their responses on the table provided. The table makes provision for: - Stadiums of plant diversity - Characteristics of moss - Structure of moss Basic scaffolding. Continuous lower cognitive questioning and answering	Access available resources Complete table	Textbooks Power point	Informal activity

Lesson 2: Bryophyta: practical attributes and scientific investigation *(Reflective observation)*			
Divides learners in groups (Due to Covid, learners were instructed to use stations alone). Supplies learners with moss and necessary equipment as well as pre-test, that amongst others, explains procedures. Explanation of necessary telematic skills. Demonstration of scientific method.	Carry out practical using microscopes and complete worksheet. Observe and make key point summaries and glossary. Process reflection on observations. Learners identify variables, ask questions, hypothesize, follow instructions, record information, interpret and conclude on present findings.	Microscope Moss Distilled water Dissecting needle Textbook Power point Pre-test	Informal assessment: Pre-test Teacher rubric and memorandum

Lesson 3: Bryophyta: adaptions and impact on environments or society *(Abstract conceptualization)*			
Direct teaching of the main process and function of systems. Points out relationship between structure and adaption for survival.	Observe and make key point summaries. Research, collect, analyse and synthesise information. Narrate experiences and explain opinions based on acquired scientific knowledge.	Models Diagrams During-test	Informal assessment: During-test Teacher rubric and memorandum
Lesson 4: Bryophyta: value on scientific knowledge *(Active experimentation)*			
Gives learners an information sheet with clear diagrammatic illustrations of moss and its uses in water filtrations. Explain how water filtration takes place in nature vs impervious surfaces. Divide learners in groups. Give learners a set of questions to consolidate the information, Allow learners to explore practical system to real life models.	Write down key facts and respond to questions. Explore filtration through moss and its relationship to real model systems. Express opinions, listen to views of other and possibly reshape ideas or issues. Fill in post-test.	Information sheet Textbooks Power point Moss Bottles Post-test	Informal assessment: Post-test Teacher rubric and memorandum

EXPANDED OPPORTUNITIES: **Fast learners:** Research relationship between moss and true-North for tracking purposes. **Slow learners:** Extra time to complete tasks More revision tasks Extra notes of moss and its value to society	**BARRIERS TO LEARNING:** language social-economical infrastructure resources

APPENDIX B: PRE-TEST

LIFE SCIENCES
INFORMAL ASSESSMENT (A)
PRE-TEST
GRADE 11
TIME: 50 MINUTES
TOTAL: 15
EXAMINER: ME G. MC PHERSON
MODERATOR: Dr P. KAVAI

Complete the activity by referring to the experiment.

AIM: To observe and draw macroscopic parts of the moss plant

MATERIAL/APPARATUS

- Pair of forceps
- Hand lens/dissecting microscope OR micrograph

METHOD:

1. Obtain a live specimen of a moss plant with the attached sporophyte. Moss grows in damp places e.g. near taps, in paving or under trees. The green part of the moss plant is called the gametophyte.

   Use a pair of forceps to separate out a moss plant.

   Carefully rinse off any soil particles adhering to the plant. Place this moss plant on a piece of white paper / filter paper.

2. Using either a hand lens or dissecting microscope: identify and describe the **rhizoids, and "leaves" and "stem"** of the moss **gametophyte**. Note the sporophyte's **seta** (stalk) and **sporangium** (capsule).

3. Draw and label a diagram of the moss plant using the labels given below. Include a descriptive heading and the relative size of your specimen.

- Capsule
- Seta
- Stem and leaves
- Rhizoids
- Sporophyte
- Gametophyte

OBSERVATIONS

Question 1:
Descriptions:

1.1 Describe the physical structure that can be observed from the moss.

1.1.1 Rhizoids (1)

____

____

1.1.2 "Leaves" and "stem" (1)

____

____

1.1.3 Shoot (1)

____

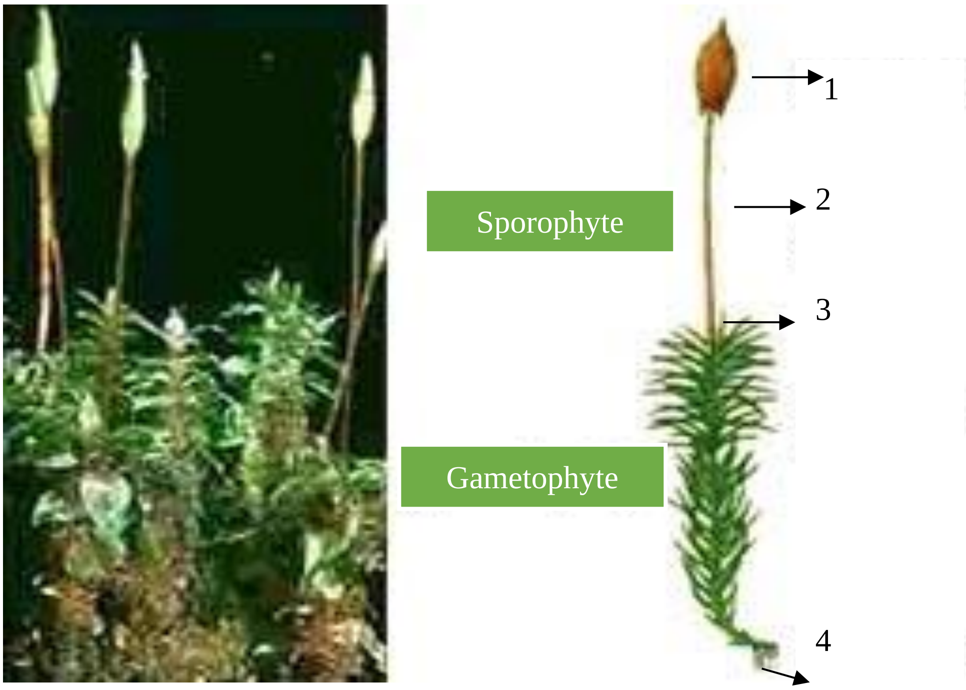
____

1.2 Identify the presence of the structures in the moss-plant by using a tick **(√)** in the correct block.

Characteristics	**Presence in Bryophyta (Moss plant)**
True Roots	
True Leaves	
Leaves have veins	
Roots and leaves have vascular tissue	
Have spores as reproductive structures	
Produces seeds	

($^{1}/_{2}$ x 6 =3)

Question 2
Give labels for structure 1-4. Write the label next to the correct number.



(4)

Question 3

A moss-plant was used as a drainage system to see how fast 50 ml of water can be drained through the plant over the course of 5 days. A 0,3 mm piece of filtrate paper was used a control drainage system as a measure to compare the results between two systems. Study the results in the table and answer the questions that follow.

DAY	Moss-plant (mm)	Filtrate paper (mm)
1	10	2
2	14	7
3	19	12
4	22	16
5	25	18

3.1 Draw a line graph that displays the relationship between the moss plant and the filtrate paper over the course of 5 days. (5)

Total: 15

APPENDIX C: DURING-TEST

LIFE SCIENCES
INFORMAL ASSESSMENT (B)
DURING-TEST
GRADE 11
TIME: 50 MINUTES
TOTAL: 15
EXAMINER: ME G. MC PHERSON
MODERATOR: Dr P. KAVAI

Plants in the division Bryophyta have features that are considered to be rather primitive. These are plants with little specialization of tissue, which are not well-adapted to life in a relatively dry land environment. They also have comparatively simple reproductive processes, and are the only plants which have a **dominant gametophyte generation**. A study of the features of mosses will illustrate the major characteristics of this plant division.

In mosses, the gametophyte is small and at least partially erects, with very little specialization of cells and tissues, specifically, no true leaves, stems, or roots. The moss gametophyte has a shoot portion that appears leafy, and has **rhizoids** which emerge from its base to attach it to the substratum upon which it grows. The gametophyte is generally green and photosynthetic, and obtains water and other nutrients from the soil by direct absorption into its cells. It contains no cells specializing in the transport of water and/or nutrients (**vascular tissue**) and therefore cannot grow as large as to prevent contact between the soil and the majority of its cells.

At maturity, the moss gametophyte is capable of developing gametangia on its surface. Sperm-producing **antheridia** can arise amongst the leaf-like structures along the length of the thallus; egg-producing **archegonia** most often develop at the tip of the erect gametophyte. When fully developed, flagellated sperm are released from an antheridium and swim through a film of water to reach an egg-containing archegonium.

Fertilization of the egg and sperm produce a zygote within the archegonium. This zygote undergoes mitosis to produce an embryo, again retained within the archegonium. Finally, the embryo matures into a sporophyte, consisting of a **sporangium** (**capsule**), a **seta** (**stalk**), and a **foot** which remains embedded in the gametophyte tissue. The continued attachment of the sporophyte to the gametophyte allows the sporophyte to absorb most of its needed nutrients from the gametophyte.

Meiosis occurring within the sporangium produces **spores**. Following spore production, the capsule opens up to release the spores, which germinate to produce new moss gametophytes.

(http://www.esu.edu/~milewski/intro_biol_two/lab_2_moss_ferns/MossandFern_Diversity.htmlKingdom:Plantae)

Complete the activity by referring to the experiment.

OBSERVATIONS

Question 1

1.1 Describe concisely the type of habitat. (1)

____

1.2 Evaluate how the leaves are arranged? State its importance. (2)

____

____

1.3 Judge the general function of the rhizoids. (2)

____

____

RESULTS

Question 2

2.1 Labelled drawing of a moss plant. (3)

A moss-plant was used as a drainage system to see how fast 50 ml of water can be drained through the plant over the course of 5 days. A 0,3 mm piece of filtrate paper was used a control drainage system as a measure to compare the results between two systems. Study the results in the table and answer the questions that follow.

DAY	**Moss-plant (mm)**	**Filtrate paper (mm)**
1	10	2
2	14	7
3	19	12
4	22	16
5	25	18

2.2 Calculate the average water that has been drained through the moss plant over the course of 5 days. (2)

____

____

2.3 Draw a conclusion on a drainage system of moss that can be used in your garden. (2)

____

____

Question 3

DISCUSSION

3.1 From the description given above explain the importance of water in the different structures in the life cycle of the moss plant. (3)

____

____

____

____

Total:15

APPENDIX D: POST-TEST

LIFE SCIENCES
INFORMAL ASSESSMENT (C)
POST-TEST
GRADE 11
TIME: 50 MINUTES
TOTAL: 15
EXAMINER: ME G. MC PHERSON
MODERATOR: Dr P. KAVAI

In this lab, you will simulate the water filtration that occurs in a bog, one of the four main types of wetlands. Part of the water cycle involves a certain amount of water flowing into, and through, wetland areas. This includes rainwater and surface water, such as streams and rivers. Sphagnum moss is one of the plants that grow in a bog. A bog is a soft, spongy, water-saturated area. It usually has acidic soil in an area full of dead plant material. Sphagnum moss is also called peat moss because it is often found in a type of bog called a peat bog. Sphagnum moss can hold large quantities of water inside its cells, sometimes holding up to 20 times its dry weight in water. How much water would you hold if you were a Sphagnum moss plant? 20 x your weight = _____ . That's a lot of water! Wetlands are home to many plants that have special adaptations that allow them to thrive in water-saturated environments. Let's find out just how wetland plants play a role in filtering water that flows through the wetlands!

CONDUCTING THE EXPERIMENT: NATURE VS IMPERVIOUS SURFACES

Materials:

- •2 soda bottles with bottom removed
- •2 large jars about the same diameter as the soda bottles
- •duct tape
- •handful of horticultural moss (available from gardening stores)
- •handful of dried leaves
- •bag of river sand
- •bag of gravel
- •several pieces of concrete
- •old newspaper
- •old plastic cups
- •garden soil
- •bucket
- •tap water
- •vegetable oil
- •1 litre pouring jug
- •timer with seconds
- •ruler

PROCEDURE:

1. Construct two funnels with the soda bottles as shown in the diagram below. Invert one of the soda bottles to make a funnel and use the duct tape to secure the soda bottles to the large jars.

2. Mix together a handful or so each of the garden soil, sand, gravel, leaves and moss. The quantities are not important, but try to keep the amounts of each material about equal. Keep aside a small handful of moss.

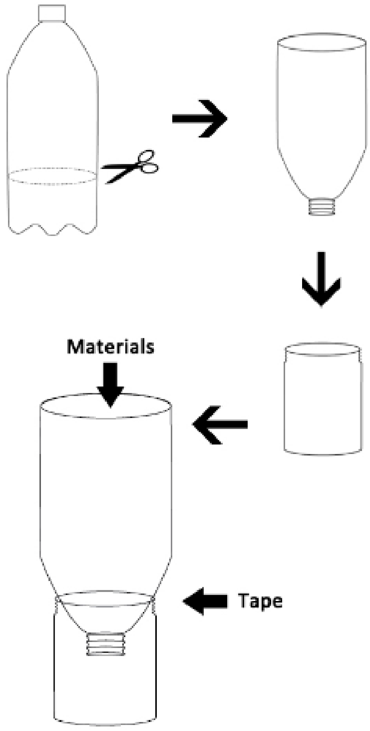
3. Place the small handful of moss in the neck of the funnel. Add the mixture to the funnel. Ensure the material is packed firmly but not too tightly. This funnel represents the soil through which water filters in natural areas.
4. In the other funnel, place the pieces of concrete, to the same volume as the soil-filled funnel. Loosely crumple the old newspaper into various sized pieces and crush the plastic cups. Add the newspaper and plastic cups into the funnel. This funnel represents areas across which water drains in paved areas. The newspaper and cups represent trash which may collect in the drains of paved areas.

5. Mix together a small amount of the garden soil with 2 litres of water and add two cups of the vegetable oil.

6. Add 1 litre of this mixture to the pouring jug.

7. Pour the mixture into the soil-filled funnel. Record how long it takes for the water to drain through.

8. Repeat the above step for funnel filled with pieces of concrete.



Complete the activity.

OBSERVATIONS

1.1 Why are non-vascular plants small? What does the size of a plant have to do with how water is transported? (2)

____
____
____

1.2 Consider the differences between the two funnels. Tabulate the differences between the two funnels in terms of the time it took to filtrate and the turbid of the water after filtration. (6)

1.3 Compare the water from the impervious surface bottle to that from the soil packed bottle. (3)

____
____
____
____

1.4 Evaluate how the experiment models a real system. (4)

____
____
____
____

Anon. Natures Lab https://www.nature.org/content/dam/tnc/nature/en/documents/nature-lab-lesson-plans/HowNaturalAreasFilterWaterTeacherGuide.pdf. 2021, July 17.

APPENDIX E: QUESTIONNAIRE

THE ALIGNMENT OF EXPERIENTIAL BASED PRACTICALS WITH CONTENT

QUESTIONNAIRE

This questionnaire is designed to investigate the development of experiential skills in Grade 11 Life Sciences. It is to find out how experiential based practicals align with content as well as its the influence on the proficiency of the Life Sciences learner. Over the years, you have probably been exposed to different skill developed learning habits that help you benefit more from some experiences than from others. You may be unaware of this, and this questionnaire will help you pinpoint your learning preferences and share them. This questionnaire will probably take you about 10 minutes to complete. The accuracy of your results depends on how honest you are. There are no right or wrong answers. Use the scale provided to indicate to what extent you agree with the statement. Decide how the statement best fits your perception of experiential skill development in the Life Sciences classroom, place a cross (X) in the relevant box. Go with your first gut reaction instead of over-thinking your response.

Please DO NOT write your name on the questionnaire.

Scale	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5

I find having specific objectives and plans beneficial in directing what I should achieve at the end of a lesson.					
Most times I believe the way in which a lesson is conducted justifies the knowledge applicable in real-life.					
I am keen on exploring the basic techniques supporting practicals with content.					
I feel that the introductory lesson gave me enough basic knowledge on the diversity of plants.					
I feel that the teacher improved my ability to answer questions that require basic understanding.					
I enjoy being exposed/doing to hands-on work in the classroom.					
I am open to change my attitude to practicals to improve my skills.					
I feel that my previous knowledge from the introductory lesson helped establish my thought process in the answering of the practical lesson.					
I feel I can use my observation skills because of the introductory lesson in order to reflect successfully on questions that requires more advance interpretation skills.					
I feel that different skills are important to answer different types of questions.					

I feel after the experiential lessons that I can answer questions which requires understanding or identification.					
I feel after the experiential lessons that I can answer questions which requires explanations.					
I feel after the experiential lessons that I can answer questions which requires me to demonstrate my knowledge.					
I feel after the experiential lessons that I can answer questions which requires me to analyse data.					
I feel after the experiential lessons that I can answer questions which requires me to judge whether a topic is relevant.					
I feel after the experiential lessons that I can answer questions which requires me to create new knowledge and apply it to known theories.					
I think I now possess ALL of the skills needed to complete a Life Sciences task which could be content based.					
I feel the manner in which the lesson was conducted allowed me to discover my own knowledge on the topic.					
With my new skills I think carefully before taking-action in certain questions or discussions.					
When things went wrong in practicals or answering content based questions, I was happy to shrug it off and 'put it down to experience'.					
I will be able to relate my current actions and skill development to the longer-term bigger picture such as tests or real-life.					
If I had to write a report, I will now be able to write the knowledge with the skills I know and answer the question according to marks allocated.					
I can now see inconsistencies and weaknesses in other people's arguments.					

APPENDIX F: PRE, DURING, AND POST-TEST MEMORANDUM

PRE-TEST MEMORANDUM
WORKSHEET: BRYOPHYTA
POSSIBLE ANSWERS

Four point Likert-scale:

Level 1: Not skilled (the learner shows no competency in the demonstration of this skill/cognitive level)

Level 2: Substandard (the learner shows basic competency of this skill/cognitive level)

Level 3: Fairly skilled (the learner shows satisfactory competency of this skill/cognitive level)

Level 4: Skilled (the learner shows excellent competency in demonstrating this skill/cognitive level)

OBSERVATIONS

1.1.1 Rhizoids **(1)**

Absorbs water for reproduction.√

Mark allocation	**0**			**1**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.1.4 "Leaves" and "stem" **(1)**

Clumped together/ thin cuticula √

Mark allocation	**0**			**1**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.1.5 Shoot **(1)**

Transports nutrients/water to the capsule√

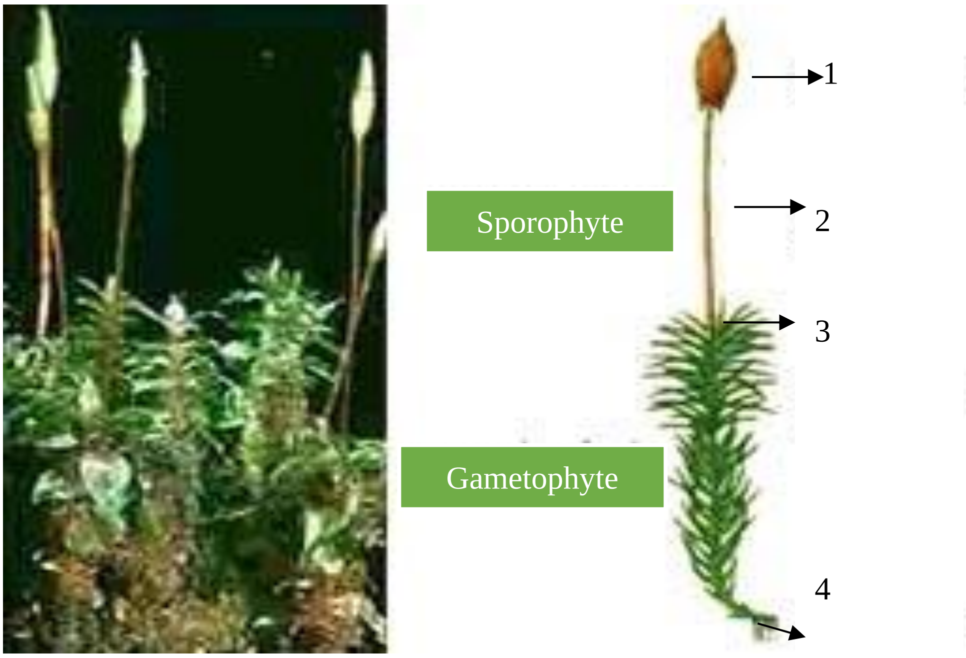
Mark allocation	**0**			**1**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.2 Identify the presence of the structures in the moss-plant by using a tick (√) in the correct block. **($^1/_2$ x 6 =3)**

Characteristics	**Presence in Bryophyta (Moss plant)**
True Roots	
True Leaves	
Leaves have veins	
Roots and leaves have vascular tissue	
Have spores as reproductive structures	√
Produces seeds	

Mark allocation	0			3
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

Give labels for structure 1-4. Write the label next to the correct number. (4)



1- CAPSULE √

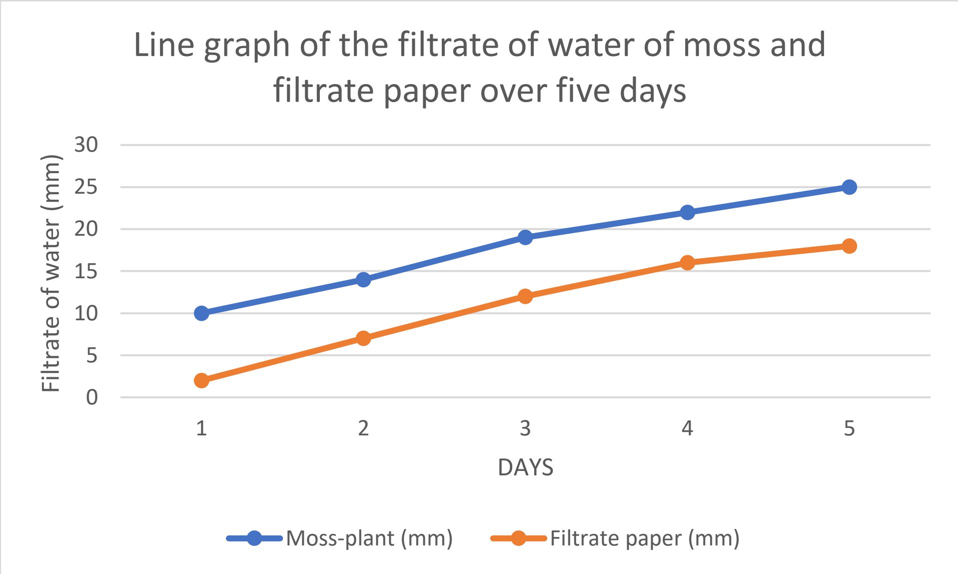
2- SETA √

3- FOOT OF SETA/STEM √

4- RHIZOIDS √

Mark allocation	0	1-2	3	4
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

3.1 Draw a line graph that displays the relationship between the moss plant and the filtrate paper over the course of 5 days. (5)



Criteria	Mark
Heading identifying the graph with both variables **(H)**	1
Both axis ladled with measurement unit **(L)**	1
Correct scale for axis **(S)**	1
Plotting of ALL data **(P)**	2
TOTAL	**5**

Mark allocation	**0**	**1-2**	**2-3**	**4-5**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

DURING-TEST MEMORANDUM
WORKSHEET: BRYOPHYTA
POSSIBLE ANSWERS

Four point Likert-scale:

Level 1: Not skilled (the learner shows no competency in the demonstration of this skill/cognitive level)

Level 2: Substandard (the learner shows basic competency of this skill/cognitive level)

Level 3: Fairly skilled (the learner shows satisfactory competency of this skill/cognitive level)

Level 4: Skilled (the learner shows excellent competency in demonstrating this skill/cognitive level)

OBSERVATIONS
Question 1

1.1 Describe concisely the type of habitat. (1)

The habitat of a moss plant should be in a shadow area with a damp √ environment which allows for the absorption of water for reproduction.

Mark allocation	**0**			**1**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.2 Evaluate how the leaves are arranged? State its importance. (2)

Leaves are closely arranged√ for diffusion to take place/thin cuticula for diffusion of water√ from one leaf to another.

Mark allocation	0	1		2
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.3 Judge the general function of the rhizoids. (2)

Rhizoids are thin and should cover a large area√ to ensure water absorption as water is important for movement of sperm to ovum. √

Mark allocation	0	1		2
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

2.1 Labelled drawing of a moss plant. (3)

Criteria	Mark
Heading **(H)**	**1**
Correct diagram **(D)**	**1**
At least two correct labels such as leaves, rhizoids, seta or stem. **(L)**	**1**
Total	**3**

Mark allocation	**0**	**1**	**2**	**3**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

2.2 Calculate the average water that has been drained through the moss plant over the course of 5 days. (2)

10
14
19
22
25

+ (/5)√=18mm√

Mark allocation	**0**	**1**		**2**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

2.3 Draw a conclusion on a drainage system of moss that can be used in your garden. (2)

The moss plant drains more water √than the filtrate paper.√ /Thus the moss plant can be used as a more successful drainage system.√

Mark allocation	0	1		3
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

DISCUSSION

3.1 From the description given above explain the importance of water in the different structures in the life cycle of the moss plant. (3)

- Rhizoids are thin and vast to ensure the absorption of water for sperm to move to ovum for reproduction.√
- Leaves are clumped/thin cuticula √for water diffusion for reproduction.
- Seta ensures that the nutrients or water are transported to capsule√ for the spores to mature.

Mark allocation	0	1	2	3
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

POST-TEST MEMORANDUM
WORKSHEET: BRYOPHYTA
POSSIBLE ANSWERS

Four point Likert-scale:

Level 1: Not skilled (the learner shows no competency in the demonstration of this skill/cognitive level)

Level 2: Substandard (the learner shows basic competency of this skill/cognitive level)

Level 3: Fairly skilled (the learner shows satisfactory competency of this skill/cognitive level)

Level 4: Skilled (the learner shows excellent competency in demonstrating this skill/cognitive level)

1.1 Why are non-vascular plants small? What does the size of a plant have to do with how water is transported? (2)

Non-vascular plant does not have xylem/phloem to absorb water into the rest of the plant. √

The small size allows for water to be transported faster as needed for reproduction.√

Mark allocation	**0**			**2**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.2 Consider the differences between the two funnels. Tabulate the differences between the two funnels in terms of the time it took to filtrate and the turbid of the water after filtration. (6)

Criteria	**Moss**	**Artificial**
Materials	- Rice, - Moss, - Filtrate paper, - Newspaper	- Rice, - Filtrate paper, - Newspaper
Start-up of water	400 ml	400ml
Filtrated water	Varies from students.	
Time	Varies from students.	
Turbid of water after filtration	Less turbid	More turbid

Criteria	**Mark allocation**
Table **(T)**	1
All data completed **(D)**	2
Time it took for water to filtrate correlates with funnels **(F)**	1
Filtrate water aligns with turbidness of water **(C)**	2
TOTAL	**6**

Mark allocation	**0**	**1-3**	**4-5**	**6**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.3 Compare the water from the impervious surface bottle to that from the soil packed bottle. **(3)**

The water that filtrated through the moss was cleaner/ less turbid√ than the water that filtrated through the packed/artificial surface.√ It took longer to filtrate through the moss but the water was cleaner./Less water filtrated through the moss as particles or water was absorbed by the materials in the bottle producing cleaner water.√

Mark allocation	**0**	**1**	**2**	**3**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

1.4 Evaluate how the experiment models a real system. **(4)**

The moss works as an effective drainage system√ to ensure drinkable water.√ It will allow for a safe alternative. √Thus, working as effective as a real system in a home.√

Mark allocation	**0**	**1-2**	**3**	**4**
Level	1	2	3	4
Description	No attempt was made to answer question/ answer is irrelevant to question	Learner shows some knowledge in understanding the question.	Learner can relate knowledge to processes that are specific to the question.	Learner can relate knowledge to processes that are specific through scientific literacy.

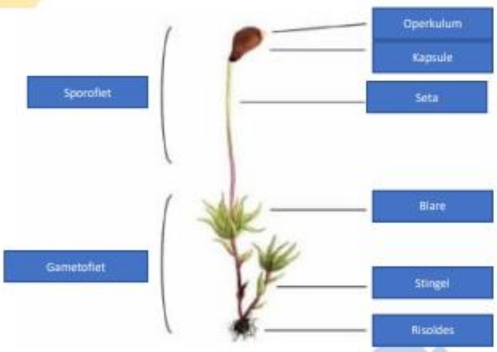
APPENDIX G: LESSON 1 POWER POINT

MEER MOSSE

Veenmos/ Peat moss
(*Sphagnum*)

LEWENSIKLUS

- Mitose
- Meiose
- Chromosoomgetal
- Spore vs gamete



Dele van Mosplant

- **Risoïede**: Neem voedsel en water op uit die grond
- **Blare/stam** (Tallus): Werk deur diffusie om water van een deel na 'n ander deel te diffundeer.
- **Seta**: Bevrugte selle beweeg na die operkulum

APPENDIX H: LESSON 2 POWER POINT

BRIOFIETE
MOS
PLANTDIVERSITEIT

Plantdiversiteit
Algemene eienskappe –aanwesig / afwesig

- Vaatweefsel
- Ware wortels / blare / stam
- Sade / spore
- Vrugte
- Hul afhanklikheid van water vir voortplanting

Briofiet bv. Mos

- HABITAT
  - skaduryk
  - klam
- STRUKTUUR
- - klein plantjies
- - 1 tot 5 cm hoog
  - nie ware wortels, stingels, blare, vaatweefsel (tallus)

MIKROSKOOP

- Basis/Voetstuk
- Reguit en soliede oppervlak
- Geen verstelling

Vraag 1:
Beskrywings:

1.1 Beskryf die fisiese struktuur wat waargeneem word.

1.1.1 Risoïede (1)

____

____

1.1.2 "blare" en "stam" (1)

____

____

1.1.3 Seta (1)

____

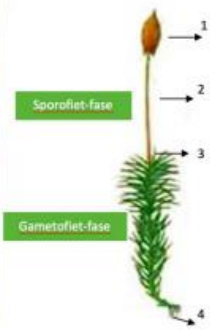
____

1.2 Identifiseer die teenwoordigheid van die structure deur met 'n (√) in die korrekte blokkie te plaas.

Eienskappe	In Bryofiete (mos) teenwoordig
Ware wortels	
Ware blare	
Blare bevat blaarare	
Wortels en blare bevat vaatweefsel	
Bevat spore as voortplantings meganismes	
Produseer sade	

($^1/_2$ x 6 =3)

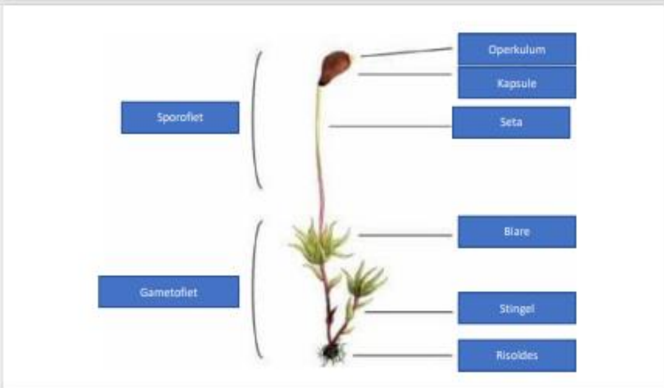
Gee byskrifte vir dele 1-4 deur na die diagram te verwys. Skryf die deel langs die korrekte nommer neer:

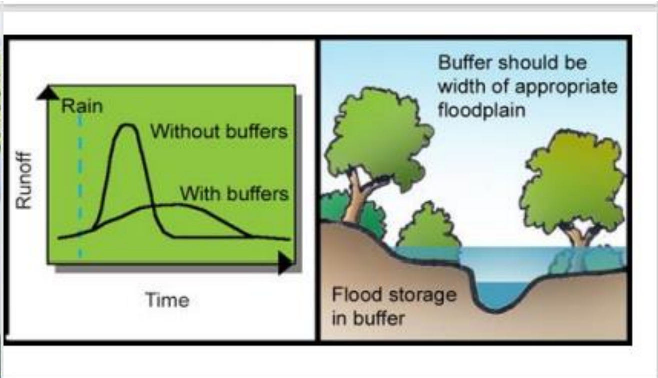


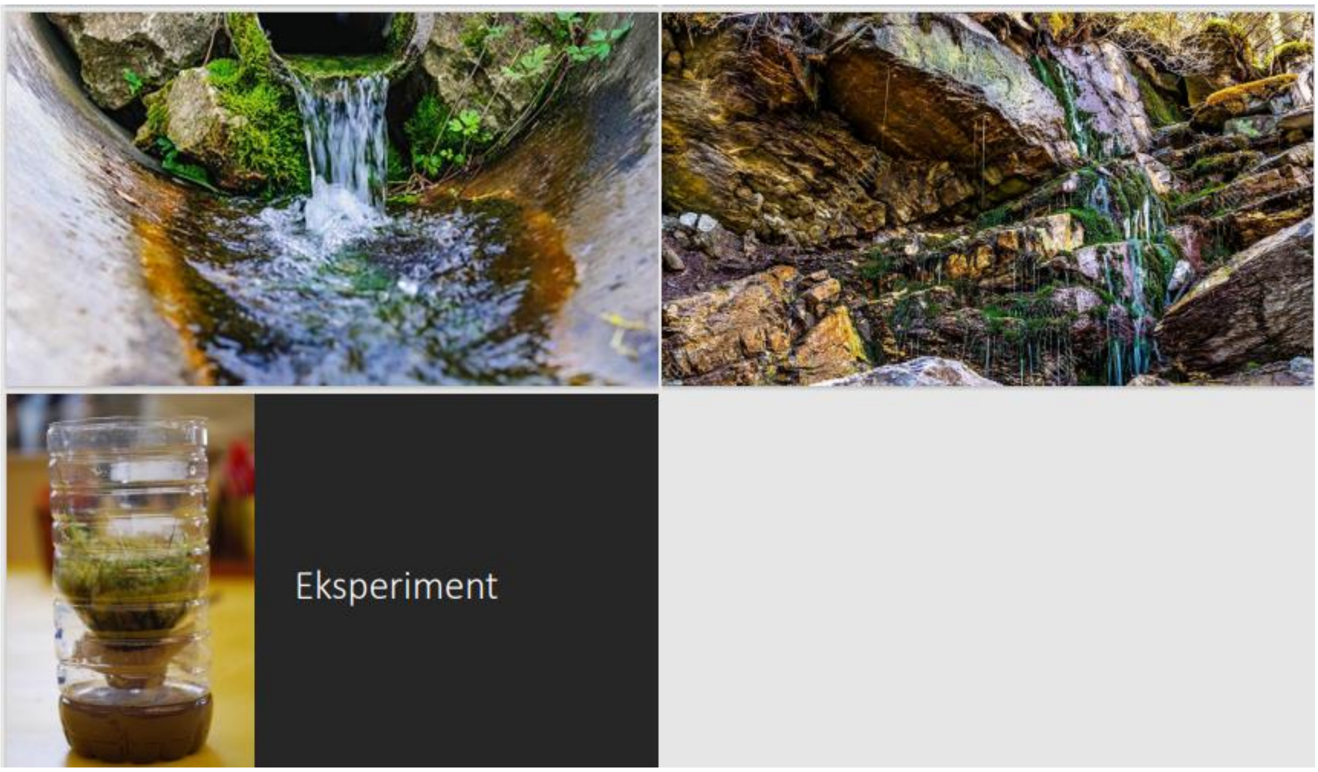
'n Mos-plantjie was gebruik as 'n dreinerings sisteem om te sien hoe vinning 50 ml water deur die plant geseifer kan word oor 5 dae. 'n 0,3mm Digte filtreer-papier was ook gebruik as 'n dreinering sisteem om die resultate tussen die twee sisteme te vergelyk. Bestudeer die reslultate en beantwoord die vrae wat volg.

DAG	Mos-plantjie (mm)	Filtreer-papier (mm)
1	10	2
2	14	7
3	19	12
4	22	16
5	25	18

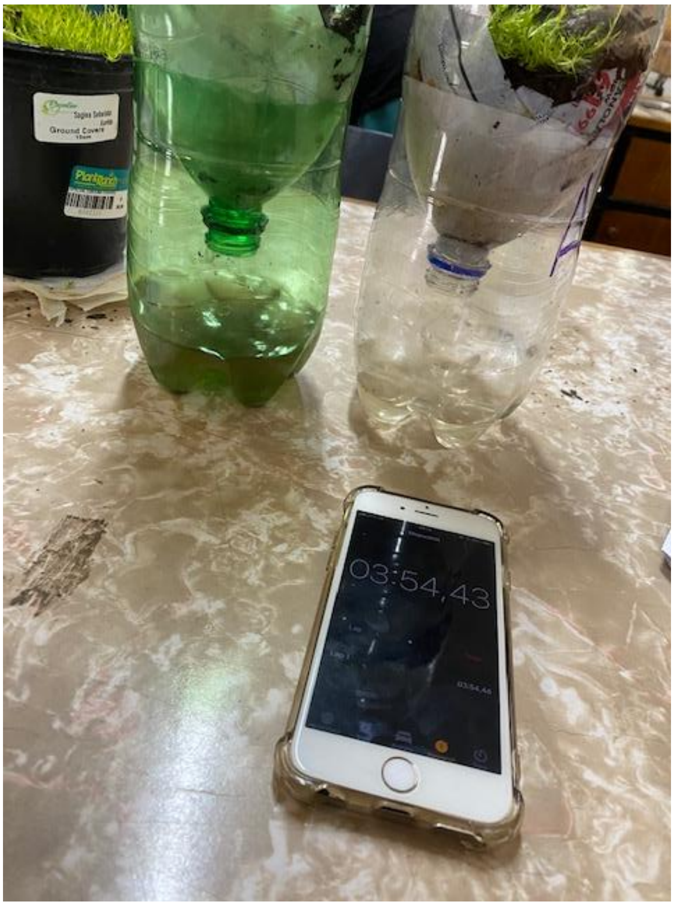
APPENDIX I: LESSON 3 POWER POINT






Eksperiment

APPENDIX J: LESSON 4 DRAINAGE SYSTEM SET-UP



APPENDIX K: DEPARTMENT OF EDUCATION ETHICS APPROVAL

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**01 February 2021**
Validity of Research Approval:	**08 February 2021– 30 September 2021** **2021/17**
Name of Researcher:	**Mc Pherson –Geyser G**
Address of Researcher:	**28 Ilanga Place**
	Klippan Street
	Doornpoort/Pretoria Noord
Telephone Number:	**084 5266483**
Email address:	**Fifim7@gmail.com**
Research Topic:	**Exploring the extent to which the four modes of experiential skill development influence the proficiency of the Life Sciences learner.**
Type of qualification	**Doctor of Philosophy**
Number and type of schools:	**4 Secondary Schools**
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 to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

01/02/2021

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

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of COVID 19 pandemic researchers can ONLY collect data online, telephonically or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate. The approval letter will then indicate the type of arrangements that have been made with the school.***
4. ***The Researchers are advised to make arrangements with the schools via Fax, email or telephonically with the Principal.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter / document that outline 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, respectively.*
7. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *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.*
10. *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.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *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.*
13. *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.*
14. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *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.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director 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

....

Mr Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 01/02/2021

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

APPENDIX L: SCHOOL'S PERMISSION LETTER

HOËRSKOOL PRETORIA-NOORD

PRIVAATSAK X05
PRETORIA-NOORD
0116
E-pos: administrasie@pnhs.co.za

H/V BERGLAAN EN EEUFEESSTRAAT
PRETORIA-NOORD
TEL: (012) 546-6590
FAKS: (012) 546-9463

6 December 2021

Attention: To whom it may concern

R/E: PERMISSION TO CONDUCT RESEARCH / DATA COLLECTION AT H/S PRETORIA-NOORD

Herewith permission is granted to Mrs. G. McPherson (student number: 1233755) to conduct research / data collection at H/S Pretoria-Noord.

Yours Faithfully

Mr. CJC Driescher

Principal: H/S Pretoria-Noord

6/12/2021.

Date

Sedert 1943 in diens van die Jeug

APPENDIX M: PRINCIPAL'S PERMISSION LETTER

HOËRSKOOL PRETORIA-NOORD

PRIVAATSAK X0... PRETORIA-NOORD 0116
H/V BERGLAAN EN EEUFEESSTRAAT PRETORIA-NOORD TEL: (012) 546-6590 FAKS: (012) 546-9463

SCHOOL'S PERMISSION LETTER

Title of Project: Investigating the development of experiential skills in Grade 11 Life Sciences.

Name of Researcher: Genevieve Mc Pherson-Geyser

I, CR Prinscher ....(principal) have read and understood the information contained in this letter, and hereby grant permission to Genevieve Mc Pherson-Geyser (the researcher), to administer an lessons on plant diversity together with pre-, during- and post-test as well as questionnaires with Grade 11 Life Sciences learners from...PNHS........... (school).

Please circle the relevant options below.

	Circle one
Permission to be audiotaped	
I agree to lessons being audiotaped.	YES/NO
I know that the audiotapes will be used for this study only.	YES/NO
Permission to use anonymous quotes	
I agree that the researcher may use anonymous quotes/test answers in her research report.	YES/NO
Permission to complete pre-, during- and post-tests	
I agree to learners completing pre-, during- and post-tests.	YES/NO
I know that the test results will be used for this study only.	YES/NO
Permission to complete questionnaires	
I agree to learners completing questionnaires.	YES/NO
I know that the questionnaires will be used for this study only.	YES/NO

Informed permission

I understand that:

- Anonymity is not guaranteed during the data collection since it is a face-to-face lessons being taught.
- However, my name and information will be kept anonymous, confidential and safe in resulting research reports or publications, and that my name will not be revealed since pseudonyms will be used.
- I will not be advantaged or disadvantaged in any way.
- I can withdraw from the study at any time.
- All the data collected during this study will be kept at the University of Witwatersrand's School of Education and will be destroyed within 6 years after completion of the project.

Sedert 1943 in diens van die Jeug

HOËRSKOOL PRETORIA-NOORD

PRIVAATSAK X05
PRETORIA-NOORD
0116
E-pos: administrasie@pnhs.co.za

H/V BERGLAAN EN EEUFEESSTRAAT
PRETORIA-NOORD
TEL: (012) 546-...90
FAKS: (012) 546-9463

.... (signature of Principal)

C.R. DREESCHER .... (name of principal)

28/9/2021 .... (date)

APPENDIX N: PARENT'S INFORMATION SHEET

Dear Parent/ Guardian,

RE: REQUEST FOR CHILD'S PARTICIPATION CONSENT

My name is Genevieve Mc Pherson-Geyser and I am a Doctor of Philosophy student at the University of Witwatersrand, Faculty of Humanities. As part of my studies, I must undertake a research project, and I am investigating the development of experiential skills in Grade 11 Life Sciences learners and its influence on learners' proficiency. The aim of this research project is to find out what aspects are considered in creating experiential skill development lesson plans. Finally, it will provide information on how learners perceive experiential based practicals aligned with Life Sciences content.

Your child's class has been selected to participate in the study. I would like to ask for your consent to have your child to take part in a classroom lesson that will be audio-recorded as taking part in completing a pre-, during- and post-test (50 minutes each) which will be completely confidential and anonymous and the information will be held securely and not disclosed to anyone. Your child's name and the name of the school will NOT be disclosed to anyone. The information collected will strictly be used for research purposes only. Participation in this research project is voluntary. There will be a total of four lessons on plant diversity that should be completed according to CAPS and with your consent, I would like to administer these tests that are developed by the researcher and written during the class time. These tests will not contribute to any formal assessment that may influence the learner's Life Sciences mark. Learners would also complete a questionnaire at the end of the research to give a voice to their perception of experiential based practicals and how they align with content.

Your child will not receive any direct benefits from participating in this study, and there are no disadvantages or penalties for not participating. The child may withdraw at any time during the study, the learner will then still having access to the lesson but will not be required to complete the tests or the questionnaires. The tests and questionnaires will be completely confidential and anonymous as I will not be asking for your child's name or any identifying information, and the information given to me will be held securely for 6 years at the WSoE and not disclosed to anyone else. If you have any questions afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. A result summary will be available to you on request. If you have any queries, concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (non-medical), telephone + 27(0)11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,
Genevieve Mc Pherson-Geyser

Researcher: G. Mc Pherson-Geyser, email: fifim7@gmail.com, phone number: 084 5266 483
Supervisor: Dr P. Kavai, email: portia.kavai@wits.ac.za, phone number: 0117173248

APPENDIX O: PARENT'S CONSENT TO PARTICIPATION SHEET

Title of Project: Investigating the development of experiential skill development in Grade 11 Life Sciences

Name of Researcher: Genevieve Mc Pherson-Geyser

Please fill in and return the reply slip below indicating your willingness for your child to participant in my voluntary research project.

I,……………………………………..(PARENT) of……………………………(LEARNER) give my consent for the following:

Circle your answer:

	Circle one
Permission to be audiotaped	
I agree to lessons being audiotaped.	YES/NO
I know that the audiotapes will be used for this study only.	YES/NO
Permission to use anonymous quotes	
I agree that the researcher may use anonymous quotes/test answers in her research report.	YES/NO
Permission to complete pre-, during- and post-tests	
I agree to learners completing pre-, during- and post-tests.	YES/NO
I know that the test results will be used for this study only.	YES/NO
Permission to complete questionnaires	
I agree to learners completing questionnaires.	YES/NO
I know that the questionnaires will be used for this study only.	YES/NO

Informed Consent

I understand that:

- Anonymity is not guaranteed during the data collection since it is a classroom lesson.
- However, my child's name and information will be kept anonymous, confidential and safe in resulting research reports or publications, and that my child's name will not be revealed since pseudonyms will be used.
- My child's participation is voluntary, and they will not be advantaged or disadvantaged in any way.
- My child does not have to answer every question and they can withdraw from the study at any time.
- My child can ask not to be videotaped.
- All the data collected during this study will be kept at the University of Witwatersrand's School of Education and will be destroyed within 6 years after completion of the project.

…………………………………… (signature of parent)

……………………..………………… (name of parent)

………………………………………………………… (date)

APPENDIX P: LEARNER'S INFORMATION SHEET

Dear Learner,

RE: REQUEST FOR LEARNER'S PARTICIPATION ASSENT

My name is Genevieve Mc Pherson-Geyser and I am a Doctor of Philosophy student at the University of Witwatersrand, Faculty of Humanities. As part of my studies, I must undertake a research project, and I am investigating the development of experiential skills in Grade 11 Life Sciences learners and its influence on learners proficiency. The aim of this research project is to find out what aspects are considered in creating experiential skill development lesson plans. Finally, it will provide information on how learners perceive experiential based practicals aligned with Life Sciences content.

Your class has been selected to participate in the study. I would like to ask for your parent's consent if you are an under-18 pupil as well as your assent to take part in a classroom lesson that will be audio-recorded as taking part in completing a pre-, during- and post-test (50 minutes each) which will be completely confidential and anonymous and the information will be held securely and not disclosed to anyone. Your child's name and the name of the school will NOT be disclosed to anyone. The information collected will strictly be used for research purposes only. Participation in this research project is voluntary. There will be a total of four lessons on plant diversity that should be completed according to CAPS and with your consent, I would like to administer these tests that are developed by the researcher and written during the class time. These tests will not contribute to any formal assessment that may influence the learner's Life Sciences mark. Learners would also complete a questionnaire at the end of the research to give a voice to their perception of experiential based practicals and how they align with content.

You will not receive any direct benefits from participating in this study, and there are no disadvantages or penalties for not participating. You may withdraw at any time during the study, you will then be allowed to have access to the lesson. But would not be required to complete the tests and questionnaires. The tests and questionnaires will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information given to me will be held securely for 6 years at the WSoE and not disclosed to anyone else. If you have any questions afterwards about this research, feel free to contact me on the details listed below. A summary of the results of the study will be available to you on request. This study will be written up as a research report which will be available online through the university library website. If you have any queries, concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (non-medical), telephone + 27(0)11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,
Genevieve Mc Pherson-Geyser

Researcher: G. Mc Pherson-Geyser, email: fifim7@gmail.com, phone number: 084 5266 483
Supervisor: Dr P. Kavai, email: portia.kavai@wits.ac.za, phone number: 0117173248

APPENDIX Q: LEARNER'S ASSENT TO PARTICIPATION SHEET

Title of Project: Investigating the development of experiential skills in Grade 11 Life Sciences.

Name of Researcher: Genevieve Mc Pherson-Geyser

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project.

I, ……………………………………………..(LEARNER) give my assent for the following:

Circle your answer:

	Circle one
Permission to be audiotaped	
I agree to lessons being audiotaped.	YES/NO
I know that the audiotapes will be used for this study only.	YES/NO
Permission to use anonymous quotes	
I agree that the researcher may use anonymous quotes/test answers in her research report.	YES/NO
Permission to complete pre-, during- and post-tests	
I agree to learners completing pre-, during- and post-tests.	YES/NO
I know that the test results will be used for this study only.	YES/NO
Permission to complete questionnaires	
I agree to learners completing questionnaires.	YES/NO
I know that the questionnaires will be used for this study only.	YES/NO

Informed Consent

I understand that:

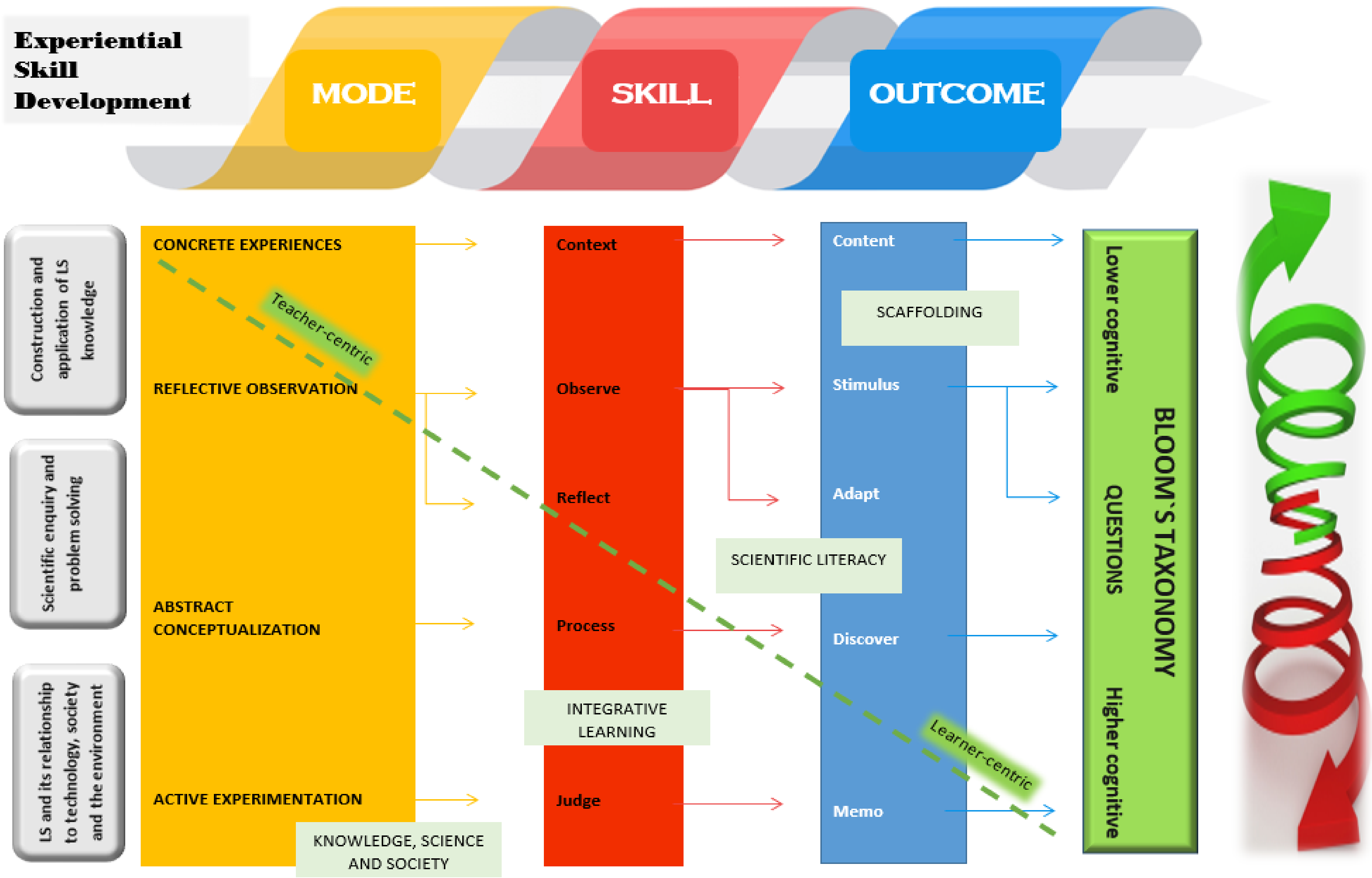
- Anonymity is not guaranteed during the data collection since it is a face to face lessons.
- However, my name and information will be kept anonymous, confidential and safe in resulting research reports or publications, and that my name will not be revealed since pseudonyms will be used.
- My participation is voluntary, and I will not be advantaged or disadvantaged in any way.
- I do not have to answer every question and I can withdraw from the study at any time.
- I can ask not to be audio-recorded.
- All the data collected during this study will be kept at the University of Witwatersrand's School of Education and will be destroyed within 6 years after completion of the project.

…………………………………… (signature of learner)

……………………..………………… (name of learner)

………………………………………………………… (date)

APPENDIX R: EXPERIENTIAL SKILL DEVELOPMENT TOOL (OWN)



APPENDIX S: DECLARATION OF ORIGINALITY

Declaration of Academic Integrity and Original Work

I, (Name and surname) Genevieve McPherson-Geyser,

Student number: 1233755 know and accept that cheating, copying and plagiarism (i.e., to use the words and ideas of others without due credit) is dishonest.

Course Code: HDA01

Name of Assignment

Doctor of Philosophy

Please confirm the following:

✓	I declare that the above assignment handed in on the date below is my own, original work.
✓	I have acknowledged all direct quotations and paraphrased ideas.
✓	I have provided a complete, alphabetised reference list, as required by the APA method of referencing (described in the Referencing Handbook).
✓	I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.
✓	I have not referred to or copied the work of another student in any way in this submission.
✓	I understand that the University of the Witwatersrand will take disciplinary action against me if evidence suggests that this is not my own unaided work or that I failed to acknowledge the source of the ideas or words in my writing

Signed: ____________________

Date: 15 March 2023