TEACHERS' IMPLEMENTATION OF INQUIRY-BASED LEARNING ACTIVITIES IN LIFE SCIENCES CLASSROOMS

by

NCAMISO DERRICK MLIPHA

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SUPERVISOR: MRS. MOLEBOHENG MALEKOA RAMULUMO

CO-SUPERVISOR: PROF AWELANI V MUDAU

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DECLARATION

Name: Ncamiso Derrick Mlipha

Student number: 56845499

Degree: MED (Curriculum studies)

Teachers' implementation of inquiry-based learning activities in Life Sciences classrooms.

I declare that the above dissertation is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the dissertation to originality checking software and it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.

SIGNATURE

08 December 2022

DATE

DEDICATION

This study is dedicated to:

- My late father Hudson Mlipha and my late mother Sibongile Mlipha.

- My wife Thuli Nelly Mlipha, my son Malwande and my daughter Zenande.

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ABSTRACT

Inquiry-based learning in Life Sciences is both a goal and a tool for learning which incorporates a range of approaches, from teacher-led confirmatory inquiry to open inquiry. Despite the fact that inquiry-based learning is crucial in the teaching and learning of Life Sciences, only a tiny fraction of secondary school teachers implement inquiry-based learning instructions to develop problem-solving activities and abilities. The incapacity to implement inquiry-based learning, teachers teach Life Sciences to meet the National Curriculum Statement requirements standards rather than using Life Sciences to develop additional abilities that may be achieved through inquiry-based learning. The aim of the research is to explore the contribution of inquiry-based learning activities to the development of teachers' teaching strategies in Grade 11 Life Sciences classrooms. A qualitative case study research design was used for this research and data was collected through face-to-face interviews and direct observations of 3 Grade 11 Life Sciences teachers in the Gert Sibande District. The findings of this research revealed that teachers exhibited a full understanding of what inquiry-based learning entails. However, the teachers' understanding assisted them in terms of lesson preparation and in directing the teachers to utilise well-crafted problems and questioning techniques to guide learners through an inquiry-based learning process. Furthermore, the findings also show that Life Sciences teachers rarely practice inquiry-based learning as an instructional strategy, and this is supported by the fact that one teacher managed to implement inquiry-based learning while the other two had challenges with the implementation. In this regard, the findings of this research give a clear picture of the limited inquiry-based learning practices in the classroom and the poor understanding of teaching Life Sciences through inquiry-based learning.

Keywords: Inquiry-based learning; inquiry-based learning activities; implementation; Life Sciences; curriculum; classroom; National curriculum statement.

TABLE OF CONTENTS

ABBREVIATIONS

IBL	Inquiry-based learning
CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
DAS	Data analysis scheme

GLOSSARY OF TERMS

- **Life Sciences:** the scientific study of living organisms, from the molecular level through their interactions with one another and their environment, is known as Life Sciences (Department of Basic Education, 2011 p.8).
- **Inquiry-based learning:** is a learner-centred approach to teaching and learning that encourages learners to learn by asking questions (Maab & Artigue, 2013).
- **Implementation:** the evidence-based practice of both learning/attaining knowledge and teaching in Life Sciences education (Mattman, 2019).
- **Curriculum:** is the set of expected student learning outcomes (Johnson, 1965).
- **Science:** a search for knowledge about how the natural world works (Van Rooyen, 2007).
- **Teaching:** the deliberate development and enactment of actions and experiences by one person results in changes in another person's knowledge, abilities, and dispositions (Taylor & Francis, 2015).
- **Learning:** a long-term shift in knowledge, skills, or attitudes brought about by planned or spontaneous experiences, events, activities, or actions (Taylor & Francis, 2015).
- **Curriculum and Assessment Policy Statement:** a comprehensive policy statement (Ramnarain, 2020). The policy document provides teachers with guidance on what they should teach and how assessment should be done.
- **Teacher:** a person who provides education for pupils and students
- **Learner:** a term used in South Africa to indicate a school going person.

CHAPTER 1:

INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 INTRODUCTION

The research background and problem statement for the study are presented in this chapter. It also presents the research questions, aims and objectives. This chapter also discusses the rationale and limitations of the study. It also includes an outline of each chapter of the research.

1.2 RESEARCH BACKGROUND

Life Sciences education has distanced learners from the processes and nature of the subject (Habteselassie, 2015). Moreover, Habteselassie (2015) found that in Life Sciences classrooms, learners had to memorise facts and concepts. According to Goodrum et al. (2000), Life Sciences teaching at secondary schools usually involves teacher-centred instructions, dominated by lecturing, note-copying by learners, and factual demonstrations. Habteselassie (2015) maintains that the traditional method of instruction does not prepare learners to participate in today's modern society. School science reformers emphasise that school science should contribute to improving public understanding of Life Sciences (World Science Forum, 2003). To adopt inquiry-based learning (IBL), the curriculum should not only focus on Life Sciences material, which requires learners to be consumers of Life Sciences ideas, but also on developing the learners' understanding of the subject, such as those needed for the 21st century. Learners, according to Friesen and Scott (2013), require new educational models that reflect the current economy, the rise of new technologies and digital networks, and new developments in Life Sciences education.

IBL has been acclaimed by scientific academics in the field of science education as an important and effective approach of learning that involves learners in activities that make sense to them rather than providing learners with an easy way to the solution (Love et al., 2015). According to Gerli (2017), IBL is a very effective strategy for increasing learners' motivation in science, technology, engineering, and mathematics (STEM) topics. IBL is a learner-centred approach to teaching and learning that encourages learners to learn by asking questions (Maab & Artigue, 2013). More importantly, IBL helps in the development of thinking abilities and intellectual discipline in the learner. Maxwell and Lambeth (2015) assert that IBL is a teaching method that promotes the development of problem-solving abilities in learners, which are vital in everyday situations.

In science education, IBL is quickly gaining traction, with several educators becoming interested. Teachers believe that improving learners' critical thinking is very important in science (Albrecht & Sack, 2000). Science educators are encouraged to replace traditional teacher-centred instructional practices such as chalk and talk with more learner-centred approaches that encourage learners to solve problems using logic and evidence (Secker, 2002).

The introduction of the learner-centred approach in Life Sciences would be done through the implementation of IBL. According to Maab and Artigue (2013), implementation is defined as the process whereby a planned intervention is set in motion. Martin et al. (2012) argue that implementation in the Life Sciences is both a study/discipline of research and a method of attaining knowledge. Furthermore, Rebecca (2007) clarifies that implementation in Life Sciences examines techniques for adapting and implementing evidence-based interventions in a specific setting, such as a Life Sciences classroom. Mattman (2019) posits that implementation is the evidence-based practice of both learning and attaining knowledge in Life Sciences education. The ideas of inquiry as well as the sequential structure of the inquiry process favour the adoption of IBL in the Life Sciences (Blum & Fleischer, 2019).

Teachers encounter challenges in various phases of the IBL which negatively affect the success of the implementation of the IBL activities. According to Ramnarain (2018), one of the reasons teachers are less inclined to implement IBL is the lack of resources in some schools. Furthermore, Chaimala (2014) outlines the difficulties that Life Sciences teachers encounter while implementing IBL in their classrooms, which include a lack of relevant teaching resources and IBL evaluation methods. The challenges are what make teachers less interested in implementing IBL in their Life Sciences classrooms (Chaimaila, 2014). Moreover, another concerning factor that may discourage teachers from implementing IBL in their classrooms is the class size, as learners can be a limitation in doing experiments because inquiry requires more individual support than typical laboratory work (Dixon, 2011).

However, problems may arise in the implementation of IBL in Life Sciences classes, discouraging teachers from implementing the method. Some of the challenges that limit the implementation of IBL in Life Sciences teaching, according to Abd-El-Khalick et al. (2004), are: (a) lack of a philosophy of the nature of scientific inquiry in Life Sciences policies; (b) IBL is hampered by a teacher's lack of content understanding; (c) lack of resources in schools that support IBL; (d) the lack of teacher professional development; and (e) learners who are less motivated to participate in IBL because they lack the necessary knowledge and abilities.

In Life Sciences, IBL is both a goal and a tool for learning (Kurten & Henriksson, 2021). According to Kurten and Henriksson (2021), IBL teaching and learning incorporates a range of approaches ranging from teacher-led confirmatory inquiry to open inquiry. Furthermore, with open inquiry, the teacher establishes the backdrop while the learners develop their own research topics and execute various inquiry projects. Gutierrez and Boero (2016) accentuate that critical thinking skills are linked to human reasoning and knowledge development. In other words, experience, action and critical thinking are basic abstract thoughts that lead to deductive abstract thinking (Masilo, 2018). Alex and Mammen (2014) assert that learning critical thinking and problem-solving skills are still a challenge for many Life Sciences learners in South Africa, especially in public schools. Teaching critical thinking and problem-solving skills using the traditional approach contributes to the failure to learn these skills properly (Masilo, 2018). IBL, on the other hand, teaches learners skills such as critical thinking and learner-centred thinking to identify, pose and solve problems.

Life Sciences learners in Grade 11 are expected to have sufficient experience since they have accumulated knowledge, understanding, and skills in identifying and solving problems during their lower grades (Cairns, 2019). According to Cassim (2007), learners in Grade 11 should be able to apply the knowledge acquired in the lower grades through the exploration to create confirmations based on their understanding. Therefore, at this level, learners' understanding should allow for progression from passive participation, memorisation and rote learning of concepts, but Masilo (2018) discovered that most Life Sciences learners in Grade 11 struggle at almost all the levels of knowledge and comprehension.

According to Clark (2012), teachers need to support learners to achieve the requirements of the advanced level of reasoning to complete the knowledge and understanding of the lower levels. According to Constantinou et al. (2018), inquiry-based instruction approaches can help learners acquire higher-order cognitive skills that can allow learners to apply their deeper understanding of scientific principles to daily phenomena. In my observation, I noticed that Grade 11 Life Sciences learners in public schools with limiting factors still lack the required lower-level knowledge and I postulate that teaching through IBL would help a reasonable number of learners master the concepts and skills they missed in the lower levels.

1.3 STATEMENT OF THE PROBLEM

Several educational philosophers and other academics (Capps et al., 2012) have advocated that the use of IBL approaches is vitally important in the teaching and learning of Life Sciences. IBL techniques in Life Sciences teaching and learning, according to Capps et al. (2012), give a framework for the development of critical thinking and problem-solving abilities for learners. Despite the fact that IBL is critical in Life Sciences teaching and learning, only a small percentage of secondary school teachers use IBL instructions to build problem-solving activities and abilities (Capps et al., 2012). Furthermore, Capps et al. (2012) assert that, owing to the inability to implement IBL, teachers teach Life Sciences to meet the criteria of the National Curriculum Statement standards rather than using Life Sciences to develop additional abilities that could be acquired through IBL. Masilo (2018) advocates that learners in Life

Sciences classrooms are struggling with the basic levels of knowledge and understanding as most teachers display a lack of confidence in terms of facilitating IBL.

It has become my interest to investigate and address the question – What contributions do IBL activities play in the development of teachers' teaching strategies in Life Sciences classrooms? This is based on the review of literature in preparation for this research. There seems to be a dearth of literature in South Africa that focuses on the implementation of IBL activities in the Life Sciences classroom. As research shows that there are many challenges to the implementation of IBL in Life Sciences (Anderson, 2002) and hence because the challenges occur mostly in public schools. I have more of an expectation to see IBL being implemented in public schools than in private or independent schools.

Owing to a variety of reasons, Life Sciences teachers in public schools encounter challenges which range from overcrowding, class size, unavailability of resources, teachers' beliefs towards IBL and lack of teachers' professional development. The question is: What should a teacher do in such a situation? However, in South Africa, there is no literature available about the contribution that IBL activities bring to the development of teachers' teaching strategies in Life Sciences. This study is contextual to South Africa and can make a good contribution in the body of knowledge, especially the teaching methods.

1.4 RESEARCH AND SUB-RESEARCH QUESTIONS OF THE STUDY

In response to the problem statement, the study sought to provide answers to the following main question and sub-questions:

1.4.1 Main question

What contribution do inquiry-based learning (IBL) activities bring to the development of teachers' teaching strategies in Life Sciences classrooms?

1.4.2 Sub-questions

- What understanding do teachers have about the implementation of IBL activities?

- How do teachers implement IBL activities to improve their teaching strategies in Life Sciences classrooms?
- How do teachers' IBL practices develop as a result of the implementation of IBL activities?

1.5 RATIONALE OF THE STUDY

According to the Department of Basic Education (DBE) (2020), the number of learners who wrote the Life Sciences examination has increased but the performance of the learners reflects a slight decline of 30% level from 72,3% in 2019 to 71,0% in 2020 as well as at the 40% level from 49,0% in 2019 to 47,9% in 2020. Furthermore, the DBE (2020) asserts that challenging areas that have been seen include the understanding of scientific investigation. The scientific process is a crucial component of assessment in Life Sciences and is often tested at a higher cognitive level (DBE, 2020). In addition, DBE (2020) teachers must use relevant and contextual examples to reinforce an understanding of the scientific process.

Based on my years of experience teaching Life Sciences in the classroom, I believe that learners who were exposed to more IBL activities performed better in the Life Sciences than learners who were only exposed to theoretical concepts. Kavai (2013) concurs that most topics in Life Sciences have traditional teaching styles that are educator-focused, and that the themes provide numerous obstacles to both teaching and learning. The traditional approach to teaching destroys the spirit of IBL in Life Sciences classrooms and creates an unhealthy relationship between teachers and learners (Habteselassie, 2015). When learners are offered IBL tasks in Life Sciences, however, I have noticed that learners seem to be more interested in IBL. From the observations, I concluded that implementing IBL in Life Sciences classrooms would be beneficial in assisting learners in developing skills such as critical thinking and problem-solving, which would assist learners understand the value of learning Life Sciences. The study was therefore meant to explore the contribution of IBL activities to the development of teachers' teaching strategies in Grade 11 Life Sciences classroom.

It is hoped that this study would establish the implementation of IBL in Life Sciences education. The findings are expected to supply information and assistance to Life Sciences teachers, encouraging them to recognise the value of IBL in consolidating knowledge and fostering critical-thinking abilities. The findings can also assist the DBE work with school administrators, subject advisors and provisional coordinators to encourage Life Sciences teachers to use IBL activities as a strategy to consolidate Life Sciences knowledge despite the limitations. Furthermore, the findings may assist teachers in developing their teaching strategies in Life Sciences, which may help to boost learners' interest and achievement in the subject. Finally, this research is vital in assisting teachers to understand what IBL is, how to implement IBL activities to better their teaching strategies in Life Sciences and to develop teachers' knowledge because of the implementation of IBL activities.

1.6 AIM AND OBJECTIVES OF THE STUDY

The aim of the study was to explore the contribution of IBL activities to the development of teachers' teaching strategies in Grade 11 Life Sciences classroom.

The study objectives are as follows:

- To investigate teachers' understanding about the implementation of IBL activities.
- To explore how teachers implement IBL activities to improve their teaching strategies in Life Sciences classrooms.
- To investigate how do teachers' IBL practices develop as a result of the implementation of IBL activities.

1.7 DELIMITATION OF THE STUDY

This research provides an insight into teachers' implementation of IBL activities in Life Sciences. It highlights the contribution that IBL activities make in the development of teachers' teaching strategies in Life Sciences classrooms. This research focuses on three Life Sciences teachers in the Gert Sibande District because it was accessible for me to identify participants that best fit the criteria.

The literature review was limited to that which helped answer the study's research questions about IBL in the South African education system, the nature of IBL, the characteristics of inquiry-based classrooms, the stages of IBL, and the IBL framework. As a result, nothing entirely irrelevant to the study was included in the literature review.

1.8 STRUCTURE OF THE STUDY

This section contains an outline and organisation of all of the chapters in this research.

Chapter 1: Introduction – This chapter presents the research background, problem statement, research questions, rationale, aims and delimitation of the research, study structure, and conclusion.

Chapter 2: Literature review and theoretical framework – This section focuses on IBL, IBL in the South African education system, the important features of inquiry-based classrooms, the stages of IBL in Life Sciences, the implementation of IBL activities to improve teaching strategies, teachers' content knowledge, teachers' knowledge development, teachers' challenges with IBL implementation, application of social constructivism in an inquiry-based classroom and the conclusion.

Chapter 3: Research methodology – This section presents a detailed description of the methodology of this study. This includes research paradigm, research approach, research design, sampling methods, data collection, data analysis, trustworthiness of the study, ethical consideration and conclusion.

Chapter 4: Data presentation, discussion and findings – This chapter presents data presentation, discussion and findings from the Life Sciences teachers.

Chapter 5: Summary of findings and recommendations – This chapter presents the answers to the research questions, the contributions of the research, limitations of the study and the recommendations for the study.

1.9 CONCLUSION

The introduction and background of the study were presented in this chapter. This chapter also presented the problem statement, the aims and objectives, and the research questions. The following chapter contains a thorough review of the literature as well as the study's theoretical framework.

CHAPTER 2:

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

The literature review aims to provide context for Life Sciences education globally before focusing on the implementation of IBL in South African education. This chapter focuses on IBL, IBL in the South African education system, the important features of inquiry-based classrooms, the stages of IBL in Life Sciences, the implementation of IBL activities to improve teaching strategies, teachers' content knowledge, teachers' knowledge development and the teachers' challenges with IBL implementation. The theoretical framework is also examined, and the study employs social constructivism.

2.2 LITERATURE REVIEW

2.2.1 Inquiry-based Learning

IBL is defined as a learning method that engages learners in activities that make sense to them rather than providing a clear path to the solution (Love et al., 2015). I define IBL as a learner-centred approach in which the teacher's role is limited to facilitating and guiding the learning process. IBL is better described as a component of the learning paradigm than the teaching paradigm (Barret, 2005). According to Love et al. (2015), the teacher directs learning in the process of IBL by using well-designed problems through adventurous activities that support the discovery of new concepts and the application of acquired knowledge in Life Sciences. Furthermore, according to Love et al. (2015), in the IBL process, a teacher must encourage learners in problem-solving activities such as communicating, experimenting, exploring, hypothesising, and applying. According to the researcher, IBL teachers must be familiar with the learner's cognitive processes and techniques, as well as the learners' cognitive architecture to select the best strategy for manipulating instructional processes and procedures, as well as their interactions with the learners' cognitive structures and processes. Finally, when implementing IBL activities, teachers should be aware of the factors that contribute to cognitive load, which impedes cognitive processing.

2.2.2 Inquiry-based learning in the South African education system

In Life Sciences education, IBL has been recommended as a means of overcoming previous curricula shortcomings, such as inaccessibility, irrelevance and incompatibility with the nature of science (DBE, 2011). In South Africa and around the world, IBL has been promoted as a common curriculum goal in Life Sciences. According to Ramnarain (2020), inquiry in Life Sciences education enables learners to create scientific concepts by learning how to explore and construct their knowledge and comprehension of the world through the use of scientific skills such as data gathering, justification and evaluating evidence in the context of what is currently known.

Life Sciences is the scientific study of living organisms from the molecular level through their interactions with one another and with their surroundings (DBE, 2011 p.8). According to the DBE (2011), Life Sciences must be taught using specialised teaching strategies that allow learners to expand their knowledge and learn new skills. Furthermore, the strategies must provide teachers with both a repeatable method of scientific inquiry and a systematic method of scientific study. The methods also include hypothesis formulation and experimentation.

The Curriculum and Assessment Policy Statement (CAPS) is a comprehensive policy statement developed by the DBE (Ramnarain, 2020). The policy document tells teachers what to teach and how to assess their learners. According to Du Plessis (2011), the new CAPS is a shift in what teachers teach rather than how they teach. One of the principles of the CAPS, according to the DBE (2011), is to promote active and critical learning rather than rote and uncritical learning of supplied knowledge. The CAPS emphasises the establishment commitment to social reform as well as the development of learners' critical thinking skills (DBE, 2011).

Life Sciences specific aim number two is highlighted in the CAPS: "Learners must be able to organise and conduct research, as well as solve problems that require certain experiment abilities". Furthermore, learner abilities are supported by a curious attitude and a desire to comprehend how the natural world and living things function (DBE, 2011).

The South African government worked with large-scale educational reformers to transform the education system, believing that this would be the most effective way of empowering the disadvantaged majority of South Africans who had been victims of apartheid education (Smith, 2000). The changes demonstrated that the DBE recognised the value of the IBL method (Kavai, 2013). The CAPS, according to Pretorius (2002), integrates what has been taught experimentally or theoretically as a means of enabling learners to deal with real-world problems and underscores the development of problem-solving thinking abilities. Against this background, I articulate that IBL differs from the traditional teacher-centred approach, which uses show-and-tell or chalk-and-talk methods of instruction, in that it allows learners to improve their knowledge and skills in Life Sciences (DBE, 2011).

2.2.3 The important features of inquiry-based classrooms

Many people find IBL to be an appealing teaching method as it ensures that learners became more motivated, improved problem-solving skills, and are more engaged in problem-solving (Visser, 2002). I believe that IBL also enables learners to gain knowledge by problem-solving and applying prior knowledge. Although IBL did not result in the development of a learner's problem-solving abilities, it did shift the learner's focus away from typical teacher-learner interactions and toward active, self-directed learning, which includes providing a solution to a problem (Culver, 2000).

The researcher advocates that in an IBL classroom, learning must take place in small groups, with the teacher guiding the learners. Teachers act as facilitators of learning, introducing learners to new concepts or cultural tools while also supporting and guiding them (Driver, 2004). I concur that in IBL classrooms, a teacher must act as a facilitator of learning, and any challenges that arise must be used as a tool to gain the necessary knowledge. Chin and Chin (2004) recognise that learners actively participate in their learning by discussing solutions.

2.2.4 The stages of inquiry-based learning in Life Sciences

The inquiry process, as facilitated by the teacher, allows learners to actively participate in their learning and helps them to own their learning. Cotton's (1995) outline of teacher and learner roles during the IBL process corresponds well with the stages of IBL as outlined by Dell'Olio and Donk (2007) in Table 2.1.

Table 2.1.

Stages of the scientific methods (IBL).

Stage	Teacher's role	Learners' role
1. Developing a question	• Assists in the development of original learning by asking questions and facilitating the work with those questions. • A link aloud approach is used by the teacher.	Work with the questions that have been given to the learner, and then construct the learner's questions.
2. Generating a hypothesis	• Instruct learners to explain or write the rationale for their hypothesis.	Answer questions posed at the outset of the investigation with their past knowledge and understanding.
3. Developing an experiment design	• Assist in the creation of experimental designs. It	Work with the designs that have been provided to them and then develop their

		employs a think-aloud method and includes numerous examples.	creations.
4.	**Collecting and recording data**	Provides several examples and uses a link aloud approach to assist.	Collect and record data using provided methods, and then construct their systems.
5.	**Analysing data**	Facilitates data analysis.	Analyse the data you've been given; analyse their data.
6.	**Reaching conclusions, forming and extending generalisations**	Facilitates through the use of a think-aloud method with various instances.	Form and expand generalisations based on given data as well as their data.
7.	**Communicating results**	Models a variety of methods for communicating outcomes.	Use the data provided to communicate the results. Communicate the findings of their research.

Source: (Dell'Ollo & Donk, 2007)

This study focuses on how IBL activities can be used as a teaching strategy; so, the implementation of IBL activities in Life Sciences classrooms is emphasised heavily. This research employs the inquiry method, in which learners gain knowledge and understanding of scientific concepts and how scientists study the natural world. The inquiry includes process skills that are used to investigate specific concepts and processes.

2.2.5 The implementation of IBL activities to improve teaching strategies

The study emphasises that teaching should start with implementing inquiry and end with confirming inquiry through facts. Since the predominant method of teaching in South Africa is the traditional teaching method, however, this study maintains a view that traditional teaching where a teacher is present as the facilitator can encourage learning by inquiry.

IBL as a means and process of assisting learners through creating doubt aims to enable learners to learn to retain concepts, exhibit a deeper understanding of concepts, show superior abilities in higher-order thinking skills and a higher level of creativity through experiences in inquiry (Dell'Olio & Donk, 2007). Moreover, Dell'Olio and Donk (2007) believe that direct instruction through teacher facilitation is needed as this will support learners to focus their attention on the past, that is, on what has been already discovered by others to confirm their doubts. Furthermore, Dell'Olio and Donk (2007) assert that inquiry experiences will provide learners with the tools to move into the future as producers of knowledge.

IBL is a questioning, hypothesizing and discovering the way of teaching and learning (Bevan, 1996). When most Life Sciences teachers see or hear the word inquiry, they think of a specific method of teaching and learning (Bevan, 1996). Ismail (2007), on the other hand, focuses not only on the ability to involve learners in the inquiry but also on the concept of inquiry and how it might lead to knowledge accumulation. IBL is an innovative way of teaching and learning in the Life Sciences (Ismail, 2007). The latter author highlight that in industrialised countries such as the United States of America (USA) and Canada, IBL has become one of the most popular learning approaches. Nevertheless, several related classroom strategies, such as problem-based learning, have also been used.

In the classroom, IBL can provide a variety of contexts for exploring the essence of science (Schwartz & Crawford, 2006). The importance of inquiry-based teaching and learning has been recognised in studies across the world. Some of the benefits of IBL, according to Potvin and Hasni (2014), include enhancing learner motivation and sparking interest in Life Sciences classrooms. IBL, according to White and Frederiksen (1998), improves conceptual knowledge and leads to a better understanding of the nature of science. Life Sciences teachers in South Africa have recognised these advantages (Ramnarain 2020). Table 2.2 provides the components of the instruction and their character in the realisation of the inquiry-based activity.

Table 2.2: *Components of the instruction and their character in the realisation of the inquiry-based activity.*

Instruction's component	Character in the inquiry-based instruction
Aim	The acquirement of the knowledge related to the object of cognition, inquiry-related methods, and attitudes. Development of the perception and thinking.
Teacher	Instruction using the inquiry activities, preparation of the situations appropriate for the inquiry.
Pupil	Learning through the inquiry activities, exploring.
Educational content	Knowledge acquired through the inquiry activities and acquiring the inquiry methods – e.g. the experimenting, measuring, observing.
Methodological conditions	Problem-posing presentation, heuristic methods, explaining methods, instructive method, demonstration method, method of discussion, project method, dramatization, etc.
Organisation conditions	Group instruction, excursion, frontal instruction, etc.
Material conditions	Laboratory instruments, experimental sets, etc.

Source: *(Jiri, 2015).*

To ensure effective implementation of IBL in Life Sciences, schools need to ensure that teachers are pedagogically trained (Blessinger & Carfora, 2014). I, in this study, concur with Trust (2014) that investing in teachers' pedagogical skills is important when implementing effective changes in learning practices.

Shadreck (2013) avers that teachers in IBL classrooms require the support of the school management team (SMT) and that of other members of the staff as they are important in ensuring the effective implementation of the required resources. I believe that as more Life Sciences teachers change, more teaching staff will change with the continual support of the SMT; the whole school change will eventually take place.

Learners in IBL classes use prior knowledge and experiences to engage in learning (Ulmer, 2015). I assert that IBL has several advantages for both learners and teachers. Furthermore, in a Life Sciences classroom, learners use prior information as a foundation for integrating new learning with previous knowledge (Lemlech, 1998). According to Ulmer (2015), IBL has more relevance for learners as they become a more integral part of their life and have a deeper understanding of the world around them. Furthermore, Ward (2001) asserts that learners can improve their grasp of concepts in Life Sciences and progress from simply knowing the subject to understanding Life Sciences. Figure 2.1 indicates a visualisation of the inquiry-based instruction (Jiri, 2015).

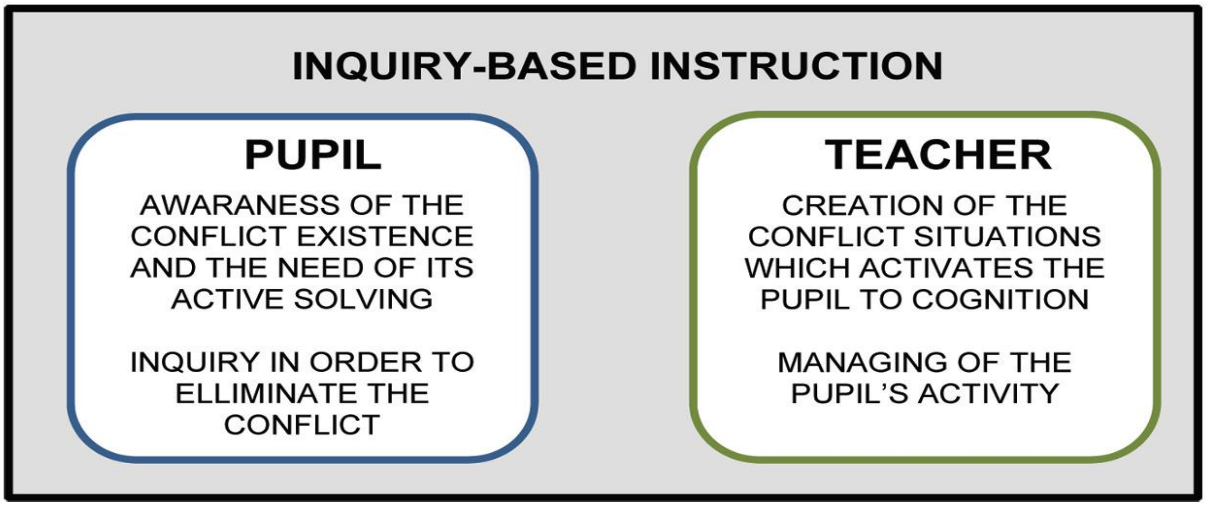


Figure 2.1:*Visualisation of the inquiry-based instruction.*

Source: (Jiri, 2015)

IBL activities can be used by Life Sciences teachers to break up the monotony of classwork, and learners can bond and develop collaboration skills because IBL activities are frequently done in groups (Kavai, 2013). I declare that learners who have engaged in IBL activities with vitality will stimulate some interests and opportunities that they may not have previously considered.

2.2.6 Teachers' content knowledge

The content knowledge of a teacher relates to the subject matter understanding as well as the knowledge of how to successfully teach the content (Habteselassie, 2015). Research conducted by Roehring and Luft (2004) shows that teachers' pedagogical content knowledge is vital in the successful implementation of IBL activities in Life Sciences classrooms. Moreover, McDermott and Constantinou (2000) assert that teachers who know their subject matter well are more successful in the implementation of IBL activities than teachers who have inadequate knowledge.

Although teachers' pedagogical content knowledge is important in creating IBL environments, I in this study believe that it does not mean that the successful implementation of IBL is predictive. Furthermore, I hope that to implement IBL successfully, teachers also need knowledge about inquiry as pedagogy.

2.2.7 Teachers' knowledge development

In Ghana, most teachers continue to use instructional strategies that are ineffective in improving learners' scientific literacy, therefore, making the application of IBL in Life Sciences difficult (Mohammed et al., 2020). Crawford (2007) claims that Life Sciences teachers are unable to develop inquiry-based instructions in the classroom owing to a lack of understanding of IBL. Moreover, Crawford (2007) clarifies that as presented in the reform documents, teaching Life Sciences through IBL is open for readers to interpret in their ways. There is no single operational definition of inquiry-orientated instructions and teachers have different interpretations of what inquiry-based teaching is all about (Crawford, 2007).

The pedagogical content knowledge of Life Sciences teachers has implications on the teacher's strategies when implementing IBL activities (Bruder & Prescott, 2013). In the Life Sciences classroom, Kahle (2000) discovered a link between teacher professional development and successful implementation of IBL activities. I concur with Kahle (2000) that teacher professional development be done shortly before the teacher begins implementing IBL activities in a school context but in other circumstances, teacher professional development continues beyond the initial development of IBL. In the IBL classroom, there is a high level of reluctance related to teaching and learning relationships whereas in traditional Life Sciences classrooms the teacher can plan for every minute of the lesson (Leikin & Rota, 2006).

Teachers' knowledge of IBL is a major aspect of the successful implementation of IBL activities in Life Science education in South Africa (Ramnarain 2020). The understanding of teachers concerning inquiry is critical for the implementation of IBL activities (Abd-El-Khalick et al., 2013). In addition, Kim and Tan (2010) assert that teachers face challenges when adopting an inquiry-based approach, as opposed to a teacher-centred method, in which learners simply follow the teacher's directions. According to Crawford (2012), IBL is a complex and difficult approach to teaching which demands proper teacher professional development. However, the DBE has made great investments to offer professional development and support to Life Sciences teachers, but I feel that there is a lack of evidence to suggest it as it has gained traction in Life Sciences classrooms (Author 2012). I, in this study, contend that one of the supports being offered has been in the form of subject workshops where teachers are instructed on what to do in classrooms without being fully engaged in critical reflection. Furthermore, I express that the second criticism of the support offered to the teachers is that it is not sustainable as it has little follow-up on the extent to which teachers can adopt IBL and the challenges they encounter during the implementation.

2.2.8 Teacher's beliefs about inquiry-based learning

Beliefs are defined in psychology as complicated mental constructions that can influence a person's behaviour (Pajares, 1992). According to Pajares (1992), beliefs can only be inferred from what people say and do rather than being physically observed or quantified. On the contrary, Bryan (2012) claims that beliefs are significantly more influential than knowledge and how people frame and organise tasks and issues and those are better predictors of behaviour. I insist that when it comes to classroom practices in Life Sciences, teachers rely on their fundamental beliefs system. In addition, I postulate that teachers had to modify their views or how they interpret occurrences in their classroom within these belief sets; the activities may be challenging. The content to include in a lesson, the instructional strategies to implement and how to manage the classroom environment are all influenced by a variety of circumstances (Grady, 2007). According to Grady (2007), personal beliefs influence a teacher's decisions and the beliefs are constructed, stored in experiences and events that occur throughout the teachers' life. I maintain that teachers' beliefs influence the interpretation of the events in the Life Sciences classroom and the cognitive knowledge of the teacher. Smith and Rumyantseva (2007) assert that Life Sciences teachers' beliefs could include the following:

- Teachers may believe that IBL instructions are less effective in their classrooms than teacher-centred instructions.
- Teachers may believe that teaching through IBL can be time-consuming.

2.2.9 Teachers' challenges with inquiry-based learning implementation

Teachers have a great deal of power over the learners they teach, and teachers spend more time with children than parents do (Kavai, 2013). I declare that the learners' tastes are likely to be influenced by the teacher's personal preferences. Moreover, implementing IBL activities is contingent on the teacher's ability to deliver the best education and encourage the most possible learning in the classroom.

According to me, when it comes to incorporating IBL at any level into the Life Sciences curriculum, teachers confront a variety of challenges. Teachers in Life Sciences are concerned about introducing more IBL into their curricula because of the greater class time required for enacting the scientific inquiry process when compared to other subjects (Grady, 2007). I assert that in Life Sciences classes in South Africa, learners sit in straight rows of desks facing the front of the classroom. In addition, in some cases, classrooms are overcrowded, and resources are scarce. In the same vein, Hobden (2005) asserts that there are minimal opportunities for learners to socialise or work in cooperative learning groups but many of the activities carried out by Life Sciences learners only validate or demonstrate science concepts, rules or principles. These prescriptive tasks, according to Ramnarain (2020), teach essential Life Sciences process skills such as seeing, inferring, meaning, communicating, classifying and predicting. Furthermore, I confirm that the most significant disadvantage of such a strategy is that it does not address the problem.

Teachers are hesitant to utilise IBL in a Life Sciences classroom because they are unfamiliar with IBL practices (Kazempour, 2009). I justify the fact that it is an abstract idea for most teachers to implement IBL because they were never taught with it. Kazempour (2009) asserts that improving the way Life Sciences teachers teach requires a transformation in how they think about Life Sciences, the learning process, their learners, and effective teaching approaches. I therefore conclude that Life Sciences teachers are aware of other challenges to the successful implementation of Life Sciences in the classroom, including a lack of time, the requirement to cover all the standards outlined in the curriculum, and the need to get learners ready for IBL activities. IBL in the Life Sciences classroom can be facilitated, according to Thoron and Myers (2011), by teachers modeling IBL directions, using IBL curriculum and lesson plans, and observing other teachers.

I acknowledge that IBL is promoted through inquiry-based implementation, which enables learners to achieve better cognitive processes in Life Sciences. As a result, the literature in this study focuses on cognitive processes based on cognitive science, as well as constructivism as a philosophy of education. IBL implementation in Life Sciences classrooms is heavily emphasised in this study because it focuses on how IBL activities can be used as a teaching approach. This study employed the inquiry method, which helps learners gain knowledge of and comprehension of scientific concepts and the methods used by scientists to examine the natural world. Process skills are employed in the inquiry to investigate certain concepts and processes.

2.3 THEORETICAL FRAMEWORK

To answer the research questions, this study was guided by the social constructivism theory. According to Mvududu and Thiel-Burgess (2012), social constructivism describes how learners make sense of material and how material is effectively taught. Furthermore, according to Mvududu and Thiel-Burgess (2012), teachers should consider what their learners already know and let them put what they have learned into practice. This is in line with the social constructivism educational theory. Social constructivism is a learning theory that, according to Christie (2005), views learning as both an active process and a representation of reality. Hare (2005) asserts that the constructivist approach places a strong emphasis on learner-centred classroom teaching strategies. Furthermore, Hare (2005) contends that constructivist teachers must design their school curriculum around the experiences of their learners. My aim in this study was to gain a better understanding of how IBL activities are implemented and how teachers develop subjective meanings from their experiences. I also look for the complexity of points of view rather than limiting meanings to a few categories or ideas.

According to Prince and Felder (2006), traditional deductive education has been the norm for centuries. This method of instruction is based on positivism, which postulates that knowledge or impartial certainty arises irrespective of human insight. Masilo (2018) contends that the main educational approach in most classrooms leads to learners to avoid the responsibility of independent thought and not having faith in their ability to find, create and test meaning for their own problem-solving. A different social constructivism theory, according to Prince and Felder (2006), should be used to address the issue of objective teaching and learning, as people make meaning of their experiences in order to develop their authenticity, whether or not there is an objective reality. Hester (2004) shares the view that teaching and learning that involve critical thinking methods and processes, such as diagnosis, speculation, and hypothesis testing, should take precedence over teaching and learning that emphasise objectivity.

According to the constructivist model proposed by Prince and Felder (2006), new evidence is clarified during the sense-making effort during learning through intellectual constructions (schemas), and the schemas incorporate the learners' prior knowledge and conceptions. Prince and Felder (2006) contend that new information can be integrated into schemas if it is consistent with these specific schemas. However, if the information contradicts the schemas, it may be memorised rather than learned. Furthermore, in support of using inquiry in teaching and learning, Hester (2004) avers that the constructivist technique of inquiry allows learners to generate ideas, challenge problems, assess concepts, and apply them in other situations.

Social constructivism has been declared as a powerful method of teaching and learning for educational reform. In their research, Prince and Felder (2006), for example, identify social constructivism as a major learning method to the positivist approach. The social constructivist philosophy is thought to be the best (in the current educational era) at engaging learners in learning, and it is defined as a philosophy of teaching and learning that assists learners in learning through exploration, investigation and discovery to actively construct knowledge (Friesen & Scott, 2013). The constructivist or inductive teaching methods specified by the authors are IBL, problem-based teaching, project-based teaching, case-based teaching, and discovery-based teaching. However, Mougan (2013) claims that social constructivism has several shortfalls, including: excessive subjectivism leads to arbitrariness and relativism and social constructivism states and investigates the origin of ideas, but does not point out the origin of sources to ensure the validity of the ideas. Furthermore, Priss (2014) emphasises that learning is viewed as the active creation of mental structures in social constructivism, without making any philosophical claims. Pierce, as a pragmatist philosopher, managed to find a middle ground between constructivist (via idealism) and realist positions (Priss, 2014). He emphasises that pragmatism, with a slightly more realist stance, supports the benefits of a constructivist view of learning. Furthermore, Mougan (2013) describes the similarities between constructivism and pragmatism as follows: both theories do not seek construction for the benefit of construction but rather seek solutions to problems of importance to people; and both have established strong links between the ideas of democracy and knowledge construction.

Constructivism is viewed as fundamental to realism in this study. Furthermore, this study takes the constructive stance that teaching should begin with an inquiry that leads to inductive reasoning, and inductive reasoning is fundamental and required for deductive reasoning. Inductive IBL allows learners to achieve lower levels of Life Sciences knowledge and understanding before moving on to meet the requirements of learning through deductive inquiry at higher levels of Life Sciences knowledge and understanding, such as formal deduction.

2.3.1 Application of social constructivism in an inquiry-based classroom

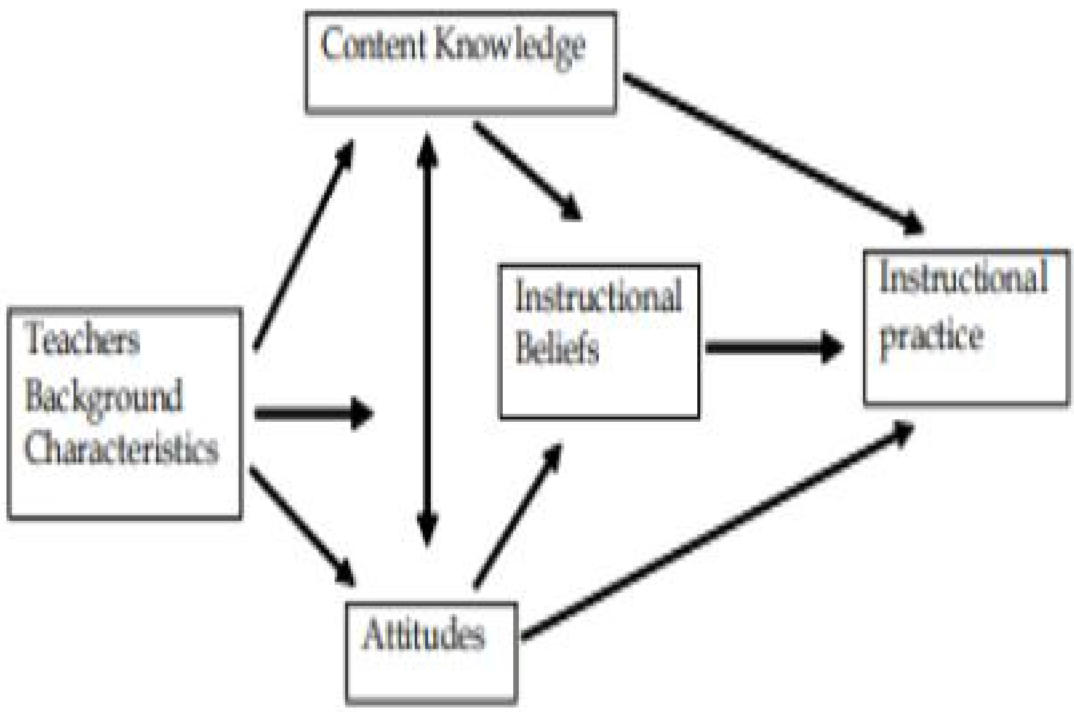
Social constructivism is defined as a broad stream of theories in the behavioural sciences and social sciences that emphasise the subject's active task (Martin, 2015). According to Martin (2015), teachers in IBL classrooms must ensure that every learner achieves the highest possible level (cognitive, social and operative) through participation and contribution. Furthermore, Martin (2015) accentuates that intelligence is a specific area that modifies and enriches itself through reconstruction. In the constructivist definition of inquiry-based activity implementation, the teacher's role shifts from being a warrantor of the method to being a warrantor of the truth. The teacher becomes a facilitator of the learners' learning, assisting the learners in identifying effective approaches to learning and cooperative instructional strategies (Martin. 2015). More importantly, the constructivist theories are based on learners creating (constructing, reconstructing) knowledge rather than on it being transferred in an already-done form.

IBL is an activity-oriented pedagogical strategy derived from constructivist learning theory. According to Kim (2006), IBL is an approach that assists learners in improving their achievement and attitude toward Life Sciences, as well as increasing learners' interest in learning. According to Jin and Bierma (2011), IBL is an approach that helps learners master inquiry skills, maintain learners' active attention on learning, and achieve more excellent results in the process of inquiry approach. According to the preceding statement, inquiry methods should be used by teachers for effective teaching.

Wilkins' (2008) theoretical model (Figure 2.3.1) relating to teachers' knowledge, attitude and belief to instructional practises is used in this study. This theoretical model is based on Ernest's (1989) model, which is concerned with mathematics teachers' knowledge, beliefs and attitudes. The model postulates that teachers' knowledge, attitude and belief are influenced by their personal characteristics. Teachers' experience, education, training, and environment are examples of background characteristics (Wilkins, 2008). Moreover, teacher's knowledge, attitudes and beliefs towards inquiry teaching are hypothesised to have a relationship with the implementation of IBL in the teaching of Life Sciences in this study and teachers' experience influences IBL implementation.

Figure 2.2 indicates a theoretical model that connects teachers' knowledge, attitudes, beliefs, and instructional practice.

Figure 2.2: *A theoretical model that connects teachers' knowledge, attitudes, beliefs, and instructional practice.*



Source: Wilkins (2008)

This model demonstrates that there are connections between teachers' knowledge, attitude and beliefs about their behaviour. According to Abd-El-

Khalick (2012), understanding the nature of science can help Life Sciences teachers structure good inquiry learning environments. Several studies on teachers' beliefs conducted in Hong Kong and Norway show that teachers' beliefs and practice knowledge have a significant impact on the implementation of IBL (Choi, 2007). According to Hutchins (2009), teachers' attitudes have a significant influence on learners' attitudes toward inquiry learning. According to the preceding discussion, teachers' knowledge, attitude and belief do have some relationships with teachers' behaviour. This prompted the researcher to investigate whether these variables can be used to predict the implementation of IBL in the teaching of Life Sciences.

2.4 CONCLUSION

This chapter presented a review of the literature that is relevant to answering the research questions for this study. This chapter discussed IBL in the South African education system, important aspects of inquiry-based classrooms, stages of IBL in Life Sciences, the implementation of IBL activities to improve teaching strategies, teachers' content knowledge, teachers' knowledge development, and teachers' challenges with IBL implementation. Furthermore, this chapter discusses social constructivism as a theory that assists in the research focus on the implementation of IBL in Life Sciences classrooms. The next chapter will introduce the current study in terms of qualitative design, site selection, and detailed methods used in data collection and data analysis.

CHAPTER 3:

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter describes the study research methods, including the research paradigm, research approach, research design, sampling procedures, data collection strategies, instrumentation, and ethical considerations.

3.2 RESEARCH PARADIGM

Ontology and epistemology are used in a research study to explain the nature and presence of social reality through knowledge (Ngulube, 2015). According to Ngulube (2015), the paradigms in research are positivism (positivism), pluralism (pragmatism), constructivism, and ways of knowing (Ngulube, 2015). Ngulube (2015), on the other hand, claims that in realism, knowledge is absolute and there is only one objective reality, whereas in constructivism, knowledge is a subjective reality that can be understood (Ngulube, 2015).

A research paradigm, according to Colman (2006), is a collection of abstract frameworks that justify a specific theoretical approach to research and cover features of ontology, epistemology, teleology, and methodology. Ary (2010) claims that different paradigms make different assumptions about the nature of reality and how we can best understand it. The quantitative approach, for example, assumes that reality exists objectively, implying that whatever exists can be objectively measured and valid conclusions drawn by observers. Moreover, the study's research paradigm is influenced by the researcher's view of the nature of the phenomenon being studied, the type of questions proposed, and the data that would supply the information required to answer the questions of interest (Maree, 2017).

Firstly, *ontology* refers to what is known (what is reality) as well as the nature of our belief systems concerning reality (Richards, 2003). Scotland's (2012) ontology deals well with the assumptions individuals make when they want to believe something is relevant or real. According to Scott and Usher (2004), ontological assumptions are about the essence of reality, which is important for understanding how people interpret the data that the researcher has collected. Ontology, as I define it, is a paradigm that enables researchers to think about the research issue, its importance, and how to approach the research to contribute to its solution. Ontology, according to Scott and Usher (2004), attempts to discover the true nature of the basic concepts that constitute aspects that people analyse in an effort to make sense of the meaning embedded in research data to get an understanding of the things that make up the world.

Second, *epistemology* is used in research to describe how people know something, especially truth and reality (Cooksey & Mcdonald, 2011). Epistemology, I believe, is a paradigm that deals primarily with the foundations of knowledge, its nature and form, and how knowledge is acquired and communicated to others. According to Kivunja (2017), the epistemological paradigm focuses on the properties of human knowledge and understanding that can be acquired by researchers to broaden, develop and deepen their understanding in their field of study.

Finally, *methodology* refers to the research designs, methods, approaches, and procedures used in well-designed investigations to discover something new (Kivunja, 2017). According to Rehman and Alharthi (2016), this includes the data collection process, participants, data collection tools, and data analysis methods. Ellies (2013) defines methodology as the process by which researchers decide what kind of data they need for their research and what data collection and data analysis tools are best suited for it.

According to Kivunja (2017), many paradigms have been proposed by researchers in the field, but one of the outstanding minds in the field argues that they all fall into three categories: positivism, interpretivism and critical paradigms. Tashakkori and Teddlie (2003a, 2003b) proposed the fourth paradigm, the pragmatic paradigm, which incorporates elements of three other paradigms.

According to Fadhel (2002), the *positivist paradigm* helps explore causal relationships in nature and is based on research methods known as scientific methods of inquiry. Studies in this paradigm use deductive logic, hypothesis formulation, hypothesis testing, operation definitions, mathematical formulas, calculations, extrapolations, and formulas to draw conclusions (Kivunja, 2017). It aims to describe and predict measurable outcomes defined by Cohen and Morrison (2000) as determinism, empiricism, parsimony, and generalisability. Positivist researchers, on the contrary, must be able to observe the occurrence of the phenomenon being studied and generalise about what would be expected in other parts of the world (Kivunja, 2017). According to Kivunja (2017), the positivist paradigm accurately describes the parameters and coefficients of the data collected, analysed, and interpreted and serves as the basis for the researcher's ability to understand the relationships embedded in the data under analysis and it has been used in quantitative research methods. According to the positivist paradigm, epistemology is objective, ontology is naive realism, and methodology is experimental (Fadhel, 2002).

Kivunja (2017) believes that the *interpretivist paradigm* seeks to get inside the mind of the subject being studied and to understand the perspective of the subject being observed rather than that of the observer. Furthermore, Kivunja (2017) argues that a central tenet of the interpretivist paradigm is that reality is socially constructed, which is why it is also known as the constructivist paradigm. I believe that the interpretivist paradigm does not precede the act of research but is based on the data generated by the act of research. According to Morgan (2007), interpretive research recognises that the social world is incomprehensible from the perspective of the individual and believes that reality is multiple and socially constructed. They accept that interactions between people are inevitable. In conclusion, we argue that the interpretivist paradigm is commonly used in scientific or observational research, with a particular interest in how people learn.

The *critical paradigm* aims to address political, social and economic problems that contribute to social inequality, conflict, struggle, and power relationships (Kivunja, 2017). According to Sobh and Perry (2005), the philosophical view of this paradigm is that truth exists independently of the researcher's mind. According to Martens (2015), the critical realism paradigm is concerned with relations of power established inside of social systems and investigates situations and people based on social positioning. Furthermore, Martens (2015) maintains that the paradigm of critical realism views research as an act of development rather than exploration, and that the researcher's deliberate attempts to expand human rights, improve social justice and mutuality are viewed as part of the researcher's deliberate attempts to advance human rights and promote social justice.

The pragmatic paradigm contended that it was never possible to identify social reality or access the reality of things in the real world purely through a single scientific process, as the positivist paradigm advocated (Kivunja, 2017). More importantly, Tashakkori and Teddlie (2003) believe that a pragmatic paradigm would provide the best research approaches for investigating the phenomenon under consideration, and they sought more experiment and pluralistic research approaches. Furthermore, Tashakkori and Teddlie (2003) contend that the pragmatic paradigm permits the use of a range of approaches that, when combined, can shed light on participants' actual behaviours, the beliefs that underpin those behaviours, and the implications that are likely to occur from various behaviours. This paradigm advocates the use of mixed methods to better understand human behaviour (Kivunja, 2017). A relational epistemology (the belief that connections in research are better established by what the researcher deems relevant to that specific research), a non-singular truth ontology (the presumption that there is not an absolute truth, and that each individual has their own distinct perception of reality), and a mixed-methods methodology (a combination of qualitative and quantitative study methods) are all part of the pragmatic paradigm (Tashakkori & Teddlie, 2003).

To comprehend the subjective world of human experience, this research employs the interpretivist paradigm (Kivunja, 2017). In this study, I used an interpretivist paradigm, which is most commonly used in scientific or observational studies where the researcher is interested in how people learn. According to Kivunja (2017), an interpretivist tries to "get into the heads of the subjects being studied," so to speak, and to understand and interpret what the subject is thinking or the meaning the researcher is making of the context. According to the interpretivist paradigm, humans construct meaning as they interact with the world they are interpreting (Creswell, 2014). According to Creswell (2014), interpretivist researchers use open-ended questions to enable participants to express their opinions during data collection. According to Kivunja (2017), interpretivist researchers seek to comprehend the participants' context or setting by having visited the context, collecting data personally, and analysing what they obtain. In this paradigm, data are collected through in-depth interviews and participant observation (Sobh & Perry, 2015). The study followed an interpretivist paradigm owing to the above definitions, the research paradigm chosen, and the nature of the inquiry under the investigative process, which enabled a better understanding of Life Sciences teachers' learning environments when incorporating IBL activities in Grade 11.

3.3 RESEARCH APPROACH

Creswell (2012) defines research approaches as research procedures and strategies that extend from broad assumptions to data gathering, analysis and interpretation. Furthermore, Creswell (2012) asserts that research approaches involve several decisions that do not need to be made in order for the researcher's philosophical assumptions to make sense: processes of inquiry (called the research designs); and detailed research methods for data collection, analysis, and interpretation. According to Maree (2012), there are three recognised research approaches in research studies: quantitative, qualitative and mixed methods. Qualitative and quantitative approaches should be viewed as different ends of a spectrum rather than as rigid, distinct categories, opposites, or contradictions (Creswell, 2014). Quantitative and qualitative approaches are well established in the social and behavioural sciences, while mixed-methods approaches are rapidly expanding. Creswell (2014) places mixed-methods research in the centre of this spectrum since it combines both qualitative and quantitative approaches.

3.3.1 Qualitative approach

According to Creswell (2012), qualitative research is an approach for investigating and being able to understand the importance that people or groups place on a human or social issue. The qualitative research approach, according to Maxwell (2018), is another approach that uses a more realistic approach to study a phenomenon in a context-specific setting. The qualitative research approach, in my opinion, is more dependent on the researcher's personal beliefs about the type of data collected and the method used to collect and analyse data. According to Mnguni (2007), this jeopardises the validity and reliability of the data because the study is dependent on the researcher's approach to data collection and analysis (Kurdziel & Libarkin, 2002).

3.3.2 Quantitative approach

According to Teddlie and Tashakkori (2009), quantitative research collects data using objective measurements to test a hypothesis or answer research questions. The quantitative approach, according to Mohajan (2017), supports the positivist paradigm and can argue that human behaviour can be understood through observation and reasoning. According to Mnguni (2007), quantitative approaches are well structured, and any deviation must be supported by substantial arguments. Furthermore, because the research strategy is based solely on hypothesis and testing, this approach is replicable. According to Sharpe (2008), the quantitative approach allows the researcher to study larger sample sizes to prove or disprove any hypothesis, making it easier to reach accurate, generalised conclusions. The quantitative approach reduces researcher bias because the researcher is not directly involved with the participants, which is especially important when data are collected through surveys or questionnaires (Danial, 2016).

3.3.3 Mixed-method approach

According to Creswell and Plano Clark (2011), the mixed-methods approach is a way of collecting, analysing and combining quantitative and qualitative data at some stage of the research process within a single study to understand a research problem. To answer the study's research questions, a mixed-method approach involves the researcher gathering both textual and numerical data. The mixed-methods research method combines quantitative and qualitative data collection and analysis methods (Newby, 2010). A mixed-methods study, according to Ponce and Pagan-Maldonado (2014), combines and integrates both quantitative and qualitative methods at various stages of the study. The purpose of applying methods is to seek clarification, illustration and explanation of quantitative methodology results with qualitative methodology results (McMillian, 2012) and to attempt elaboration, illustration and clarification of quantitative methodology results with qualitative methodology results (Greene et al., 2008).

A *mixed-methods approach*, according to Johnson and Turner (2017), seeks to study multiple ideas and opinions to develop well-balanced research. According to Scott (2014), integrating qualitative and quantitative methods will enable the development of a coherent framework of mixed methods that provides a warranty through triangulation. Furthermore, Scott (2014) adds that this argument acknowledges that quantitative and qualitative approaches have distinct epistemic and ontological foundations. Nonetheless, when both approaches are applied to the same research, the study gains more validity and reliability.

A *qualitative approach* was used in this research. A qualitative approach is defined as an investigation method that entails making sense of central phenomena while studying participants in their context (Creswell & Maree, 2010). A qualitative research approach, according to De Vos et al. (2002), stimulates participants' accounts of meanings and first-hand experience. During this research, I observed Life Sciences teachers implementing IBL activities. Observations were carried out to understand and describe their classroom practices, as well as how they implement IBL activities in Life Sciences. According to Ntuli (2019), because the researcher obtains first-hand information from the participants, the qualitative approach generates descriptive data in the participant's own written or spoken words.

The *qualitative approach*, which is concerned with making sense of central phenomena, allows interaction between a researcher and participants (De Vos et al., 2002). This study used a qualitative approach for the foregoing explanation because it provided possible explanations for the phenomena under investigation. The qualitative approach is appropriate for this study because I needed to keep in close contact with the participants because they are thought to be information rich. The participants responses assisted me in answering the study research questions.

3.4 RESEARCH DESIGN

A research design is a strategy that describes how well the researcher will conduct research, structure the study and explain how all of the study's major components will collaborate to answer the research questions (Trochim, 2006). According to Lankshear and Knobel (2004), a research design is a guideline, procedure or plan for how a researcher intends to complete a study and the theories, methods and instruments that will be used. A research design is also a strategy or framework for selecting participants, research sites and data collection procedures that will produce exceptional results (Lankshear & Knobel, 2004). It is possible to plan a quantitative or qualitative research design.

Table 3.1 indicates alternative research designs of inquiry.

Table 3.1: *The different research designs of inquiry.*

Quantitative	Qualitative	Mixed-methods
• Experimental design • Non-experimental design, such as surveys	• Narrative • Phenomenology • Grounded theory • Ethnographies • Case study	• Convergent • Explanatory sequential • Exploratory sequential • Transformative, embedded, or multiphase

Source: Creswell (2014)

3.4.1 Quantitative research designs

Maree (2016) distinguishes between experimental and non-experimental designs in the quantitative research approach. Furthermore, *experimental* designs for a specific type of research question, namely cause and effect questions, have been developed. Cooper and Heward (2007) define experimental design as "descriptive and predictive analysis or single-subject experiments in which experimental treatment is conducted on a single person or a small group of people over time." The experimental design is scientific, with the researcher manipulating the levels of independent variables in a controlled environment while measuring the dependent variables.

Non-experimental designs, according to Maree (2006), are used in descriptive studies in which the units chosen to take part in the research are determined by measuring all important variables at a specific time. According to Fowler (2008), non-experimental designs provide a numerical or quantitative explanation of a population's patterns, behaviours or thoughts by studying a subset of that population. It does, however, include cross-sectional and longitudinal studies in which data are gathered through the use of a questionnaire or structured interviews with both the goal of generalising from such a sample to a larger population.

3.4.2 Qualitative research designs

A qualitative research design is a subjective understanding inquiry process based on distinct methodological traditions of inquiry. The purpose of qualitative research is to obtain a rich, comprehensive knowledge of a particular phenomenon based on first-hand experience (Maree, 2016). There are five qualitative research designs, according to Marshall and Rossman (2011): ethnography, phenomenology, case study, grounded theory, and action research.

To begin, the *ethnographic research design* seeks to gain a thorough understanding of how members of a specific community make sense of their social reality (Maree, 2016). The ethnographic method is often associated with anthropology, which incorporates conducting research on foreign cultures in order to grasp a specific population's unique customs, value systems and cultural artifacts (Hesse-Biber & Leavy 2011).

Secondly, *phenomenology* provides an understanding of a specific issue from the participants' social realities. According to Patton (2012, p.104), the researcher's role in phenomenological research is to comprehend and identify an event or issue from the perspective of the study participants.

Thirdly, *a case study* is acknowledged to be a decision regarding what to study rather than a methodological judgement, though it does guide how any theoretical approach is to be conducted (Stake, 2005). Simons (2009, p. 21) defines a case study as "an in-depth inquiry from differing viewpoints of the uncertainty and individuality of a given project, policy, institution, program, or system in a real-world context."

Fourthly, *in grounded theory*, researchers function inductively to utilise concepts from data; unlike some other research designs, the central purpose of grounded theory is to generate theories. This design incorporates an interactive cycle of planning, implementation and reflection (Ebersohn & Ferreira, 2010). According to Martens (2005), grounded theory is distinguished by specific methodological characteristics such as the researcher's constant interaction with data, asking questions in order to generate theory, and guiding the selection of samples for data collection.

Finally, *action research*, according to Maree (2016), is based on an emergent methodological design and seeks to collaborate with participants to generate new knowledge that can lead to change. As a research design, action research aims to clarify social challenges by developing appropriate solutions to problems (Creswell, 2015). According to Stringer (2014), action research developers participate in careful thorough inquiry, but not to discover new facts but to obtain information with experiment application to the solution of particular problems associated with their work.

3.4.3 Mixed-methods research design

A mixed-methods design is indeed a comprehensive research design that incorporates both qualitative and quantitative research approaches into a single study and is utilised when both the breadth and depth of a problem are significant (Maree, 2016). According to Ivankova and Clark (2010, p. 262), the researcher would conduct quantitative research first to uncover trends, followed by qualitative research to understand the meanings and patterns of participants' opinions. Creswell (2011) outlines six types of mixed-methods design: transformative design, convergent parallel design, exploratory sequential design, explanatory sequential design, embedded design, and multiphase design.

According to Creswell (2011), in the *convergent parallel design*, the researcher collects both qualitative and quantitative data, analyses both sets of data independently, compares the findings of the analyses of both sets of data, and makes interpretations regarding whether the results sustain or contradict each other. The researcher's direct comparison of the two datasets results in data source convergence (Creswell, 2011).

Clark (2011) defines an *explanatory sequential design* as first collecting quantitative data and then collecting qualitative data to further explain or expand on the quantitative results. However, the rationale for this design is that quantitative data and results can provide general picture of the research problem, and extra analysis, especially qualitative data collecting, is required to improve, extend, or explain the general picture (Subedi, 2016).

According to Creswell and Clark (2011), in an *exploratory sequential design*, the researcher first collects qualitative data and then quantitative data. According to Subedi (2016), the purpose of an exploratory sequential mixed methods design involves the procedure of first gathering qualitative data to explore a phenomenon and then collecting quantitative data to explain relationships found in the qualitative data.

The goal of *embedded design*, according to Creswell and Clark (2011), is to collect quantitative and qualitative data concurrently or sequentially while having one type of data serve a supportive function for the other kind of data. However, the reason for gathering the second type of data is that it either argues against or supports the first type of data (Creswell & Clark, 2011). According to Creswell and Clark (2011), the objective of the transformative mixed methods design is to use one of the four designs (convergent, explanatory, exploratory, or embedding) but to encase the design within a transformative framework.

The *multiphase design* is a complicated design that is based on embedded designs, fundamental convergent designs, exploratory designs, and explanatory designs (Subedi, 2016). When researchers explore a problem in stages, they use multiphase mixed methods designs (Creswell & Clark, 2011).

This study employed a case study as its research design. The case study as a research design is especially well suited to this study owing to two major features of the research, which are depth and bound. The case study design is confined by time and activity, and in this research, I collected detailed information over a short period of time using face-to-face, one-on-one, semi-structured interviews and direct observations (Yin, 2012). I contributed to this research by investigating how teachers engage in scientific inquiry. In this research, I was involved in a small number of classes where similar activities were done; the research was limited due to time and space constraints.

A case study is a detailed examination of an entity that is accurately defined and determined by time and place (McMillan, 2004). First, I chose the case study design for this research because I wanted to understand more about how teachers implement IBL activities in Life Sciences. Second, this design (case study) enabled me to gain a better understanding of the teachers' behaviour and experiences, as well as their contextual factors. Finally, De Vos et al. (2002) avers that a case study recognises the distinctive and dynamic nature of environments by conducting an in-depth inquiry into interactions between people in a specific context. I felt obligated to interact with the teachers because they are thought to be knowledgeable about the phenomenon under investigation.

3.5 SAMPLING METHODS

A sample is a subset of a statistical population whose properties can be researched to learn more about the properties of the complete population or society (Porter & Hunter, 2008). According to De Vos et al. (2002), the most significant idea in research is sampling, which entails selecting a section of a population to represent the full population. To answer the study questions, the researcher must be able to collect data (Taherdoost, 2016). Data should be collected from all cases, and a representative sample should be chosen. According to Taherdoost (2016), because the researcher may not have the time or resources to analyse the complete community; so, he or she should select a sample from the population.

Porter and Hunter (2008) highlight that it is usually impossible for a researcher to include all members of the population of interest in their research. As a result, a sample, which is a subset of a statistical population having characteristics that may be examined to learn more about the complete population or culture, is selected. This sample group is much smaller than the overall population, but it is meant to represent the original population group (Gravetter & Forzano, 2003). In addition, Gravetter and Forzano (2003) distinguish between two types of research sampling techniques: probability sampling and non-probability sampling.

According to Gravetter and Forzono (2003), probability sampling is the process of choosing a participant from a population using probability approaches. According to Acharya (2013), in probability sampling, each individual within the population has an equal chance of being chosen for the study. In quantitative research, the probability sampling technique is recommended because it increases the sampling group's representativeness with respect to the population and hence tends to improve the generalisability of the results. According to Maree and Pietersen (2007), there are several types of probability sampling, including simple random sampling, systematic sampling, stratified random sampling, and cluster sampling.

According to Maree and Pietersen (2007), in simple random sampling, each individual has an equal probability of being chosen from the population to be included in the sample. Acharya (2013), on the other hand, claims that data are chosen using a random number table or a computer-generated list of random numbers. The advantages of simple random sampling are that it requires little knowledge of the population, has high internal and external validity, and is simple to analyse data (Prakash, 2013).

Stratified random selection divides people into sub-groups (strata) based on shared factors such as age, gender, race, income, education, and ethnicity (Prakash, 2013). According to Acharya (2013), the benefits of stratified random sampling include ensuring representation of all groups in the population. Moreover, stratified random sampling also lowers the variability associated with systematic sampling (Maree & Pietersen, 2007).

According to Maree and Pietersen (2007), in systematic random sampling, the initial subject is chosen at random, and the succeeding subjects are chosen by a periodic procedure. According to Acharya (2013), systematic random sampling has a moderate utilisation, a moderate cost, excellent internal and external validity, is simple to draw, and is straightforward to verify.

Cluster sampling is a two-step technique that divides the total population into clusters or groupings, usually geographic areas or districts such as villages, schools, wards, and blocks (Acharya, 2013). According to Maree and Pietersen (2007), cluster sampling is most feasible for use in large national surveys, and the clusters are picked at random. Cluster sampling, according to Prakash (2013), is effective when the population is widely dispersed and it is experimented to sample and pick a representative sample of all the elements.

Non-probability sampling, on the other hand, is commonly utilised in qualitative research where the purpose of the study is to generate an in-depth description rather than to generalise findings (Merriam, 2009). Non-probability sampling, according to Gravetter and Forzano (2003), is employed when the probability of selecting a specific person in a population is uncertain and sampling an entire population group is problematic. There are various types of non-probability sampling, according to Onwuegbuzie and Collins (2007), including convenience sampling, quota sampling, opportunistic sampling, and purposeful sampling.

The sample in convenience sampling is chosen for the researcher's convenience (Merriam, 2009). According to Acharya (2013), convenience sampling is most typically utilised in clinical research where patients who match the inclusion criteria are recruited. More importantly, convenience sampling is beneficial in exploratory research where the researcher wants a cheap, quick approximation of the truth, as well as in pilot studies where only a few respondents are needed to test the questionnaire (Maree, 2016).

Quota sampling, according to Acharya (2013), ensures that a certain attribute of a population sample is reflected to the exact amount that the researcher needs. To utilise this method of sampling, the researcher must first select the categories of persons who must be included in the sample, as well as the required number of people in each category (Maree, 2013).

In contrast, snowball sampling involves selecting initial respondents using probability or non-probability methods, and then obtaining further respondents based on information provided by the first respondents (Acharya, 2013). According to Maree (2016), this strategy is frequently utilised when the population is difficult to discover or when the research interest is in an interconnected group of people.

According to Acharya (2013), the most prevalent method is purposeful sampling, which is less expensive and does not require a list of all population characteristics. Purposive sampling, on the other hand, is employed in exceptional cases where the sampling is done with a specific goal in mind and the outcomes of the data cannot be generalised beyond the sample (Maree, 2016).

Purposive sampling was employed in this research to select participants and sites in order to inform an understanding of the research problem (Creswell, 2007). I chose the purposive sampling method to save time and money while also increasing the experimentality of the research. Furthermore, Maree (2016) chose the purposive sampling strategy since it relies on the researcher's judgement as to whether the participants meet the conditions needed to answer the study questions. Purposive sampling is employed when sampling is done with a specific goal in mind, such as when I intended to evaluate the contribution of IBL activities to the development of teachers' teaching strategies in Grade 11 Life Sciences classes in this study. Furthermore, purposive sampling was appropriate because the participants were informed and informative about the topic under investigation. As a result, the study goal is to investigate the role of IBL activities in the development of teachers' teaching strategies in the Life Sciences classroom.

3.5.1 Sampling description

To choose participating teachers, a purposive sample method was used. Purposive sampling, also known as criterion-based sampling, is a method by which the enquirer chooses individuals and places for study because they can purposefully inform an understanding of the research problem and core phenomenon in the study (Creswell, 2007, p.125). According to Merriam (2009), purposive sampling assumes that if one wishes to discover, understand or acquire insight, one should select a sample from which one may learn the most. This section addresses the selection criteria, which are based on the reasoning presented earlier.

The research was conducted in the Gert Sibande District. The Gert Sibande District is one of four districts in Mpumalanga, with 19 circuits. One circuit was chosen for the district. The observation patterns in the topic workshops I attended motivated me to conduct the study in this district and circuit, where teachers looked to have differences in terms of classroom practices and the incorporation of IBL activities in their classrooms. Because the majority of the schools in the chosen circuit are public, it was more experiment for me to select public schools, which also saved me money on transportation to all of the schools in the district. According to my observations, Life Sciences Grade 11 learners in public schools still lack the necessary lower-level knowledge, and I believe that teaching using IBL would enable a reasonable number of learners to understand the ideas and abilities they missed at lower levels. This research included Grade 11 Life Sciences teachers from public secondary schools in the Gert Sibande District.

Out of the 121 Life Sciences teachers in the designated district, only three were chosen. The selection of the three Life Sciences teachers significantly lowered my expenses because I no longer needed to travel considerable distances around the district to collect data from each Life Sciences teacher. I chose the criterion for Grade 11 teachers, and I chose all situations that met the standard.

The selected teachers had to have worked in the selected schools for more than three years and be teaching Life Sciences, guaranteeing that the learners were acclimatised to the teachers' teaching style. Three teachers were given the pseudonyms Alfred, Nico and Lizzy. The following are among the sample selection criteria:

- Teachers' qualifications, which can include a three-year diploma in education with a major in Life Sciences.
- Two or more years of experience teaching Life Sciences in Grade 11.
- All the teachers must work in public schools.

Table 3.2 provides a summary of the criteria considered for selecting the teachers.

Table 3.2: *A summary of the criteria taken into consideration for selecting teachers.*

Pseudonyms of Teachers	Teacher work environment	Teacher experience	Lab. Facilities & apparatus	Teacher's qualification
Alfred	Rural	3>5	Inadequate	3+ years teaching qualification
Nico	Rural	More than 5	Inadequate	3+ years teaching qualification
Lizzy	Rural	3>5	Adequate	3+ years teaching qualification

3.6 DATA COLLECTION

According to Merriam (2009), "data" are information in the form of bits and pieces that can be found in the environment. I can obtain access to the research topic as well as reputable data by collecting data. Several methods (including observations and interviews) were employed to collect data for this research in order to provide precise and crucial information. The observations and interviews were utilised to triangulate data, converge data and validate data. According to Mouton (2001), data come in various formats and has diverse properties: interview schedules, direct observations, audiotapes, and videotapes are all data gathering techniques, as are triangulation procedures.

Data for the study were gathered using the case study method. According to Cohen and Morrison (2000), a case study approach is a specific instance that is frequently aimed to illustrate a more general principle; or, conversely, it is a study of an instance in motion. Case studies, according to Nieuwenhuis (2010), give a multi-perspective study in which the researcher analyses not just the voice and perspective of one or two individuals in a circumstance, but also the perspectives and interactions of other relevant groups. The case study approach strength is the utilisation of multiple data gathering sources and methodologies, such as interviews, document analysis and observations.

This section discusses the data collection methods for this study. The data for this study was gathered in two phases.

3.6.1 Phase one: Lesson observations during teachers' implementation of IBL activities

There are four categories of observations (Maree, 2016): (1) complete participant, in which the researcher becomes completely immersed in the setting, to the point where those being observed are unaware that they are being observed; (2) participant as an observer, in which the role of the researcher is known; (3) observer as participant, in which the researcher enters the situation but focuses primarily on his or her role as observer in the situation; and (4) complete observer, in which the researcher observes without taking part.

The observation type adopted for this research was that of a complete observer, in which I did not influence the teaching process in the classroom. According to Maree (2016), the complete observer is the least obstructive style of observation, but it has the disadvantage that the researcher does not become engaged in the environment. Creswell (2014) argues that a complete observer ensures that participants are free to express themselves. I observed teachers implementing IBL activities and qualitatively analysed the data. I used an observation checklist because I knew exactly what I was looking for (Cohen et al., 2000) (see Appendix C). I developed a detailed outline of what I intended to focus on throughout the observation. These outlines assisted in the methodical recording of information and behavioural patterns as well as focusing analytically on events of interest during the observation period (Hartas, 2010).

The observations of teachers conducting IBL exercises were videotaped, and the video recording was used by me to back up and catch information, behaviour patterns, or any other occurrences of interest that I had missed or failed to capture in my observation checklist. The observation checklist and video recording were used to gain an understanding of how teachers' knowledge improves as a result of IBL activity implementation and how teachers implement IBL activities to improve their teaching practices in Life Sciences. The fact that the lessons were video-recorded also helped to confirm the observations made during the lessons. The video analysis was carried out in accordance with the observation checklist.

Lessons were observed in the classroom or in the laboratory. I tried to keep the observation to one hour to avoid weariness for both the teacher and the learners. In laboratories or classrooms, the video camera was positioned at an angle to be as unobtrusive and disruptive as possible. I answered some of the study questions by observing the teachers. (a) How do teachers implement IBL activities to improve their teaching strategies in the life sciences? (c) How do teachers' IBL practises develop as a result of the implementation of IBL activities?

During the observation, I assured that all COVID-19 protocols were observed through the following:

- The teacher, learners and I were sanitised, and that the temperature was taken when entering the classroom or laboratory.
- The classroom or laboratory was fumigated.
- The teacher, learners and I wore masks throughout the lesson.
- A one-meter social distance was maintained.

3.6.2 Phase two: Interviews with Life Sciences teachers

In this study, I conducted face-to-face, one-on-one, semi-structured interviews that were audio-recorded. I chose a face-to-face interview because my goal was to observe the environment through the participant's eyes to acquire rich descriptive data that may be used to better understand the participant's construction of knowledge and social reality (Nieuwehuis, 2010). According to Ntuli (2019), semi-structured interviews are adaptable, which means that new topics can be raised throughout the interview, and they include a set of open-ended questions that allow for spontaneous and in-depth responses. As a result, the audio recorder was used to record the responses of the participants to ensure that I had appropriately captured their responses. Following the interview, I invited participants to listen to the recording for further explanation, if necessary, and checked that I had captured exactly what the participant wanted to say. This type of interview was viewed as significant because it provided me with qualitative data that I used to address the research questions of this research.

After performing an exhaustive literature analysis on how to arrange and conduct interviews, I prepared the interview schedule. According to Opie (2004), an interview schedule is a well-structured set of questions that can be answered during an interview to guarantee that the interview goes well. The interview questions were designed to elicit teachers' perspectives on the role of IBL activities in the development of their teaching strategies as well as teachers' understanding of the implementation of IBL activities (see Appendix B). The interview location had been fumigated prior to the interview. I and the interviewee were both sanitised, and our temperatures were taken. Moreover, I ensured that the one-meter social distance was kept, and masks were worn during the interview.

The interview process lasted for 30 minutes, which kept the teachers from becoming exhausted. My responsibilities were as follows:

- Suggest and schedule dates for interviews with each of the three teachers as soon as possible.
- Teachers were allowed to select a convenient location as long as it was quiet enough for audio recording.
- Contact the teacher a day before the interview to confirm the appointment.
- Meet with the teacher at the agreed-upon location.
- Before beginning the interview, I checked the recording equipment and prepare it for recording with permission from the interviewee.
- Provide a brief explanation of the purpose of the study and assure the interviewee of his/her confidentiality.

For the following reasons, the interviews were audio-recorded:

- To ensure that all important information was accurately recorded.
- To avoid the researcher's recall bias.
- To avoid disrupting the flow of the interview by taking notes or asking the respondent to repeat any statements, as Fraenkel and Wallen (1990) warn.
- According to the research, audio-recording decreases interviewers' bias or inclination to make an unconscious selection of facts that supports their study if they are taking notes.

3.7 DATA ANALYSIS

Data analysis entails making sense of information collected based on participants' descriptions of the event and finding patterns, themes, categories, and consistency (Cohen et al., 2012). As part of the data analysis process, the researcher, according to Saldana (2009), must capture their knowledge of the data in writing. This study used a typology technique to analyse the data, and the themes and categories were developed based on the research objectives, the literature review and the participants' own experiences (Hatch, 2002).

The data were analysed using open, axial and selective coding (De Vos et al., 2011). Before moving on to axial coding, which compared paragraphs to achieve improved categorisation accuracy, line by line open coding was performed. Finally, core categories were determined through selective coding. The analysis was done in two steps. The first step was to transcribe audio-recorded material, such as individual interviews. Before coding, the transcripts were read numerous times to become acquainted with them. Because this was a case study of three teachers' reflections, I focused on the analysis and grouping of their viewpoints rather than the teachers themselves. In the second phase, data from the document analysis were classified.

3.7.1 Phase one: Analysis of the interviews

The data analysis process began with categorising each component. Data can become overwhelming, unfocused and repetitious if it is not regularly analysed. To circumvent the previously described difficulty, I began analysing interview data as soon as it was collected. To acquire a feeling of the overall picture and to make analysing smaller units of data much easier, I first listened to the audio-recorded interview and read the transcribed interview multiple times. Furthermore, participants were able to read the transcripts before they were considered the final product, allowing them to remark and make adjustments. I read the transcripts while having a single subject in mind, noting changes and varied language and emphasising the categories and qualities of each theme. I read over the coded data to double-check the transcript.

3.7.2 Phase two: Lesson observation analysis

The analysis of the lesson observation, which was documented on an observation checklist, occurred at the same time as the analysis of the video that was recorded during the lesson. By playing the video recordings and translating them into word documents, I analysed the data acquired from the teacher's observations. I watched the video numerous times to guarantee that what is written in the transcripts corresponds to what is shown on the video. I coded the lessons using information from the checklists as well as the video recordings. The data were classified and summarised depending on the frequency of events in each of the three teachers' lessons.

3.8 TRUSTWORTHINESS OF THE STUDY

Trustworthiness is the most significant part of qualitative research since it is studied in terms of credibility, dependability and transferability (Rule & John, 2011). This study follows the trustworthiness idea, which comprises four components: credibility, transferability, dependability, and confirmability (Shenton, 2004).

3.8.1 Credibility

According to Maree (2016), credibility is concerned with the congruence of the findings with reality. How does the researcher ensure that the reader believes the researchers' findings? The study presents a realistic picture of how teachers implement IBL and improve their teaching strategies through IBL activities to ensure credibility. In addition, I had regular debriefing sessions with superiors, as well as reflective notes and member checks. The numerous methodological approaches determined the validity and reliability of this research by allowing for data inspection, which resulted in idea evaluation (Trachim, 2001). To triangulate the results and confirm the validity of the findings, multiple data gathering methods (interview and observation) were used. During the interviews, I asked the participants to certify that the data collected were correct and that my interpretation of what they had said was correct.

3.8.2 Transferability

The extent to which qualitative research findings can be generalised or transferred to different contexts or settings is referred to as transferability (Maree, 2016). In the context of qualitative research, transferability is the obligation of the individual doing the generalising. Transferability, according to Lincoln and Guba (quoted in Moodley, 2013, p. 61), is the obligation of the individual who wishes to adapt the findings to a different circumstance or population than the original study researcher. Trachim (2006) asserts that qualitative researchers might increase transferability by thoroughly defining the research context and the study core assumptions. The individual who intends to transfer the results to a different environment is then in charge of defining the sensitivity of the transfer. To ensure the study transferability, the following measures were applied:

- Findings that can be applied in other contexts.
- Sampling is purposive
- Thick description of:
  - Literature link
  - Results
  - Verbatim quotes from interviews

I provided a thorough and meaningful overview of the setting, participants and research design to the reader. In this research, purposive sampling was used to guarantee that the results were representative of the overall population.

3.8.3 Dependability

Dependability is utilised instead of reliability in qualitative research since it is demonstrated through study design and implementation, operational aspects of data collection, and the project's reflective evaluation (Maree, 2016). I did the following to ensure the study dependability:

- Inquiry audit

- Peer review is used to evaluate the accuracy of data and interpretations.
- Consensus among the researcher and his or her colleagues.
- Triangulation.

It was crucial to keep a diary of study decisions, especially during data collection and processing, as this allowed others to follow the researchers' rationale (Maree, 2016). Furthermore, the analysis process should be documented so that others can see the researcher's decision, how he conducted the analysis and how he arrived at the interpretations.

3.8.4 Confirmability

According to Lincoln and Guba (1985), confirmability is the degree of impartiality or the level to which a study finding is formed by the participants rather than the researcher's bias, incentive, or interest. To improve confirmability, I used the following strategies:

- Raw data, data summaries, data coding themes and relationships are all part of the audit trail.
- Minimising the influence of researcher bias.

The ability of conclusions, interpretations and recommendations to be traced back to the source of enquiry (Wiersma, 2000).

I took field notes during the observations and videotaped the implementation of inquiry-based activities to ensure credibility as I referred back to them, watched the video recordings again, and cross-referenced them with data from the observation checklist and what Life Sciences teachers said in the interviews. The data from interviews and experiment observations were triangulated.

3.8.5 Crystallisation

Crystallisation, according to Maree and Van der Westhuizen (2009), is the practice of confirming results utilising numerous data gathering and analysis methodologies. Different views that all reflect the individuals' distinct reality and identity, according to Nieuwenhuis (2010), are required to provide a complex and deeper knowledge of the phenomenon. Crystallisation creates a more suitable lens for observing components, which can be accomplished by using various data collection methods to improve dependability (Kavia, 2013). In this research, I used a range of data collection methods to assure crystallisation. Among the tactics employed were interviews and lesson observations. The data collected using the multiple methodologies was multidimensional, correlated and converged to provide a greater understanding and meaning of the research.

3.8.6 The pilot study applied to validate the instruments

According to De Vos et al. (2002), a study pilot is a procedure in which a study research design is evaluated to acquire information that the researcher can utilise to improve the main study. Furthermore, Ntuli (2019) asserts that a pilot study is an important aspect of a research project since it provides an overview of the study ahead of time of what to expect when doing research by analysing the feasibility of the study and bringing any shortcomings to the forefront.

The pilot in this research was designed to ensure the clarity of the interview questions, determine the effective period for administering the instruments and improve the quality and sensitivity of the interview questions. The instruments in this research were given to the supervisor for feedback. Eventually, the tools were refined with one individual who was not a participant in this research but fits all of the criteria for participant selection.

The observation instrument was refined after piloting it with the non-participant teacher. The reason for refining the observation comes after realising that the aspects that were in the instrument were not allowing me to see how teacher implemented IBL and was not focusing more on the roles of the teacher. I refined it using the roles of the teacher in an IBL classroom with an aim of getting better understanding of the teacher's practices of IBL.

A pilot study interview was conducted with a Life Sciences teacher, and the interview was audio-recorded with his informed agreement. The teacher was instructed to note out any questions on the interview schedule that were unclear, ambiguous, or repeated. I also made note of the time it took to do the interview, which was 24 minutes. This ensured that the interview was not very long, given the anticipated interview duration was 30 minutes. The well-revised and changed interview schedule and observation instrument were issued as final drafts as a result of the aforementioned procedures (see Appendix B and C). The final drafts were used for collecting data.

3.9 ETHICAL CONSIDERATIONS

To comply with research ethics, researchers must get permission from individuals and sites before collecting data. Individuals are in charge of research locations, data providers (teachers, learners, and their representatives, such as parents), and campus-based institutional review boards (Creswell and Plano Clark 2007). In light of this, the University of South Africa's College of Education Ethics Review Committee was asked for ethical clearance to guarantee that the research was carried out properly and ethically, while minimising the danger to humans and ensuring that the research produced useful results.

Furthermore, DBE in Mpumalanga Province was contacted to obtain authorisation to gather data at Gert Sibande District schools. Before beginning to collect data or interact with participants, the teachers were given a full description of the research's goal and methodology. English is the primary language of instruction in the Life Sciences. However, code switching was used as needed. I translated the interviews schedule to teachers' mother tongues, IsiZulu, to ensure that each participant understood the study expectations and their involvement in it. Consent letters were issued to teachers who participated in the study. Each participant was requested to sign a consent form, and the following topics were covered: participants might withdraw or refuse to participate if they so desired; anonymity and confidentiality would be respected when publishing the findings; and the findings could be disseminated for academic reasons if relevant.

To maintain the participants' privacy and confidentiality, they were not asked to identify themselves in public. The signed consent letters provided participants with further assurances about their anonymity and the study confidentiality. While taking field notes, I videotaped the classroom observations and audio-taped the interviews. The interviews were conducted in a low-noise environment to ensure that they were audible. Furthermore, the information gathered during the observations and interviews was kept strictly confidential, and it was not shared with or revealed to anyone. Instead of mentioning participants' names, pseudonyms were established throughout the study. The participants were informed that the obtained data would be retained on a password-protected computer for five years before being deleted. The appropriate authorities can grant permission to utilise the acquired data. Before the interview transcript was finalised, the teachers who were interviewed were asked to check the summary. No participants were physically or psychologically harmed throughout this research.

3.10 CONCLUSION

This chapter presents the study design and methodology used to address the research questions. The qualitative research approach is discussed in depth, along with data collection methods such as face-to-face semi-structured interviews and direct observation. An explanation of the method of participant and site selection to assess the trustworthiness and rigour of the research project, the credibility and transferability criteria are used in place of reliability and validity. The techniques and processes of data analysis are discussed. Finally, the ethical concerns of informed consent and confidentiality are discussed in depth. The findings and discussion of data collection are presented in Chapter 4.

CHAPTER 4:

DATA PRESENTATION, DISCUSSION AND FINDINGS

4.1 INTRODUCTION

The previous chapter described the research design and methodology employed to collect data for this research. The data gathered through semi-structured one-on-one interviews and direct observation are presented in this chapter. The three participants (cases) were subjected to the same interview questions as well as observation procedures, but in different settings, in order to gain a better understanding of how they implement IBL activities. The data were gathered and analysed in response to the research question:

- What contribution do IBL activities play in the development of teachers' teaching strategies in Life Sciences classrooms?

And the sub-research questions:

- What understanding do teachers have about the implementation of inquiry-based learning activities?
- How do teachers implement inquiry-based learning activities to improve their teaching strategies in Life Sciences?
- How do teachers' inquiry-based learning practices develop as a result of the implementation of inquiry-based learning?

The purpose of this chapter is to present the findings' applicability in light of the gathered information. It is through the collection and interpretation of data that I attempted to develop a base knowledge on how Life Sciences teachers implement IBL activities to improve their teaching strategies in Life Sciences. I did this by further investigating teachers' understanding of the implementation of IBL activities and how Life Sciences teachers' IBL practices develop as a result of the implementation of IBL activities.

The instruments used to collect data for this research were interviews with Life Sciences teachers and lesson observations. Following data gathering, I familiarised myself with the data to uncover patterns that would assist in the creation of a coding system. The coding method was used to summarise the data gathered from the teachers interviewed and the lessons observed. To extract the material and produce themes and categories, a logic analysis method was used.

4.2 DATA PRESENTATION AND DISCUSSION

Table 4.1: *Data analysis scheme (DAS).*

Themes	Categories
Teachers understanding of IBL	The definition of IBL
	The characteristics of IBL
	The stages of IBL
The implementation of IBL activities	The implementation process of IBL
	The benefits of implementation
	The implementation issues
Teachers practice of IBL	Teaching method or approach
	The type of inquiry applied

The results from the interviews and observations of the three teachers, namely Lizzy, Nico and Alfred (pseudonym), who participated in the current research are presented in section 4.3 to 4.8. The results reveal details about the teachers' understanding of IBL, the implementation of IBL and the teachers' practices regarding inquiry. In this section, I present data per case, with section 4.3 and 4.4 illustrating data obtained from Lizzy's interview and observations, section 4.5 and 4.6 data obtained from Nico's interview and observations and section 4.7 and 4.8 data obtained from Alfred's interview and observations. The data will be presented by using the themes and categories from the DAS in each case.

4.3 CASE ONE: LIZZY

4.3.1 Teachers understanding of IBL

4.3.1.1 The definition of IBL

IBL is defined as a learning strategy that engages learners in tasks that make sense to them rather than offering a clear path to the result (Love et al., 2015). Habteselassie (2015) describes IBL as learner activities that promote knowledge and understanding of scientific concepts, as well as an understanding of how scientists research the natural world.

Lizzy showed some comprehension and understanding of IBL during the interview. This was obtained from her response to the questions that was aimed at measuring her understanding of IBL. Lizzy defined IBL as:

> *"Inquiry Based Learning I think it is a method of teaching and learning, it is an approach to learning that encourages learners to engage in solving the problem and experimental learning".*

The preceding response shows that Lizzy understood IBL because she defined it as "an approach to learning". This means that Lizzy viewed IBL as a method of teaching and learning. Lizzy's understanding linked well with the definition of IBL as defined by Love et al. (2015). This revelation showed that, contrary to popular belief, some Life Sciences teachers do understand what IBL entails. Apart from the definition that teacher Lizzy gave, she also add what she thought about teaching Life Sciences as inquiry. Teacher Lizzy's thoughts were:

> *"Life sciences is all about Life, plants and animals and systems that are taking place in our bodies; it is about making life and IBL fits well in Life Sciences because of all the experiments and investigation that we are doing, we get to learn the theory part and do experiments, we get to investigate physically, and we get to create our own questions sometimes and solve them".*

The foregoing explanation revealed that Lizzy was able to express her beliefs about IBL in the sense that she fully comprehends that IBL is more learner-orientated with minimal effort from the teacher.

4.3.1.2 The characteristics of IBL

According to Barrow (2006), in inquiry-based classroom, learners are expected to actively engage in investigative activities like asking scientifically orientated questions, collecting evidence to answer questions, explaining situations and then evaluating, as well as communicating and justifying their findings. Teacher Lizzy explained the characteristics of IBL as:

> "*Through IBL we get to learn the theory part and do experiments, we get to investigate physically, and we get to create our own questions sometimes and solve them*".

The foregoing explanation indicates that Lizzy characterised IBL as a problem-solving strategy through hands-on learning activities. However, though our subject, Lizzy exhibited full comprehension of what IBL entails. According to Love et al. (2015), the teacher guides learning during an IBL class by using well-designed problems, activities that encourage the development of new concepts, and the application of acquired information in Life Sciences. When asked about her understanding of the teacher's role during IBL, Lizzy stated:

> *"The role as a teacher is to provide direct instructions to learners, help learners create questions about the topic and we guide learners into finding questions and solutions on their own, facilitating the teaching and learning. As a teacher we guide them into investigating and doing experiment work. I believe that the learners should create their own questions and answer them along with the teacher".*

From her response, I can deduce that Lizzy had some understanding of her roles as a teacher during an IBL lesson and this was also supported by the lesson observation as Lizzy was interacting with the learners as follows:

> *Lizzy: Right, what will be your investigative question for this experiment?*
>
> *Peppy (pseudonym): which gas is released by living organisms during respiration?*
>
> *Lizzy: yes during an experiment you can ask yourself that question. Okay, which gas is released?*

From the foregoing observation, it is evident that teacher Lizzy was able to assist learners in developing an investigative question which is one of the roles that a teacher must do in an IBL classroom.

4.3.1.3 The stages of IBL

A teacher must enable learners through the stages of inquiry during an IBL activity, which include establishing an investigative question, generating a hypothesis, developing an experiment design, collecting and recording data, analysing data, drawing conclusions, and conveying results (Habteselassie, 2015). This means that Lizzy understood her roles as laid out by Love et al. (2015), which was to facilitate and engage learners in problem-solving activities. Lizzy have an understanding of IBL but she also understood what was required of her in an IBL classroom. This was obtained when Lizzy was breaking down the roles as follows:

> *"We guide learners into finding questions and solutions on their own, facilitating the teaching and learning".*

The explanation shows that teacher Lizzy did understand the expectation of IBL from her which is to facilitate the lesson by guiding the learners through all the stages of IBL. Teacher Lizzy's understanding from the interview was also supported by the observed lesson as Lizzy was interacting with the learners as follows:

> *Lizzy: what are your prediction on this experiment?*
>
> *Musa (pseudonym): in the germinating seed glucose is broken down to produce carbon dioxide.*
>
> *Nhlanhla (pseudonym): the lime water will become milky.*
>
> *Lizzy: which apparatus will be milky between A and B?*
>
> *All learners: B*

From the observation, it is evident that Lizzy was able to assist learners in generating a hypothesis and reaching conclusion. It was evident from the observation that Lizzy applied the stages of inquiry during her lesson. It shows that Lizzy was aware of the stages of inquiry.

The following table indicates the summary of Lizzy's understanding of IBL.

Table: 4.2: *Summary of teachers understanding of IBL*

The definition of IBL	Able of defining IBL as a teaching and learning method as well as a learning approach that encourages learners to participate in problem solving and experimental learning.
The characteristics of IBL	Exhibited full comprehension of what IBL entails which includes engaging learners in the scientific world, establishing and developing background knowledge, and deepen learners knowledge to frame a deep question that direct their inquiry.
The stages of IBL	Assist learners in formulating an investigative question, developing a hypothesis, designing an experiment, collecting and recording data, analysing data, and reaching a conclusion.

4.3.2 The implementation of IBL activities

4.3.2.1 The implementation process of IBL

Studies has put more emphasis on the fact that teaching should start with the implementation of IBL and end with confirmation of inquiry through fact (Ramnarain, 2020). Lizzy exhibited lack of confidence with regards to the implementation of IBL in Life Sciences classrooms. This lack of confidence towards IBL in the Life Sciences classroom was obvious in Lizzy's response:

> *"In our classes it is very difficult to follow everything because of the high number of learners in our classes and to follow everything that IBL requires is difficult. Classes are full, and the syllabus is too long, and we also don't have all the resources to do everything by the book so sometimes it more theory and less experiment work done. We try but it is difficult; hence, I do not have much experience, instead we focus in using the traditional methods of teaching rather than IBL".*

From the above response, it was evident that Lizzy was not frequently implementing IBL. What Lizzy explained in the interview was evident from her second lesson that she does not frequently incorporate IBL. This was observed as:

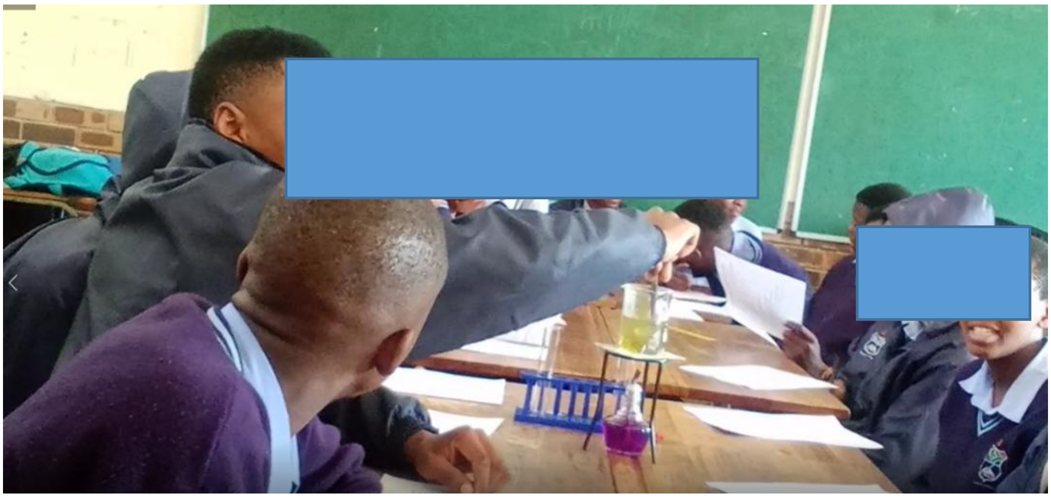
> *There was no material/ apparatus. The teacher was having a box with worksheets. She distributed the worksheets to all the learners.*
> *Lizzy: Good afternoon, today we will be looking on cellular respiration. The teacher starts to read the aim of the investigation, the apparatus used and the method from the worksheet.*

These observation demonstrated that Lizzy lacked sufficient experience in implementing IBL. Lack of sufficient experience when implementing IBL has many implications for Life Sciences teachers because even if they do implement IBL, it is not done with the goal of developing and assisting the learner (Ramnarain, 2020). This revelation is vital because it contends with assertions already made by scholars in education such as Hobden (2005) who argues that in South Africa there are minimal opportunities for learners to socialise or work in cooperative learning groups. Based on that, one can argue that Life Sciences teachers do not implement IBL as frequently as they should because it is made impossible by the lack of resources, lack of teacher's understanding and overcrowded classrooms. Lizzy asserts that she did not have enough experience. That was the reason why she implemented the traditional method of direct teaching. During the first lesson, teacher Lizzy grouped the learners and gave them the apparatus to use doing the experiment investigation. The observation was captured as follows:

> *Lizzy: number 4, boil the leaf in water for about 1 minute.*
> *Each group was boiling the leaf in water and observing the changes in the leaf.*
> *Lizzy: you observe the colour change. Any colour change?*
> *Learners: they were talking to each other but not answering the teacher.*

The following figure indicates the learners interacting with the IBL activity.

Figure 4.1: *Learners interaction during the IBL activity*



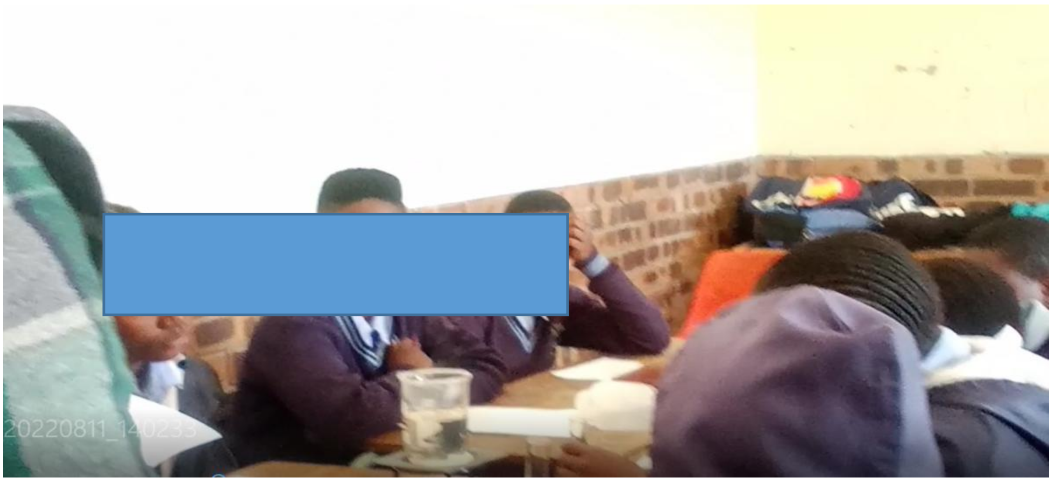
Lizzy: Are you observing the colour change?

All learners: yes

From the observation, I can deduce that the teacher was implementing IBL even though in the interview she indicated that she does not implement IBL because of lack of experience in incorporating IBL. During the observation it was seen that the teacher provided learners with the opportunity to conduct the IBL activity and initiated group work. This is what was being observed:

Figure 4.2 demonstrates Lizzy facilitating during the activity.

Figure 4.2: *Teacher Lizzy facilitating during the activity*



Lizzy: take the test-tube and put it into the boiling water.

The teacher was in one of the groups checking if they were doing okay. She then moved to the other groups checking.

Lizzy: now we are observing the colour change in the test-tube, the colour change of the alcohol.

From the observation, it is evident that the teacher was facilitating learning and allowing learners to develop scientific understanding.

4.3.2.2 The benefits of implementation

IBL has benefits for both the teachers and learners when it is effectively implemented. Lizzy mentioned the following:

> *"If everything was done correctly like teaching and learning as well as experiments then IBL forces curiosity in learners and it teaches skills, encourages learning experience for learners and creates a well understanding of a topic for learners".*

Lizzy understood that IBL is used to stimulate the development of learners in the Life Sciences classroom. This contention by Lizzy agreed with contentions made by scholars such as Du Plessis (2015) and Ramnarain (2020), that IBL serves to stimulate learner growth and development while ensuring comprehension and understanding of the Life Sciences curriculum. It was quite surprising to note that Lizzy listed the benefits of IBL for the learners but failed to mention the benefits that IBL brings to the teacher, especially considering that in previous questions she kept on linking IBL as a tool to achieve assessment purposes in the Life Sciences curriculum.

4.3.2.3 The implementation issues

Limitations are a part of every method used in the process of teaching and learning. IBL is no exception to those challenges. One can argue that many Life Sciences teachers avoid IBL owing to the challenges it comes with. Lizzy addressed this well in her response.

> *"The common problem for learners even for the teachers is the inability to recognise when we are successful. We just jump on teaching and learning if the work is done well. We are unable to recognise that and because of many learners in our classes we don't usually work in groups, and it makes it difficult for the teacher to find a problem or identify learners who are in need. Mostly it is the lack of resources especially our schools we struggle to even do a simple experiment, so*

the lack of resources limits us from fully implementing IBL, we do have a laboratory, but it is lacking resources and there is also the lack of textbooks".

From Lizzy's passionate response, it can be argued that it is not the lack of understanding that prohibits Life Sciences teachers from using IBL but rather a lack of resources such as textbooks and well-equipped science laboratories. According to Ramnarain (2016), there is a serious lack of resources in public or government schools, and this shoots deep into the classrooms and affects the delivery of lessons to learners. Lizzy reported that because of the shortage of resources, she was unable to conduct assessments that require the use of IBL, such as experiments or investigations. This revelation destroyed the notion that Life Sciences teachers do not prefer IBL because they lack understanding. Moreover, Lizzy stated that another limiting factor was the issue of overcrowding, as she add: *"because of many learners in our classes we don't usually work in groups"*.

The preceding extract is vital because it contends with assertions already made by scholars in education, such as Hobden (2005), who declares that in South Africa there are minimal opportunities for learners to socialise or work in cooperative learning groups. Based on that, I deduce that Life Sciences teachers do not implement IBL as frequently as they should because it is made impossible by the lack of resources and overcrowded classrooms. However, the extent to which these factors limit IBL is not quite clear because earlier responses suggest that Lizzy used IBL sparingly, meaning that regardless of lack of resources and overcrowding, she was still able to make compromises when it came to implementing IBL for assessment purposes. This is what was observed in Lizzy's classroom:

Figure 4.3 indicates the learners in a group during the IBL activity.

Figure 4.3: *The learners in a group during the IBL activity*

During Lizzy's first lesson I saw her making compromises by grouping learners, even though the groups were too big but learners were able to observe while some handling the apparatus. While in the second lesson, the learners were not exposed to any experiment activity as observed next:

Figure 4.4 shows the arrangement in the classroom.

Figure 4.4: *The arrangement in the classroom*

Based on my observations, teachers do not fully implement IBL owing to a lack of resources and other limiting factors such as overcrowding.

Table 4.3 indicates the summary of Lizzy's implementation of IBL activities.

Table 4.3: *Summary of teachers implementation of IBL activities*

The implementation process	IBL was not fully implemented and learners prior knowledge was not identified. The learners were provided the opportunity to conduct IBL activity and the teacher was able to initiate group work. The teacher was able to facilitate the lessons and assisted the learners in the development of original learning by asking questions.
The benefits	The teacher was able to develop learners conceptual understanding. Higher-order thinking skills were not fully developed such as synthesis and critical thinking but able to develop analysis and evaluation.
Implementation issues	Lack of resources in the school, lack of teacher professional development, overcrowding of classroom, and learners who are less motivated to participate in the IBL activity because they lack the necessary knowledge and abilities were identified.

4.3.3 Teachers practices of IBL

4.3.3.1 Teaching method or approach

A teacher's instructional strategies are those that are required to improve learning for different learners (Conklin, 2007). However, when going to class, a teacher should not rely on a single method (Halai & Khan, 2011). According to Hollon, Roth and Anderson (1991), instructional strategies should be utilised as a tool to enhance learners' thinking capacity and make them aware of the importance of their thinking ability during the learning process. According to Kuzniak and Rauscher (2011), the choice of instructional strategies is strongly influenced by the teacher's content knowledge, which indicates that a teacher who lacks subject matter knowledge may struggle to identify effective instructional strategies and will therefore revert to rote learning. This suggests that teachers' expertise and teaching practices are mutually dependent. According to Masilo (2018), to provide a sound and relevant learning experience in an inquiry-based classroom, teachers must first equip themselves with a thorough understanding of teaching approaches. As a result, teachers must understand the foundations and essence of teaching practices that capitalise on learning through inquiry and problem-solving (Ramnarain, 2016). The instructional strategies in teaching and learning are important because they help teachers create a classroom environment in which students dominate discussions and encourage students to see life sciences as a dynamic process of investigation rather than a static collection of unchanging facts (Ramnarain, 2020). Based on the suitable instruction strategy when teaching Life Sciences, Lizzy responded as follows:

> *"In Life Sciences, the strategy that works well in our classroom is teaching and learning because there are a lot of notes that need to be taught and explained before experiments. It has a lot of theory; so, it is difficult to group them or allow them to do experiment work. Direct teaching is the best strategy for me especially prior to doing experiments.*

Lizzy believed that teaching using direct teaching was the best strategy for her, mostly prior to experiment teaching practice. Lizzy indicated that since Life Sciences is a subject that requires more explanation, it was difficult to allow group discussions. From Lizzy's explanation, it was clear that she did not believe that teachers had to allow learners to discover information that was new to them as well as develop a good relationship between the teacher and the learners. Even if there were no limitations in the classroom, Lizzy mentioned that she believed in the implementation of direct teaching as a strategy as she explained as follows:

> *"I think that if resources were not problem, then certainly, we need to give learners more work and more feedback. Most of the time I focus on direct teaching and allocate time for revision, experiments and feedback".*

From the explanation, even if resources were all available, Lizzy would remain positive with her direct teaching strategy. This showed that Lizzy was not for the implementation of IBL in her classroom because of her focus on the completion of the annual teaching plan and improving the learners' scores on a test or exam. According to Kuzniak and Rauscher (2011), IBL is an innovative learning technique that includes not only the ability to engage in inquiry but also an understanding of how enquiry results in knowledge acquisition. Teachers must first educate themselves with a strong understanding of IBL as a strategy in order to give a good and meaningful learning experience in an inquiry-based classroom. What teacher Lizzy said during the interview contradict what she did during the lessons as she do the following:

> *Lizzy: Okay today I will be demonstrating that starch is produced in the green colour of the leaf during photosynthesis.*

From the extract, Lizzy's teaching method was demonstration not the direct teaching that she mentioned during the interview. Based on the lesson observation, teacher Lizzy was using demonstration and discussion as the teaching methods.

4.3.3.2 The type of inquiry applied

There are various degrees of learning inquiry, and teachers are labelled differently depending on the responsibilities they play (Caliskan, 2008). Colburn (2004) distinguishes three types of IBL: structured inquiry, directed (guided) inquiry and open inquiry. The teacher who has begun the inquiry practice can begin with structured learning environments and progressively progress to the open inquiry method. During the lesson of teacher Lizzy, the learners investigated the given questions through observations, creating solutions and making generalisations. This was observed in teacher Lizzy's classroom as she did the following with the learners:

> *Lizzy: Right, what colour change was observed in test tube A*
> *Musa (pseudonym): it remains clear*
> *Lizzy: yes, it means what?*
> *Ben (pseudonym): There was no carbon dioxide*
> *Lizzy: No carbon dioxide means?*

All learners: No cellular respiration take place. Test tube B?

Mazwi (pseudonym): Milky

Lizzy: It means carbon dioxide has been produced and cellular respiration has taken place. 1.1.5 give the reason for the colour in test tube B. everyone can give me the reason. What is the reason?

All learners: presence of carbon dioxide

Lizzy: Now, between A and B which one is a control?

Learners: A

The observation indicates that teacher Lizzy was facilitating the learners through questioning and that assisted in the learners in creating solutions and making generalisations. During the lesson, Lizzy stated the focal questions and was facilitating the learners when answering the questions. From the observation I can deduce that Lizzy was using guided inquiry.

Table 4.4 indicates the summary of Lizzy's practices of IBL.

Table 4.4: *Summary of the teachers practices of IBL*

Teaching method or approach	Demonstration and discussion was used
The type of inquiry applied	Applied guided inquiry

4.4 FINDINGS

4.4.1 Teachers understanding of IBL

The study discovered that Lizzy was able to define IBL as she defined it as the teaching and learning method and an approach to learning that encourages learners to engage in problem-solving and experimental learning. Lizzy exhibited full comprehension of what IBL entails which includes engaging learners in the scientific world, establishing and developing background knowledge, and deepen learners' knowledge to frame a deep question that direct their inquiry. Lizzy assisted learners in developing an investigative question, generate a hypothesis, develop an experiment design, collect and record data, analyse data and reaching conclusion. Lizzy understood IBL because she defined it as "an approach to learning". This means that Lizzy viewed IBL as a method of teaching and learning. Lizzy had some understanding of her role as a teacher during an IBL lesson. This was seen when breaking down the role as "we guide learners into finding questions and solutions on their own, facilitating the teaching and learning." This understanding of the teacher's role was important because it further proves that not only does Lizzy had understanding of IBL but she also understood what was required of her in an IBL classroom.

4.4.2 The implementation of IBL activities

This study discovered that Lizzy did not fully implement IBL as she was unable to identify learners' prior knowledge before the introduction of the new knowledge. The identification of prior knowledge was going to assist in the activation of learners understanding of the new concept. The observation revealed that teacher Lizzy was able to provide learners with the opportunity to conduct the IBL activity. Even though the groups that were formed where big to allow all the learners to interact with the apparatus, but the learners were all involved in the experiment investigation. Lizzy was able to facilitate the lessons as she was moving in all the three groups and assisted the learners in the development of original learning by asking questions. The questions that Lizzy was asking assisted in the development of conceptual understanding. Higher-order thinking skills were not fully developed such as synthesis and critical thinking but able to develop analysis and evaluation. The study discovered that there were challenges during the implementation of the activity which includes, lack of resources in the school, the lack of teacher professional development, overcrowding, and learners who were less motivated to participate in the IBL activity because they lack the necessary knowledge and abilities.

4.4.3 Teachers practice of IBL

In this study, it was discovered that Lizzy was practising guided inquiry as she stated the aim of the investigation and guide learners in choosing the material in responding to the aim of the investigation. During the lesson, the teacher helped the learners to become responsible for their actions and learning by asking questions which was to get more from the learners. The learners investigated the given questions, creating solutions and making generalisations. More importantly, the learners gained independent inquiry skills. During the observation, it was discovered that teacher Lizzy was practising demonstration and discussion as teaching methods. Lizzy showed the learners how to do the experiment and explaining the step-by-step process. The learners received immediate feedback through their product during the experiment and also gave the learners a real-life situation on how to use tools and materials.

4.5 CASE TWO: NICO

4.5.1 Teachers understanding of IBL

4.5.1.1 The definition of IBL

According to Pedaste (2012), IBL is characterised as a process of discovering new causal relationships, with learners developing hypotheses and verifying them through experiments and observations. According to LIewellyn (2005), IBL is a learning process that combines active interaction with the environment and continuous knowledge development. Based on the foregoing definition, Nico understood what IBL is through his explanation:

> *" Ok, what I can say about inquiry-based learning is [that it is] a teaching and learning methods that focuses more on learners in experiencing the processes of knowledge creation. I can add that it is a learner-centred [method] that allows learners to learn on their own pace. It allows learners to be lifelong learners. The only thing that the teacher can do is to guide the learners".*

According to the explanation, Nico understood IBL as a learning method that allows learners to be active throughout the learning process and as a process rooted in the rapid advancement of scientific knowledge. Nico also believed that IBL assisted learners in developing the ability to ask questions, determine the learning material, gather knowledge about the unit, and draw conclusions, as demonstrated by his explanation:

"I believe teaching Life Sciences as inquiry is a good idea since it enhance the Life Sciences teacher to gain competence, practices and also improve their conceptual understanding. I believe that in the learning space we learn from the books, we learn from our peers, so I believe teaching through inquiry will assist me and also the learners to gain more knowledge".

Nico's answer was founded on his belief that the IBL approach enables learners to develop the necessary abilities to become free individuals and life-long learners. When learners structure their learning with IBL procedures, he claims that they obtain conceptual understanding, which helps them to mature into learners who know how to learn. I may conclude that Nico's beliefs demonstrated a comprehension of IBL.

4.5.1.2 The characteristics of IBL

IBL is characterised as the teaching approach where learners are involved in asking scientifically orientated questions, giving learners priority of evidence with respect to a problem and using the evidence to develop an explanation (Pedaste, 2015). In addition, IBL also connects explanations to scientific knowledge and learners communicate and justify explanation (Pedaste, 2015). During the interview teacher Nico characterised IBL as:

"Life Sciences is all about life, plants and animals and systems that are taking place in our bodies; it is about making life and IBL fits well in Life Sciences because of all the experiments and investigation that we are doing. We get to learn the theory part and do experiments, we get to investigate physically, and we get to create our own questions sometimes and solve them"

From the explanation, Nico characterised IBL as a teaching method that assists during experiment investigations in Life Sciences and assisted learners to create investigative questions. Therefore, I can deduce that teacher Nico has some understanding of the characteristics of IBL.

4.5.1.3 The stages of IBL

Cotton (1995) reveals that analysis is another stage that teachers implementing IBL must meet. The teacher is expected to facilitate this process and help learners go through the analysis. It is at this point that the teacher begins equipping the learners with more skills (Ramnarain, 2016). Furthermore, the teacher must remain strictly as a facilitator observing the activity and ensuring that the learners are following the activity instructions as laid out (Ramnarain, 2016). However, Nico did not ensure that all the stages were fully implemented. Nico managed to assist learners in generating a hypothesis as he was doing the following with his learners:

Nico: When you are doing the testing you must have the hypothesis, prediction. What do you think will happen when we testing for starch? What is your hypothesis? Predict the outcome what will happen?

Vusi (pseudonym): Colour change

Nico: What colour are you expecting on this leaf when the leaf is de-starched?

Learners at the back: Blue black

Nico: Please raise up your hands, don't sing. Lapho Mandla (pseudonym)

Mandla (pseudonym): If the leaf is de-starched the colour change will be yellow brown.

The observation shows that teacher Nico was aware of the stages of inquiry because he assisted learners in generating a hypothesis. Apart from the generation of a hypothesis Nico, also assisted the learners in reaching the conclusion, forming and extending generalisation as he did the following during his interaction with the learners:

Nico: Those that are closer what is the colour change? Bongi (pseudonym) come and observe. What is the colour change?

Bongi: Yellow brown

Nico: The colour is yellow brown what does this mean?

Amahle (pseudonym): It means the plant was not receiving sunlight.

Nico: Is this correct?

Other learners: No

Bongi (pseudonym): It means that there is no starch on the leaf.

Vusi (pseudonym): Instead of saying there is no starch on the leaf, we can say the leaf was not photosynthesising.

Nico: If the leaf remains yellow brown, it means there is no starch; the *plant was not photosynthesising but if the colour change to blue black, it means it was photosynthesising and receiving sunlight. Thank you that is the end of the lesson.*

From the observations, I can deduce that Nico did not do well in terms of ensuring that the stages of IBL were fully implemented as he only managed to assist learners in generating a hypothesis and reaching conclusions. Moreover, Nico was not able to assist the learners in terms of developing an investigative question, collecting and recording data, data analysis and communicating the results. Table 4.5 summarises Nico's understanding of IBL.

Table 4.5: *Summary of teachers understanding of IBL*

The definition of IBL	Nico understood what IBL is all about. Nico understood IBL as a learning approach that enables the learners to be active throughout the learning process and as a process that is rooted in the rapid development of scientific knowledge.
The characteristics of IBL	Nico has some understanding of the characteristics of IBL. Nico characterised IBL as a teaching method that assists during experiment investigations in Life Sciences and assist learners to create investigative questions.
The stages of IBL	Nico did not ensure that all the stages were full implemented.

4.5.2 The implementation of IBL activities

4.5.2.1 The implementation process of IBL

Implementing IBL activities is contingent on the teacher's ability to deliver the best education and encourage the most possible learning in the classroom (Kavai, 2013). Ramnarain (2018) asserts that IBL is promoted through inquiry-based implementation, which enables learners to achieve better cognitive processes in Life Sciences. The teacher guides and engages learners during the implementation of IBL activities so that they can gain a comprehensive grasp of science rather than immediately presenting the material to the learners. Nico's response from the interview showed that he had knowledge of how to implement IBL in the classroom by saying:

> *"I believe that it is to help learners to generate content-related questions and to guide them during an investigation. I think that is my role. I can add by saying in controlled learning, my role can be to provide several essential questions so that learners can unpack those questions".*

According to Nico, a teacher's role is to ask learners probing questions about the subject matter, to lead them through an investigation and to give them a few key questions to consider. In addition, Nico said that the teachers must transform the textbook-centred learning patterns of their learners into learner-focused research questions and assume the role of a facilitator in the IBL setting. What teacher Nico said in the interview was also observed in his first lesson as he did the following with the learners:

> *Nico: yes, that shows that the leaf has no starch. Let say there is starch, we didn't de-starch the plant. What will happen to the colour change, is it going to be yellow brown or change to blue black or pink. There is starch now on the leaf. Yes Mahle (pseudonym).*
>
> *Mahle (pseudonym): It is going to change to blue-black.*
>
> *Nico: Yes, it will change to blue-black indicating that starch is present, meaning photosynthesis has been taking place. What is gona happen now? You must observe the leaf the colour of the leaf is gonna change because the hot water is softening it up, breaking the cuticle and the cell membrane.*
>
> *The teacher was stirring the leaf that was boiling in the water in the glass beaker.*

From the observation, Nico was facilitating through questioning and also guiding the learners as he was explaining and elaborating from the learners responses. I can deduce that teacher Nico was aware of his roles in an IBL classroom. According to Hodson (2014), the implementation of IBL requires changes in classroom practices, as well as a new understanding of science. Nico activated learners' understanding and this was observed as:

Nico: Ok, the first thing that we need to do is to de-starch the leaf that we be using. In this case we will be using this leaf. The teacher pick the leaf in his table and was showing it to the learners. You de-starch the leaf for how many hours? Without waiting for the answer. For 48 hours which is equivalent to two days. After that you take the plant out of the dark cupboard umangabe ubuyifake ku ***(if it was in a cupboard)*** *cupboard for de-starch then you place it in sunlight. This leaf has been de-starched for you. So now I will light up the Bunsen burner so that we will heat up the water. When you look on the leaf you can remember that the leaf is protected by the cell membrane, nani?* ***(and what?)***

All learners: Cell wall

The observation indicates that Nico was explaining what was done before the lesson in order for learners to understand the process from the beginning. In IBL, the teacher does not directly introduce information to learners, but rather guides them through the process of gathering information (Crasford, 2000). One aspect of the information generating process is identifying learners' past knowledge and integrating it with the new knowledge (Crasford, 2000). Apart from activating learners knowledge, teacher Nico also identified learners' prior knowledge as he did the following with the learners:

Do you still remember when we were learning about photosynthesis. I talk about the requirements for photosynthesis in the beginning. Can you remind me about the requirements, just give me three.

Vusi (pseudonym): Carbon dioxide

Bongi (pseudonym): Sunlight

Lwandi (pseudonym): Temperature

Teacher: Aaah… temperature … is the same as sunlight can you give me other one.

Sihle (pseudonym): enzymes

Teacher: When we are testing for starch there are methods that we need to follow so that we can get the results. Yini okumele siyenze ***(what is it that we have to do)*** *when testing for starch?*

Amahle: We must use iodine solution

The observation indicates that Nico's implementation process was guided by the steps that IBL requires. Teacher Nico reminded the learners through questions what they did in the previous lessons which he believed was also important for this lesson. Even though they were not in a laboratory and the apparatus were not enough for every learner, teacher Nico provided the learners the opportunity to conduct the IBL activity by grouping the learners and distributed the material that was available. This was evident from Nico's lesson as he did the following:

> *Learners were in groups or six; some were four and others were more but less than ten. This arrangement indicates that the teacher had the preparation prior before my arrival. This arrangement indicates that the teacher was preparing for group work.*
>
> *Nico: As we are still waiting for the leaf let me see in your groups. The teacher moved around in different groups checking if everything is fine.*
>
> *That group over there, pointing the group at the back right corner, you must observe everything that is happening. If the bubbles are formed around, or there is one bubble. Observe carefully because at the end I will give you questions to answer. So for us to make this investigation reliable what is it that we need to do at the end?*

The observation indicates that teacher Nico was facilitating group work and also allowing the learners to conduct the IBL activity. The observation corresponds well with what teacher Nico said in the interview when asked about the implementation of IBL. Teacher Nico said:

> *"Aaah, since I started my teaching career I was using it but not noticing that I was using it. I was allowing learners to find information and in some cases, I used to give learners activities which require them to go and search information or to ask to people outside the school, so I can say yes I am using IBL."*

The response indicates that teacher Nico was for the implementation of IBL. I can deduce that Nico's implementation process was guided by the teacher's roles in an IBL classroom.

4.5.2.2 The benefits of IBL

The advantages of IBL have been thoroughly proven through empirical research investigations (Love et al., 2015). According to Osborne (2010), IBL is motivating and increases interest in the Life Sciences. IBL has also been demonstrated to assist in the formation of conceptual knowledge in the Life Sciences (Leonor, 2015). According to teacher Nico, IBL has the following benefits:

> *"It must allow my learners to be able to solve problems they come across in learning and also expose them to experimental learning. It allows them to questions ideas rather than being passive in their learning."*

From the explanation, teacher Nico believed that when learners are exposed to IBL activities, they will be able to develop skills that can assist them in problem-solving within and outside the classroom. He also claimed that IBL may help learners achieve relatively high thinking skills like analysis and evaluation. Apart from what teacher Nico said in the interview, it was also observed in the lessons that he was passionate to develop learners' conceptual understanding and higher-order thinking skills. This is what happened in the classroom during Nico and the learners:

> *Nico: No, by boiling the leaf in water we are not removing the chlorophyll but breaking the cell wall, cell membrane and the cuticle.*
>
> *Sizwe (pseudonym): Ngicela ukubuza Sir* ***(can I ask sir)****, i alcohol ozoyi add izoba ngakanani?****(how much is the alcohol that you will add?)***
> *Nico: It will depend on the size of the leaf. Any other question?*
> *Zizi (pseudonym): What chlorophyll do in a plant?*
> *Nico: Oooh, who can answer that question?*
> *Two girls with the first raw: To trap sunlight*
> *Nico: Yes, to remove chlorophyll so that the iodine solution will have an impact. When you see the leaf is it soft or hard?*
> *Learners: hard*
> *Zinhle (pseudonym): Sir, so the iodine uzoyi* ***(will)*** *apply on top of the leaf?*

From the observation, I can assert that teacher Nico was developing learners' conceptual understanding as he was explaining why they were to boil the leaf in water. The learners' questions revealed that they have developed analysing and their critical thinking skills. Inquiry is also an important tool for understanding the nature of science (Abd-El-Khalick, 2014). This was evident from the lesson observation as Nico do the following:

> *Nico: We have the iodine solution which is our re-agent, the ethanol, the Bunsen burner as you can see it is burning; we will need fire, I have the beakers, which I will use to boil the water, I also have the stand (tri-pot stand). I have the cold water; I have the test-tubes. This is the spirit that is assisting us with the fire. Because of time I decided to boil the water. Here we are having the leaves that will be tested. Tell me, if we want to test for starch, what are the methods that we need to follow.*

The observation indicates that teacher Nico was explaining to learners which he believed was going to develop the understanding of names and functions of the different apparatus. I can deduce that Nico's explanation of the apparatus was part of the development of the nature of science.

4.5.2.3 The implementation issues

According to Chiu and Cheng (2014), researchers have indicated that IBL faces several challenges, including (1) the problem of large classrooms; (2) the time required to develop learning activities; and (3) the difficulty of facilitating learners' motivation in learning to organise information and follow the learning context. Furthermore, Ramnarain (2016) discovered that important barriers in adopting IBL in South African township schools include characteristics such as resource adequacy, professional assistance, school moral belief and time. To have a good IBL environment, the learning environment in the classroom should have learning materials that can improve and stimulate learners' curiosity. Furthermore, it should respond to the learners' questions. As a result, it is best to equip the classroom with a wide range of reading materials relevant to the subject being studied, such as books, journals, brochures, pamphlets, and newspapers (Love et al., 2015). Furthermore, because the internet connects to a vast amount of knowledge, its use should be encouraged. Nico stated in the interview that the IBL activities were difficult to accomplish owing to a lack of resources. Nico further clarifies:

> *“Limiting factors, the first one is the absence of resources in the school, the absence of Wi-Fi in the school; so, it becomes difficult to give learners something to research on. There is shortage of textbooks so some learners relay on copies”.*

Nico indicated that it becomes difficult for him to implement IBL because of the shortage of internet connectivity and also textbooks for the learners. What teacher Nico said in the interview about the limiting factors was also observed during his lessons.

> *The lesson was taking place in a classroom where the learners use for all the subjects. In short, the teacher was not using a laboratory.*

The observation can affect the implementation process because learners can become less motivated to participate in IBL activity as they are not exposed to an environment that promotes IBL. To accomplish IBL, learners must be given with a learning environment that allows them to produce new ideas, deepen their understandings, learn to think critically, and obtain diverse experiences (NRC, 2000). The implementation issues were further observed as learners do the following:

> *Learners were observing but other were busy making noise until the teacher tells them to stop making noise.*

The observation revealed that overcrowding led to the noise in the classroom which destructed the teaching and learning. Kim and Tan (2010) assert that teachers face challenges when adopting an inquiry-based approach, as opposed to a teacher-centred method, in which learners simply follow the teacher's directions. According to Crawford (2012), IBL is a complex and difficult approach to teaching which demands proper teacher professional development. Table 4.6 summarises Nico’s understanding of IBL.

Table 4.6: *The implementation process of IBL*

The implementation process of IBL	He had knowledge of how to implement IBL in the classroom. Nico was facilitating through questioning. Identified learners prior knowledge. Nico activated learners' understanding. Nico was facilitating group work and also allowing the learners to conduct the IBL activity.
The benefits of implementation	Teacher Nico believed that when learners are exposed to IBL activities they will be able to develop skills that can assist them in problem-solving within and outside the classroom.
The implementation issues	The classroom was overcrowded and that led to the noise in the classroom which distracted teaching and learning. Shortage of resources like internet connectivity and textbooks.

4.5.3 Teachers practices of IBL

4.5.3.1 Teaching methods or approach

IBL is an appealing instructional technique (Kavai, 2013). According to Visser (2002), learners who have encountered IBL are more motivated, more competent in problem solving and engage in problem-solving more successfully and spontaneously than learners who have experienced traditional learning environments. Within the framework of constructivist theory, IBL can be implemented through the use of various learning approaches such as project-based learning, problem-based learning, cooperative learning, and example-based learning (Kavai, 2013). These methods encourage inquiry, and the constructivist approach helps learners learn science in a meaningful way. According to Masilo (2018), teaching sciences requires the use of specialised instructional strategies that allow learners to expand their knowledge and develop new abilities. Furthermore, the techniques must also give teachers a reproducible scientific inquiry process as well as a systematic scientific study strategy (Masilo, 2018). During the interview, Nico was asked about the instructional strategy that he implemented in his lessons and he responded as follows:

> "*The first one for me is hands-on learning. It involves the active participation of learners to experience scientific concepts rather than to be audience in their learning. I allow my learners to explore scientific concepts rather than watching me as a teacher doing the experiment task."*

The response indicates that teacher Nico was using hands-on learning as a teaching strategy. Teacher Nico further explained that his teaching strategy allows learners to be active participants and allows learners to explore scientific concepts. I can deduce that Nico was practising IBL in his classroom. What teacher Nico said in the interview was also observed in the lessons as:

> *Nico: Today I want us to test for starch.*

The observation indicated that Nico was not the one who was doing the experiment but the learner through his guidance. The observation showed that Nico was practising IBL as he also did the following during his interaction with the learners:

> *Nico: yes we will rinse it in water to remove the alcohol. i ethanol iyona I alcohol esiyisebenzisayo la* ***(The ethanol is the alcohol that we use****). Sizo remove le leaf bese si yi rinse kumanzi a clean* ***(we are going to remove the leaf and rinse it in clean water)****….clean water. Ok let me prepare leaf I think…you must try to be careful kulamanzi ashisayo (****in hot water)****. You must use forceps. The teacher was rolling the leaf and putting it into the test tube. Pour the alcohol. Don't forget that ethanol is flammable, when doing this you must observe precautions. The teacher takes test-tube with the leaf and put it into the boiling water. The burner was still burning. You can see the chlorophyll leaving the leaf. Those that are close can see bubbles. Can you see the bubbles?*

Learners in the front: yes. Learners were observing.

Nico: When the leaf is soft I will take it out and try to roll it in one of the test tubes. These are the test-tubes. The teacher was showing the tray with the test tubes to the learners.

Nico: You know it angithi?

All learners: yes

Nico: I will put it in the test tubes and pour this, picking up a bottle. What is this?

All learners:…ethanol.

In the observation, teacher Nico also used demonstration and discussion as his method of teaching and learning. Nico's teaching approaches aimed to foster active, motivated learning, problem-solving skills, and extensive field knowledge based on conceptual understanding.

4.5.3.2 The type of inquiry applied

According to Culver (2002), IBL may not contribute to the development of problem-solving skills on its own. However, IBL that deviates from traditional teacher-learner interactions toward active, self-directed learning by the learner, which includes providing answers to problem-based questions through inquiry, may result in the development of problem-solving skills. From the observed lessons, I can deduce that teacher Nico was practising guided inquiry as he did the following:

Nico: As we are still waiting for the leaf, let me see in your groups. The teacher moved around, in different groups checking if everything is fine. That group over there, pointing the group at the back right corner you must observe everything that is happening. If the bubbles are formed around, or there is one bubble. Observe carefully because at the end I will give you questions to answer.

The observation revealed that Nico acts as the guide or facilitator. As facilitators of learning, teachers acquaint learners with new ideas to support and guide learners as they make sense of the new knowledge (Kavai, 2013). In teacher Nico's lessons, the learners took an active role by carrying out and engaging with the IBL activities in small groups, discuss the observed parts, linking them to real-life experiences and then answer the problem-solving questions individually. Table 4.7 summarises Nico's practices of IBL.

Table 4.7: *Teachers practices of IBL.*

Teaching method or approach	Practice IBL, demonstration and discussion.
The type of inquiry applied	The application of guided inquiry was observed

4.6 FINDINGS

4.6.1 Teachers understanding of IBL

This research reveals that Nico understood IBL as a learning method that enables learners to be involved throughout the learning process and as a process rooted in the rapid development of scientific knowledge. Nico's response was founded on his belief that the IBL approach teaches learners the necessary abilities to become free individuals and lifelong learners. When learners organise their learning with IBL procedures, he claims that they obtain conceptual understanding, which helps them mature into individuals who have learned how to learn. This study discovered that Nico's beliefs showed that he understood IBL. Nico characterised IBL as a teaching method that assists during experiment investigations in Life Sciences and assisted learners in creating investigative questions. This research also discovered that Nico has some understanding of the characteristics of IBL. However, Nico did not do well in terms of ensuring that the stages of IBL were fully implemented as he only managed to assist learners in generating a hypothesis and reaching conclusions. Moreover, Nico was not able to assist the learners in terms of developing an investigative question, collecting and recording data, data analysis and communicating the results.

4.6.2 The implementation of IBL activities

This study discovered that Nico was facilitating through questioning and also guiding the learners as he was explaining and elaborating from the learners' responses. Nico was aware of his roles in an IBL classroom. Nico's implementation process was guided by the steps that IBL requires. Furthermore, teacher Nico reminded the learners through questions what they did in the previous lessons which he believed was also important for the lesson. Even though they were not in a laboratory and the apparatus were not enough for every learner, teacher Nico provided the learners the opportunity to conduct the IBL activity by grouping the learners and distributed the material that was available. Nico was facilitating group work and also allowing the learners to conduct the IBL activity. Teacher Nico implemented IBL.

This study discovered that Nico's implementation process was guided by the teacher's roles in an IBL classroom. Nico believed that when learners are exposed to IBL activities they will be able to develop skills that can assist them in problem-solving within and outside the classroom. He also believed that IBL can develop learners' higher-order thinking skills such as analysis and evaluation. Apart from what teacher Nico said in the interview, it was also observed in the lessons that he was passionate to develop learners' conceptual understanding and higher-order thinking skills. Nico explained to learners which he believed was going to develop the understanding of names and functions of the different apparatus. Nico's explanation of the apparatus was part of the development of the nature of science. This study discovered that Nico had challenges that affected the implementation which includes the shortage of internet connectivity and also textbooks for the learners.

4.6.3 Teachers practices of IBL

This study discovered that Nico was practising IBL in his classroom. The observation indicated that Nico was not the one who was doing the experiment but the learner through his guidance. Teacher Nico's teaching and learning methods included demonstration and discussion. Moreover, Nico's teaching approaches aimed to foster active, motivated learning, problem-solving skills, and extensive field knowledge based on conceptual understanding. According to the observed lessons, teacher Nico was using guided inquiry. Nico served as a guide or facilitator. More importantly, teacher Nico introduced learners in different ideas in order to help and guide them while they make sense of the new information. This research reveals that in teacher Nico's lessons, learners take an active participation by carrying out and interacting with IBL activities in small groups, discussing the observed parts, relating them to real-life experiences, and then answering problem-solving questions independently.

4.7 CASE THREE: ALFRED

4.7.1 Teachers understanding of IBL

4.7.1.1 The definition of IBL

IBL is a learning method that engages learners in activities that make sense to them rather than providing learners with an easy path to the solution (Love et al., 2015). Teachers need to demonstrate an understanding of IBL as a teaching strategy and as a concept along with its features to successfully implement IBL activities. During the interview, Alfred was asked to define IBL and he responded as follows:

> *“According to my own understanding, inquiry-based learning focuses on teaching and learning of learners. Learners are active participants. The teacher is a facilitator. In summary, it ensures that learners are active participants in learning not just taking instructions from the teacher. They are taking a huge role in their learning.”*

Alfred's response revealed that she fully understand what IBL is as he defined IBL by listing some of the features or characteristics of IBL particularly roles of learner's as being active participant and the teacher as a facilitator.

4.7.1.2 The characteristics of IBL

IBL as a teaching method has important characteristics that form part of its basis. These characteristics are a weighing scale that can be used to determine if IBL is properly implemented (Love et al., 2015) . Cotton (1995) argues that unlike some teaching strategies, IBL has a specific set of features or characteristics that must be adhered to ensure successful implementation. Alfred also failed to provide background knowledge of the task. this is another characteristic of inquiry based learning; this was evident from the lessons observed:

Alfred: we want to demonstrate that if there is a presence of starch that means photosynthesis yenzekile ***(has happened).*** *we are having the following apparatus and chemicals, the glass beaker, the test-tube, the Bunsen burner, the test-tube holder, the petri-dish, the dropper and the forceps. We need to check the method, number 1 bathe* ***(they said)*** *we must de-starch the plant by placing it in a dark cupboard for 48 hours.*

The observation indicates that after mentioning the aims and expected outcome of the experiment Alfred immediately proceeds to the experiment by immediately focusing on what they will be working on instead of using the opportunity to identify and provide background knowledge. Our teacher Alfred demonstrated an understanding of what IBL is in the interview. However, his implementation of IBL in the observed lessons was in contrast to his understanding. Alfred put no effort in trying to form connection between the experiment as well as the real world, connection from an important part of IBL and it even assists in identifying a learner's prior knowledge which is another important characteristic of IBL.

According to Ramnarain (2016), exploration and examination are more of the characteristics of IBL, as the teacher is expected to ensure that learners deepen their knowledge and utilise their critical thinking skills by looking and examining different information during the activity. The observation revealed that Alfred missed the opportunity to deepen the learner's understanding by asking relevant questions. This was evident from the observation of Alfred and the learners as:

Alfred: Come Dlamini and Shongwe (pseudonyms). Let's go to the methods. We need to feel the texture before and after boiling.
The teacher and the two learners they were distributing the leaves to the other learners to feel the texture of the leaf.
Alfred: after boiling sizonika oyi one ***(after boiling we will give one).***
The teacher was showing them how to feel the texture by rubbing the leaf between the fingers.
Learners: They were also doing the same. Feeling the texture.

Alfred: Dlamini (pseudonym) put the leaf. Who will be our time keep? We must boil for one minute.

Zinhle: Me

The observation reveals that Alfred made no attempt in coming up with questions to deepen the learner's understanding and encourage critical thinking. For instance, after feeling the leaf, he could have encouraged the learners to describe the texture of the leaf. He also should have asked the learners what they think is the reason they have to boil the leaf. Based on the observed learners, I can deduce that Alfred did not understand the characteristics of IBL even though in the interview he defined IBL correctly, but implementation shows lack of comprehension.

4.7.1.3 The stages of IBL

According to Ramnarain (2015), IBL has features but also important stages that a teacher is expected to go through to successfully implement IBL. The first stage of IBL is developing a question; this is meant to ensure that the activity has substance and works towards a certain outcome based on the question. Alfred was unable to formulate a question before beginning the IBL activity but instead she outlined aims to achieve instead of coming up with guiding question. This was seen in the observed lesson as follows:

Alfred: Today we are learning real science. Okay let us look on the activity. When you look on the aim, the aim is to investigate that starch is produced in the green part in a variegated leaf during photosynthesis.

The teacher was reading from the activity that he distributed to the learners.

The observation indicates that Alfred did not do well when it comes to the stages of IBL,. She focused more on the aims of the task than formulating questions that were going to guide the learners' towards the aims. The second stage of IBL requires the teacher to assist the learners in formulating a hypothesis with regards to the activity. Teacher Alfred was unable to assist learners with the formulation of the hypothesis, but he focused on making sure that the learners understand the purpose of the task. From there on, she moved the lesson towards the experiment without having formulated a hypothesis. This was evident from the observation as follows:

Alfred: This is our test-tube sizoyifaka la ***(we will put it here)****; putting the test-tube in the beaker. Then we need to observe the colour change. So, le practical lena kumele yeziwe nguwe as a learner* ***(this practical must be done by you as a learner).*** *So we will assist each other so that all here we will be hands-on.*

The observation shows that upon stating the aims of the experiment Alfred then proceeded to handing out the instructions on how to do the experiment. By doing so Alfred skipped one of the stages of IBL meant to assist her in successfully implementing IBL which was assisting learners in formulating the hypothesis for the activity. However, there are stages of IBL that Alfred was able to implement during his lessons particularly when it comes to collecting and recording data. This was proven when Alfred interacted with the learners as follows:

Alfred: As we are still waiting for the leaf, let us look on the activity. Let's look on observation one, the texture of the leaf before boiling. Uyizwe injani? ***(How did you feel it?)***

Sizwe: Rough

Alfred: Write your observation. After boiling we will give it to one and will tell us the texture. What is the colour of the alcohol after boiling?

In the observation, it was noted that Alfred encouraged learners to record their observations. I can deduce that Alfred went through this stage successfully because firstly he asked all learners to write down their observations. Secondly, he did not try to influence the learner's observation instead he allowed them to write based on their different perspective. According to Cotton (1995), learners must be able to collect, record data, analyse and able to communicate the findings during a practical experiment. It was noted during the observation that Alfred was able to guide the learners through the activity but left out an important step of analysing the data. This was observed as follows:

Alfred: Okay let us finish all the questions and submit.

All learners: They were answering the questions.

The observation shows that Alfred was unable to allocate time for learners to go through the data and analyse it before making them answer the activity questions. The above observation also indicates that Alfred deprived learners the opportunity to communicate their ideas regarding what they had observed during the IBL activity. Table 4.8 summarises Alfred's understanding of IBL.

Table 4.8: *Summary of teachers understanding of IBL*

The definition of IBL	Susan successfully defined IBL correctly.
The characteristics of IBL	She meets some of the characteristics of IBL.
The stages of IBL	Did not go through all the stages of IBL.

4.7.2 The implementation of IBL activities

4.7.2.1 The implementation process of IBL

The importance of IBL and teaching has been recognised in studies across the world (Potvin, 2014). However, each study emphasised and echoed the calls for science educators to implement IBL. However, implementation has various processes that must be followed for it to be successful. Homer (2015) argues that in an IBL classroom the learners use prior knowledge to engage in learning. This is the reason why it is important that educators identify and activate the learners' prior knowledge. Based on the implementation of IBL in Life Sciences, Alfred said:

> *"My thoughts are that for effective teaching and for learners to enjoy and capture or master the content easy. Life Sciences should be taught using partial inquiry-based learning because since learners are active participants, they will bring their own experience and combine it with the content that is taught in the classroom. Life Sciences will be enjoyable if inquiry-based learning is used."*

From the above extract, one could tell that Alfred understood the importance of learners being active during an IBL lesson. However, his observation reveals that he was not well informed about the implementation of IBL as he did the following:

> *Alfred: This is our test-tube sizoyifaka la* ***(we will put it here)****; putting the test-tube in the beaker. Then we need to observe the colour change. So le practical lena kumele yeziwe nguwe as a learner* ***(this practical must be done by you as a learner).*** *So we will assist each other so that all here we will be hands-on.*

The observation reveals that Alfred did not spend any of his time to identify prior knowledge and activate it. Instead Alfred focused more on making sure that the learners understand what was in front of them. Potvin (2014) emphasises ensuring that the learners are taking initiative during an IBL lesson; this is an important step of implementation of IBL. The teachers are expected to allow the learners to implement the activity with minimal interference from the teacher whose role is solely to facilitate. When it comes to our subject Alfred, firstly it was noted that his learners were not divided into groups as required by the IBL approach instead the learners were seated in pairs. However, this could be attributed to the fact he did indicate during his interview that resources are limited. Secondly, he selected two learners to head up the activity while the others observe. This is what happened:

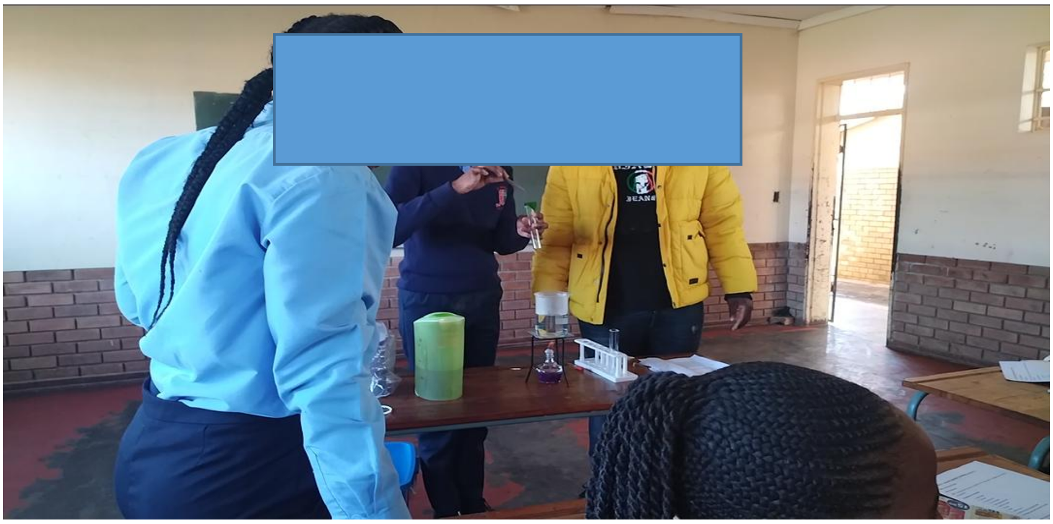
> *Alfred: Ngubani ofuna siyenze Nate (Who wants to do it with me?)*
>
> *Learners: They were raising hands so that the teacher will pick.*
>
> *Alfred: Come Dlamini and Shongwe (pseudonyms). Let's go to the methods. We need to feel the texture before and after boiling.*
>
> *The teacher and the two learners they were distributing the leaves to the other learners to feel the texture of the leaf.*

The above observation reveals that Alfred opted to have two learners to experiment do the activity. However, it is important to note that instead of giving the learners the liberty to do the activity on their own, she chose to do the activity with the learners. Moreover, Homer (2015) argues that in IBL the teacher's role is to facilitate and initiate group learning. This means that unlike the direct teaching approach, IBL puts the teacher in the background and the learners under the spotlight. For instance:

Alfred: Dlamini (pseudonym) put the leaf. Who will be our time keep? We must boil for one minute.
Zinhle: Me

Figure 4.5 depicts the learners carrying out the IBL activity.

Figure 4.5: *The learners carrying out the IBL activity*



Alfred: we are now putting the ethanol/alcohol. How much it suppose to be?

Figure 4.6 depicts teacher Alfred demonstrating to the learners.

Figure 4.6: *Teacher Alfred demonstrating to the learners*

The observations provide important information regarding Alfred and the role he played during the lesson which was to facilitate. During the interview, Alfred was asked to define IBL and she said:

> *"According to my own understanding inquiry-based learning, it focuses on teaching and learning of learners. Learners are active participants. The teacher is a facilitator. In summary, it ensures that learners are active participants in learning not just taking instructions from the teacher. They are taking a huge role in their learning."*

From the definition, Alfred stresses that in IBL the learners are active participants and the teacher facilitate. However, the previous observations show that Alfred was taking part during the activity instead of facilitating. Alfred had the option to provide guidance and supervision as the learners conduct the activity but instead opted to do the activity alongside the two learners he initially selected.

4.7.2.2 The benefits of implementation

According to Homer (2015), IBL has various benefits for both educators and learners. the development of conceptual understanding is one of the benefits of IBL. The argument is that if IBL is properly implemented, it makes it easier for scientific concepts to be understood by the learners. Teacher Alfred unfortunately was unable to develop conceptual understanding among the learners as he skipped some stages of IBL during the implementation process.

During the observation, no attempt was made to go through scientific concepts while in the interview he said:

> *"The benefits are very vast, number one we are building an independent learner. Learners are able to think on their own. Learners will be able to gain knowledge. It builds self-confidence and allows learners to think outside the box."*

The explanation from the interview shows that Alfred did not consider the development of conceptual understanding. However, Alfred recognises the development of higher order thinking skills as some of the benefits of IBL. This was evident in the interview when asked about the benefits of IBL. He argued that IBL creates an independent individual capable of thinking outside the box. This response is important because it reveals that Alfred knew the aim of IBL which includes the development of critical thinking skills. Moreover, Alfred also acknowledged the fact that IBL does not only help in the learners' development of critical thinking skills but also provides the learner with information that boosts their self-confidence. This is important because Alfred was revealing an unexplored benefit which is confidence. IBL enables the learners to independently think and gain understanding which result in a more confident learner in Life Sciences.

4.7.2.3 The implementation issues

The CAPS policy document calls for the use of IBL as a teaching strategy for Life Science educators in South Africa. The policy itself is structured to accommodate IBL (DBE, 2011). Alfred like many other teachers does not fully comprehend reasons why the CAPS document calls for IBL, when asked if he was aware of the fact that CAPS advocates the use of IBL he said:

> ***"****It requires us to perform, and it allows teachers to perform experiments. It also want us to assess learners using the practical activities in order to meet the demands of the cognitive levels."*

The explanation shows that Alfred does not understand the CAPS policy in the context of IBL. Alfred generalised what the CAPS document requires. I can deduce that there exists a lack of philosophy of the nature of scientific inquiry in

Life Sciences policies because if that was not the case Alfred would have been aware of what exactly the policy advocates for in the teaching of Life Sciences. Moreover, a teacher's lack of content knowledge is another issue that makes educators stray away from using IBL as part of the teaching strategies. To successfully implement IBL, the teacher must have enough content knowledge and possess the ability to link content with IBL as the teaching strategy. Alfred does understand what is IBL but during the interview he responded as follows with regards to the implementation issues:

> *"Research, as a teacher you must do research to gain knowledge before the lesson, so our school does not have the resources to do the research which limits the knowledge of the teacher. A teacher must have more knowledge. Inquiry-based learning activities need more time. Our annual teaching plan (ATP) is long; so, if you can use IBL you will not finish teaching the content. Our classrooms are overcrowded and IBL needs learners to explore the resources. So, in our situation it is difficult to implement IBL activities with the limited resources that we have. Our learners lack prior knowledge which makes it difficult to teach using IBL."*

The response from Alfred acknowledges that content knowledge is a huge issue when it comes to implementation of IBL. Moreover, teacher Alfred also revealed that the shortage of resources as another factor that affects the implementation of IBL, and this was also evident from the observation as:

Figure 4.7 indicates that teacher Alfred and the learners during the IBL activity.

Figure 4.7:*Teacher Alfred and the learners during the IBL activity.*

The above observation shows that the were no groups formed due to the shortage of resources. Teacher Alfred decided to choose two learners so that they will do the experiment with him while the rest of the class observing and participating in discussions.

Table 4.9 summarises Alfred's implementation of IBL activities.

Table 4.9: *The implementation of IBL activities*

The implementation process of IBL	Understood the importance of learners being active during an IBL but he was not well informed about the implementation of IBL. Did not spend any of his time to identify prior knowledge. Alfred was taking part during the activity instead of facilitating.
The benefits of implementation	Unable to develop conceptual understanding amongst the learners as she skipped some stages of IBL during the implementation process. Recognises the development of higher order

	thinking skills as some of the benefits of IBL.
The implementation issues	Acknowledges that content knowledge is a huge issue when it comes to implementation of IBL. Indicates that the shortage of resources is an issue when implementing IBL.

4.7.3 Teachers practice of IBL

4.7.3.1 Teaching methods or approach

Teachers usually impart knowledge in the same manner in which they were taught (Habteselassie, 2015). Despite the fact that lecturing is not the best teaching style for their learners, they frequently use it to teach their learners (McDermott et al., 2000). Moreover, if they experienced inquiry-based science in their secondary schools and undergraduate programmes, teachers are more likely to use inquiry-based teaching in their classrooms. According to Brown and Melear's (2006), for teachers to change their teaching practices, they should have experienced an authentic, inquiry-based science classroom. As studies show, most teachers choose to use the traditional method of teaching (Bass, 2009). The teacher-centred way of teaching disconnects science from the lives of the learners (Habteselassie, 2015). In the teacher-centred approach, learners are not expected to know the processes but only know the scientific findings. During the interview with teacher Alfred, he indicated the following with regards to the practice and teaching strategies:

> *"I don't have a direct strategy, but I use a teaching strategy based on the lesson demands and focusing on the learners needs. I use direct teaching when introducing a lesson but mostly I use a learner-centred approach."*

From the explanation, teacher Alfred indicated that he used a teaching strategy that will assist the learners in terms of knowledge development. In addition, he also indicated that in a single lesson he can use more than one teaching method depending on the demands of the learners. However, the observed lessons indicated that teacher Alfred was not practising the learner-centred approach as indicated in the interview as he do the following:

Alfred: Today we are learning real science. Okay let us look on the activity. When you look on the aim, the aim is to investigate that starch is produced in the green part in a variegated leaf during photosynthesis.

The teacher was reading from the activity that he distributed to the learners.

Alfred: we want to demonstrate that if there is a presence of starch that means photosynthesis yenzekile ***(has happened).*** *we are having the following apparatus and chemicals, the glass beaker, the test-tube, the Bunsen burner, the test-tube holder, the petri-dish, the dropper and the forceps. We need to check the method, number 1 bathe* ***(they said)*** *we must de-starch the plant by placing it in a dark cupboard for 48 hours. Then expose the plant to sunlight for few hours. Then pick a leaf that has been exposed to sunlight. So we are having our leaves here, even though it was not de-starched. Number 4 then boil the leaf in water for about one minute. You remove the leaf then you put it in a test-tube. Number 5 pour the ethanol/alcohol in the test-tube to cover the leaf. Careful put the test-tube in the boiling water and allows it to boil for few minutes. This is our glass beaker niyayibona angithi?* ***(Do you see it right?)***

All learners: Yes

The observation shows that teacher Alfred was using lecturing method as he was introducing the lesson. According to Van Rooyen (2006), there is evidence that effective teachers are those who can develop flexibility of approach and warmth towards their learners. It was also noted that teacher Alfred apart from the lecturing method he also use discussion. This was observed as Alfred was interacting with the learners as follows:

Alfred: Now we are in number 9. Spread the leaf in the petri-dish. We are going to add the iodine solution and allow it to stay for few minutes and observe the colour change. And, also in number 2, you must bear in mind that you have to draw the leaf before and after the investigation. Senze how many drops? ***(How many drops we can add?)***

Zama (pseudonym): Three

Teacher: What is the colour change?

Zwandi (pseudonym): Brown

Alfred: What is that means?

All learners: No starch present.

Alfred: Okay, let us finish all the questions and submit.

The observation indicates that teacher Alfred practised more than one method of teaching as he explained in the interview. I can deduce that Alfred practised lecturing and discussion method during the implementation of the IBL activity.

4.7.3.2 The type of inquiry applied

According to Keller (2001), a teacher determines and offers everything in structured inquiry, from the question to the research methods, from answering the questions to the method itself. Based on the observed lesson Alfred did the following:

The learners were sitting in pairs in the classroom. There were four rows in total with 23 learners in the classroom. The teacher enters the class with a box. He opens the box and take out the material which he was going to use. He then asked one learner to go and get boiling water in the staff room. The learner went out. He distributed the hand-out with the learning activity.

Alfred: Now we are in number 9. Spread the leaf in the petri-dish. We are going to add the iodine solution and allow it to stay for few minutes and observe the colour change. And also in number 2 you must bear in mind that you have to draw the leaf before and after the investigation.

The observation also shows that teacher Alfred was practising structured inquiry. This type of inquiry is not allowing learners to think when inquiring. Learners are not mentally active and may become demotivated during the process (Keller, 2001).

Table 4.10 summarises Alfred's practice of IBL.

Table 4.10: *Teachers practice of IBL*

Teaching method or approach	Practised lecturing and discussion method.

The type of inquiry applied	Alfred was practising structured inquiry.

4.8 FINDINGS

4.8.1 Teachers understanding of IBL

The study discovered that Alfred fully understand what IBL is as he defined IBL by listing some of the features or characteristics of IBL, particularly roles of learners as being active participants and the teacher as a facilitator. Our teacher Alfred demonstrated an understanding of what IBL is in the interview. However, his implementation of IBL in the observed lessons was in contrast to his understanding. The observation revealed that Alfred missed the opportunity to deepen the learners' understanding by asking relevant questions. Moreover, Alfred made no attempt in coming up with questions to deepen the learners' understanding and encourage critical thinking. For instance, after feeling the leaf he could have encouraged the learners to describe the texture of the leaf. He also should have asked the learners what they think is the reason they have to boil the leaf. Based on the observed lessons, I can say Alfred had no understanding of the characteristics of IBL even though in the interview he defined IBL correctly but implementation shows lack of comprehension. Alfred was unable to formulate a question before beginning the IBL activity but instead she outlined aims to achieve instead of coming up with guiding question.

This study discovered that Alfred did not do well when it comes to the stages of IBL. She focused more on the aims of the task than formulate questions that were going to guide the learners towards the aims. Teacher Alfred was unable to assist learners with the formulation of the hypothesis, but he focused on making sure that the learners understand the purpose of the task. From there on, he moved the lesson towards the experiment without having formulated a hypothesis. Teacher Alfred encouraged learners to record their observations. Alfred went through this stage successfully because firstly he asked all learners to write down their observations. Secondly, he did not try to influence the learners' observation instead he allowed them to write based on their different perspective. Alfred was unable to allocate time for learners to go through the data and analyse it before making them answer the activity questions. Alfred deprived learners the opportunity to communicate their ideas regarding what they had observed during the IBL activity.

4.8.2 The implementation of IBL activities

This study discovered that Alfred understood the importance of learners being active during an IBL lesson. However, his observation reveals that he was not well informed about the implementation of IBL. The observation revealed that Alfred did not spend time in assisting learners in identifying prior knowledge and activate it, instead Alfred focused more on ensuring that the learners understand what was in front of them. Alfred was taking part during the activity instead of facilitating. Alfred had the option to provide guidance and supervision as the learners conducted the activity but instead opted to do the activity alongside the two learners he initially selected.

This study discovered that teacher Alfred unfortunately was unable to develop conceptual understanding among the learners as he skipped some stages of IBL during the implementation process. Alfred like many other teachers does not fully comprehend reasons why the CAPS document calls for IBL, the interview response showed that Alfred does not understand the CAPS policy in the context of IBL. It has been discovered that there existed a lack of philosophy of the nature of scientific inquiry in Life Sciences policies because if that was not the case Alfred would have been aware of what exactly the policy advocates for in the teaching of Life Sciences. Alfred acknowledged that content knowledge is a huge issue when it comes to implementation of IBL. Moreover, teacher Alfred also revealed that the shortage of resources is another factor that affects the implementation of IBL.

4.8.3 Teachers practice of IBL

Teacher Alfred indicated that he used a teaching strategy that can assist the learners in terms of knowledge development. In addition, he also indicated that in a single lesson he can use more than one teaching method depending on the demands of the learners. This study discovered that teacher Alfred was using lecturing method as he was introducing the lesson. It was also noted that teacher Alfred, he also use discussion as apart of the lecturing method.

This study discovered that teacher Alfred was practising structured inquiry. Alfred determines and provides everything, from the question to the research methods, from answering the questions to the method itself. Moreover, teacher Alfred was not allowing learners to think when inquiring. The learners were not mentally active and become demotivated during the process.

4.9 CONCLUSION

This chapter was based on the presentation, discussion and findings of the data that was collected from the three Life Sciences teacher from different schools. The interview was the initial phase of the data collection where each teacher was to answer the 12 questions structured from the literature review and the theoretical framework. The second phase of the data collection was through observation where in the initial plan was to have three observations per participant but owing to the reasons, postponement and time. Only two observations were done per participant. The findings of the three participants was done through the establishment of three themes from the research questions. The next chapter will focus on the summary of the findings, limitations of the study, recommendations and conclusion.

CHAPTER 5:

SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents an overview of the study, including a summary of the study findings based on the three teachers, the study contribution, the study limitations, and the study recommendations.

5.2 RESEARCH QUESTIONS

The study aim was to explore the contribution of IBL activities to the development of teachers' teaching strategies in Grade 11 Life Sciences. The contribution of IBL was determined by answering three sub-questions, which are as follows:

- What understanding do teachers have about the implementation of inquiry-based learning activities?
- How do teachers implement inquiry-based learning activities to improve their teaching strategies in Life Sciences?
- How do teachers' inquiry-based learning practices develop as a result of the implementation of inquiry-based learning?

This research was informed by one main research question:

- What contribution do IBL activities bring to the development of teachers' teaching strategies in Life Sciences classrooms?

This main question was addressed by the study findings, which addressed the three sub-questions. The study findings are summarised in the form of responses to the research sub-questions, which are expressed as themes.
The following are the answers for each research question presented per case.

5.2.1 What understanding do teachers have about the implementation of IBL activities?

CASE 1: LIZZY

The research revealed that Lizzy was able to define IBL, which she defined as a teaching and learning method and an approach to learning that encourages learners to engage in problem-solving and experiential learning. Furthermore, among all the three teachers, Lizzy showed a better understanding of IBL. This is because Lizzy's definition was also supported by IBL characteristics, which include engaging learners in the scientific world, establishing and developing background knowledge and deepening learners' knowledge to frame a deep question that directs their inquiry. The findings also revealed that Lizzy had some understanding of her role as a teacher during an IBL lesson, as she only mentioned facilitating the teaching and learning. In addition to the definition and characteristics mentioned, Lizzy demonstrated understanding of the stages of IBL by assisting learners in developing generating hypotheses, investigative questions, collecting and recording data, analysing data, developing an experiment design, and reaching a conclusion.

CASE 2: NICO

This research discovered that Nico was able to define IBL as a learning approach that enables learners to be active throughout the learning process and as a process that is rooted in the rapid development of scientific knowledge. However, Nico demonstrated a better understanding of IBL than Alfred, as he explained that IBL is an approach to teaching that makes learners gain the required skills to become free individuals and life-long learners. Nico was also able to characterise IBL as a teaching method that assists during experiment investigations in Life Sciences and assists learners in creating investigative questions. Even though Nico was able to characterise IBL, the characteristics that he mentioned were not the same as those of Lizzy. Nico only characterised IBL as the method that assists learners in creating investigative questions while Lizzy characterised IBL as the learning that engages learners in the scientific world, establishing and developing background knowledge and deepening learners' knowledge to frame a deep question that directs their inquiry. This research also discovered that Nico had some understanding of the characteristics of IBL. However, Nico was unable to ensure that all the stages of IBL were implemented as well as Lizzy did. Lizzy was able to manage to assist learners in developing investigative questions, generating hypothesis, developing an experiment design, collecting and recording data, analysing data, and reaching a conclusion, but Nico only managed to assist learners in generating a hypothesis and reaching a conclusion.

CASE 3: ALFRED

The study discovered that Alfred was able to define IBL as a learning strategy that ensures that learners are active participants, not just taking instructions from the teacher. Alfred's definition was not as specific as those of Lizzy and Nico. Alfred only mentioned IBL as the type of learning that ensures that learners are active participants while Lizzy indicated that it is a teaching and learning method and an approach to learning that encourages learners to engage in problem-solving and experimental learning. Nico, on the other hand, mentioned that it is a learning approach that enables learners to be active throughout the learning process and is rooted in the rapid development of scientific knowledge. In contrast to Nico and Lizzy, Alfred did not show an understanding of the characteristics of IBL. However, Alfred made no attempt in coming up with questions to deepen the learners' understanding, encourage critical thinking, or form a connection between the experiment and the real world.

This research discovered that Alfred did not do as well when it came to the stages of IBL as Lizzy did. Alfred focused more on the aims of the task than assisting learners in formulating questions that were going to guide the learners towards the aims while Lizzy managed to assist learners in developing investigative questions, generating hypotheses, developing an experiment design, collecting and recording data, analysing data, and reaching a conclusion. Teacher Alfred was unable to assist learners with the formulation of the hypothesis, but he focused on ensuring that the learners understood the purpose of the task. From there on, he moved the lesson towards the experiment without having formulated a hypothesis. Even though Alfred showed a lack of understanding of the stages of IBL, his understanding was better than that of Nico, as Alfred managed to encourage learners to record their observations, write down their observations, and not influence the learners' observations. Instead, he allowed them to write based on their different perspectives. However, Alfred was unable to allocate time for learners to go through the data and analyse it before making them answer the activity questions. Alfred deprived learners of the opportunity to communicate their ideas regarding what they had observed during the IBL activity.

5.2.2 How do teachers implement inquiry-based learning activities to improve their teaching strategies in Life Sciences?

CASE 1: LIZZY

This research discovered that Lizzy did not fully implement IBL as she was unable to identify learners' prior knowledge before the introduction of the new knowledge. The identification of prior knowledge was going to assist in the activation of learners' understanding of the new concept. However, teacher Lizzy was able to provide learners with the opportunity to conduct the IBL activity, even though the groups that she formed were too big to allow all the learners to interact with the apparatus, but the learners were all involved in the IBL activity. More importantly, Lizzy was able to facilitate the lessons as she was moving in all three groups and assisted the learners in the development of their own learning by asking questions. During the implementation of the activity, Lizzy was asking the learners questions, which assisted in the development of conceptual understanding. However, the questions that Lizzy asked were unable to develop higher-order thinking skills, such as synthesis and critical thinking, but they were able to develop analysis and evaluation. The study also discovered that there were challenges during Lizzy's implementation of the activities, which included a lack of resources in the school, a lack of teacher professional development, overcrowding, and learners who were less motivated to participate in the IBL activity because they lacked the necessary knowledge and abilities.

CASE 2: NICO

This research discovered that Nico was better than Lizzy and Alfred in terms of the implementation of IBL. Nico was facilitating through questioning, explaining and elaborating on the learners' responses while Lizzy was only asking questions but not elaborating on the learners' responses, and Alfred was taking part in the activity instead of facilitating it. Nico was aware of his role in an IBL classroom as he was facilitating the group work and allowing the learners the opportunity to conduct the IBL activity. Nico's implementation process was guided by the teacher's roles in an IBL classroom. Nico exposed learners to the IBL activity, which developed problem-solving skills and developed learners' higher-order thinking skills such as analysis and evaluation, whereas Lizzy's implementation was unable to develop higher-order thinking skills, such as synthesis and critical thinking, but they were able to develop analysis and evaluation. This study discovered that Nico had challenges that affected the implementation, which included the shortage of internet connectivity and textbooks for the learners. The challenges that Nico had were not as many as those of Lizzy, which were a lack of resources in the school, a lack of teacher professional development, overcrowding, and learners who were less motivated to participate in the IBL activity because they lacked the necessary knowledge and abilities. However, some of the challenges that Nico, Lizzy and Alfred had were common, among them being the lack of resources.

CASE 3: ALFRED

This research discovered that Alfred was unable to implement the IBL activity. However, Alfred understood the importance of learners being active during an IBL activity, but he was unable to spend time identifying learners' prior knowledge and also activating it. Alfred focused more on ensuring that the learners understood what was in front of them through explanation. Alfred was taking part in the activity instead of facilitating, unlike Nico, who was facilitating through questioning, explaining and elaborating on the learners' responses. Alfred had the option to provide guidance and supervision as the learners conducted the activity, but instead opted to do the activity alongside the two learners he initially selected. The study discovered that teacher Alfred was unfortunately unable to develop conceptual understanding among the learners as he skipped some stages of IBL during the implementation process. However, Alfred acknowledged that content knowledge is a huge issue when it comes to the implementation of IBL. Moreover, teacher Alfred also revealed that the shortage of resources was another factor that affected his implementation of IBL.

5.2.3 How do teachers' inquiry-based learning practices develop as a result of the implementation of inquiry-based learning?

CASE 1: LIZZY

The study discovered that Lizzy was practising guided inquiry as she stated the aim of the experiment and guided learners in choosing the material in response to the aim of the experiment. Lizzy helped the learners to become responsible for their actions and learning by asking questions, which was to get more from them. The learners investigated the given questions, creating solutions and making generalisations. The learners gained inquiry skills for the inquiries that they will make independently. The study also discovered that teacher Lizzy was practising demonstration and discussion as teaching methods. Lizzy showed the learners how to do the experiment and explained the step-by-step process. The learners received immediate feedback on their products during the experiment, which also gave the learners a real-life situation on how to use tools and materials.

CASE 2: NICO

This research discovered that Nico was practising IBL in his classroom. Teacher Nico was not the one who was doing the experiment, but the learner through his guidance. Teacher Nico's teaching and learning methods included demonstration and discussion. Nico's teaching methods were designed to encourage active, motivated learning, problem-solving abilities, and extensive field knowledge based on conceptual comprehension. Nico, the teacher, was practising guided inquiry. Unlike Lizzy and Alfred, Nico was a facilitator of learning who introduced new ideas to learners to support and guide them as they made sense of the new information. This research also found that teacher Nico's learners participated actively in the activities by carrying out and engaging in the IBL activities in small groups, discussing the observed parts, connecting them to real-life situations, and answering the problem-solving questions individually.

CASE 3: ALFRED

This research discovered that teacher Alfred was practising structured inquiry. Alfred determined and provided everything, from the question to the research methods, from answering the questions to the method itself. Moreover, teacher Alfred was not allowing learners to think when inquiring. Consequently, learners were not mentally active and became demotivated during the process. The study discovered that teacher Alfred used the lecturing method as he was introducing the lessons. It was also noted that teacher Alfred, apart from the lecturing method, also used discussion.

5.3 CONTRIBUTION OF THE STUDY

This research contributes to the body of knowledge on the use of IBL to increase teachers' knowledge and skills, as well as inquiry practices in the Life Sciences classroom. The study findings reveal that teachers were able to define IBL, indicating that they had a thorough comprehension of what IBL includes. However, the teachers' comprehension aided them in lesson planning and in directing them to use well-crafted problems and questioning approaches to bring learners through an IBL process.

The findings also show how IBL is practised as an instructional strategy and strengthen other findings that IBL is rarely practised. However, this was supported by the fact that one participant managed to implement IBL while the other two participants had challenges with the implementation. Therefore, the findings of this research gave a clear picture of the limited IBL practices in the classroom and the poor understanding of teaching Life Sciences through IBL among the curriculum developers who have called for the implementation of IBL since 1998. Since the whole reform idea was centred on teachers, it is important to see the teachers’ readiness for change in the way that they teach Life Sciences through IBL.

The intervention indicated difficulties in implementing IBL. To begin with, time constraints continue to be an issue. As a result, more time is required to allow learners to learn at their own pace. Discussions should be provided adequate time to enable teachers to understand what their learners are thinking and help them step by step toward self-directed learning. Second, IBL learning requires resources and facilitator inventiveness. However, the intervention found that a lack of resources in schools was another barrier to IBL implementation.

These research contributions suggest to teachers how to implement IBL and to universities how to develop their teacher development programmes. This research demonstrates that inquiry-based methods are linked to the development of abilities like problem-solving. The IBL exercises implemented by the teachers, in my opinion, served as an eye-opener for the teachers, as they learned that IBL could be used to develop their teaching strategies in the classroom. The research findings can be used to influence future research in areas such as IBL, problem-solving, project-based learning, and the use of IBL to increase teachers' content understanding in the Life Sciences.

5.4 LIMITATIONS OF THE STUDY

This research only included a small number of Life Sciences teachers from the Gert Sibande District. Implementation in diverse environmental conditions may not yield exactly the same results since issues such as resource constraints may be minor. The study conclusions may not be applicable to all Life Sciences teachers in South Africa. Therefore, the goal was not to generalise the findings but to gain a better understanding of the situation in a specific scenario.

5.5 RECOMMENDATIONS OF THE STUDY

- To encourage Life Sciences teachers to use IBL in their classrooms, the DBE must work with schools and subject advisers. Subject advisers, on the other hand, should organise and encourage Life Sciences teachers to participate in professional development activities geared toward organising IBL in order to enhance their abilities and strategies.

- It is believed that the outcomes of this research would enable policymakers and Life Sciences teachers in maximising the adoption of IBL rather than implementing it to meet the requirements of the DBE's NCS.
- From the observations, the inquiry-based practices that occurred in this research were the results of the teachers' personal efforts to teach Life Sciences in the best way possible, not necessarily that they were trained to teach inquiry. I therefore suggest that teacher training institutions train Life Sciences teachers on how to implement IBL in their classrooms.
- Teachers practice some aspects of IBL without knowing that they are even practising it. Therefore, it is important that the schools ensure that teachers get trained on how to teach Life Sciences through IBL.

5.6 CONCLUSION

The findings are summarised in this chapter. Before presenting the study contributions and limitations, the research questions were also addressed. Finally, the study recommended additional research and suggestions to the Department of Education. This research shows that teachers had an adequate understanding of IBL but were unable to fully implement it in their classrooms. Two participants practised a teacher-centred approach to teaching in which their focus was on teaching scientific facts rather than processes. The teachers showed positive efforts towards inquiry teaching since two of the participants were practising guided inquiry. However, these positive efforts in the classroom should be supported by all parties to ensure the successful implementation of IBL in Life Sciences.

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APPENDIX A: PROOF OF REGISTRATION

UNISA university of south africa

0920 MIRST

MLIPHA N D MR
P O BOX 2143
PIET RETIEF
2380

STUDENT NUMBER : 5684-549-9

ENQUIRIES NAME : M&D ADMIN SUPPORT
ENQUIRIES TEL : (012) 441-5702

DATE : 2022-03-01

Dear Student

I wish to inform you that your registration has been accepted for the academic year indicated below. Kindly activate your Unisa mylife (https://myunisa.ac.za/portal) account for future communication purposes and access to research resources.

DEGREE :	MED (CURRICULUM STUDIES) (98434)
TITLE :	Teacher's implementation of inquiry-based learning activities in Life Science classroom
SUPERVISOR :	Mrs MM RAMULUMO (ramulmm@unisa.ac.za)
CO-SUPERVISOR :	Prof AV MUDAU (mudauav@unisa.ac.za)
ACADEMIC YEAR :	2022
TYPE:	DISSERTATION
SUBJECTS REGISTERED:	DFDID95 MEd - Didactics

A statement of account will be sent to you shortly.

You must re-register online and pay every academic year until such time that you can submit your dissertation/thesis for examination.

If you intend submitting your dissertation/thesis for examination you have to submit an Intention to submit form (available on the website www.unisa.ac.za) at least two months before the date of submission. If submission takes place after 15 November, but before the end of January of the following year, you do need not to re-register and pay registration fees for the next academic year. Should you submit after the end of January, you must formally reregister online and pay the full fees.

Please access the information with regard to your personal librarian on the following link:
https://bit.ly/3hxNqVr

Yours faithfully,

Prof M S Mothata
Registrar

UNIVERSITEIT VAN SUID-AFRIKA PRETORIA UNIVERSITY OF SOUTH AFRICA

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

APPENDIX B: INTERVIEW QUESTIONS

1. What do you understand about inquiry-based learning?
2. What are your thoughts and believes about teaching Life Sciences as inquiry?
3. Do you have experience in incorporating IBL in you lessons? If yes, how? If not, what prevents you from incorporating it?
4. What are the benefits of incorporating IBL?
5. What is your role as a teacher when implementing IBL activities?
6. What limiting factors do you face when implementing IBL activities?
7. Do you know that CAPS require IBL in Life Sciences? If yes, what CAPS says about IBL?
8. Do you think CAPS places an emphasis on IBL? Why?
9. As a Life Sciences teacher, which instructional strategy do you think is best when you teach Life Sciences in your classroom and why?
10. If limitation of resources was not a factor, which instructional strategies would be the best to use? Why?
11. Do you sometimes use inquiry as an instructional strategy in your classroom? And if yes how often? If not, what limits you from using it?
12. Do you think IBL activities have any contribution to the development of teaching strategies in Life Sciences? If yes, how? If not, why?

APPENDIX C: LESSON OBSERVATION

Source: Kavia (2013)

Title: Teacher's implementation of inquiry-based learning activities in Life Science classroom

TEACHER'S ACTIVITIES	YES/NO	NOTES/COMMENTS
Classroom environment		
Learners desks are arranged in pairs, in triples or quadruple groups.		
The class is a learning centre for individual or group studies.		
Teacher's desk is not located in the centre or in front of the classroom; it is rather located on one side or at the back of the classroom		
The teachers' role in the inquiry-based learning environment		

The teacher identifies learners prior knowledge and integrates it with the new one before the lesson starts		
Teacher instruct learners to explain or write the rationale for their hypothesis.		
The teacher activates learners so that they can develop a thorough understanding of science		
The teacher provides opportunities for learners to conduct the inquiry-based activity		
Teacher assists in the development of original learning by asking questions and facilitating the work with those questions.		
The teacher has the ability to find different techniques of asking questions		
The teacher takes up the role of a facilitator in inquiry-based learning environment		

Teacher initiates group activities		
The teacher shows respect to different learners and different types of learning styles		
The teacher ensures that the learners think further		
The teacher contributes to increasing scientific literacy among learners		
The teacher contributes to learners' existing knowledge and examines the changes in their understanding		
Teacher helps learners uncover their thoughts		
The teacher contributes to learners' development of critical thinking, scientific processing, problem solving and high level thinking skills		

APPENDIX D: INFORMED CONSENT LETTER TO THE CIRCUIT MANAGER

Cell: 072 826 0621

Email: 56845499@mylife.unisa.ac.za

The Circuit Manager
Mkhondo east circuit

Dear Sir/Madam

I am Ncamiso Derrick Mlipha currently doing a research entitled: Teacher's implementation of inquiry-based learning activities in Life Science classroom under the supervision of Ms M.M. Ramulumo, a lecturer at the University of South Africa College of Education in the Department of Science and Technology Education. I am currently doing Master of Education with specialisation in Curriculum studies at the University of South Africa. I am requesting your permission in a form of writing to conduct the research in some schools in your circuit. There are no incentives or remuneration for participating in the research.

The purpose of this research is to explore the contribution of inquiry-based learning (IBL) activities to the development of teachers' teaching strategies in Grade 11 Life Sciences classroom. The study investigate teacher's understanding about the implementation of IBL activities, explore how teachers implement IBL activities to improve their teaching strategies in Life Sciences classrooms and investigate how teachers knowledge develop as the result of implementation of IBL activities.

The study will provide information and encouragement to Life Sciences teachers, encouraging them to recognise the value of IBL in consolidating knowledge and fostering critical-thinking abilities. The findings will also assist the Department of Education work with school administrators, subject advisors, and provisional coordinators to encourage Life Sciences teachers to use IBL activities as a strategy to consolidate Life Sciences knowledge despite of the contextual factors. Furthermore, the findings may assist teachers in developing their teaching strategies in Life Sciences, which may help increase learners' interest and achievement in the subject. Finally, this research is vital in assisting teachers to understand what IBL is, how to implement IBL activities to improve their teaching strategies in Life Sciences and to develop teachers knowledge as a result of the implementation of IBL activities.

There are no known risks associated with this study, anonymity and confidentiality will be maintained by not disclosing the names of schools and participants. The data that will be collected from the participants will be kept confidential and will be strictly used for research purpose. Upon the completion of the qualification the participants will receive the summary of the findings for this study.

For more information with regard to this study contact me on: 0728260621 or email: 56845499@mylife.unisa.ac.za and my supervisor Mrs. M.M Ramulumo at email: ramulmm@unisa.ac.za.

Yours sincerely,

Ncamiso Mlipha

19 JULY 2022

Date

APPENDIX E: INFORMED CONSENT LETTER TO THE SCHOOL PRINCIPAL

Cell: 072 826 0621

Email: 56845499@mylife.unisa.ac.za

The Principal

Mkhondo east circuit

Dear Sir/Madam

I am Ncamiso Derrick Mlipha currently doing a research entitled: Teacher's implementation of inquiry-based learning (IBL) activities in Life Science classroom under the supervision of Ms M.M. Ramulumo, a lecturer at the University of South Africa College of Education in the Department of Science and Technology Education. I am currently doing Master of Education with specialisation in Curriculum studies at the University of South Africa. I am requesting your permission in a form of writing to conduct the research in some schools in your circuit. There are no incentives or remuneration for participating in the research.

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For more information with regard to this study contact me on: 0728260621 or email: 56845499@mylife.unisa.ac.za and my supervisor Mrs. M.M Ramulumo at email: ramulmm@unisa.ac.za.

Yours sincerely,

Ncamiso Mlipha

19 JULY 2022

Date

Cell: 072 826 0621

Email:

56845499@mylife.unisa.ac.za

Consent

In terms of the ethical requirements of the University of South Africa, you are now requested to complete the following section:

I, __________________________ (Principal) have read this letter and understand the terms involved.

On condition that the identity of my school and of the participating teachers and the information provided by the teachers are treated as confidential at all times, and that the participants will not be harmed in any way and there will be no risks involved in their participation, I hereby grant that Mr. N.D. Mlipha to conduct the research in my school.

Signature: ___________________

Date: _________________

Thank you for your time.

APPENDIX F: INFORMED CONSENT LETTER TO THE TEACHER

Cell: 072 826 0621

Email: 56845499@mylife.unisa.ac.za

Dear Sir/Madam

I am Ncamiso Derrick Mlipha currently doing a research entitled: Teacher's implementation of inquiry-based learning (IBL) activities in Life Science classroom under the supervision of Ms M.M. Ramulumo, a lecturer at the University of South Africa College of Education in the Department of Science and Technology Education. I am currently doing Master of Education with specialisation in Curriculum studies at the University of South Africa. I would like to invite you to participate in this study. Should you wish to participate, I will like to observe your lesson and have an interview with you. I will not interfere with any class activities during these observations. You will also be required to take part in an individual interview which will be audio-recorded.

The purpose of this research is to explore the contribution of IBL activities to the development of teachers' teaching strategies in Grade 11 Life Sciences classroom. The study investigate teacher's understanding about the implementation of IBL activities, explore how teachers implement IBL activities to improve their teaching strategies in Life Sciences classrooms and investigate how teachers knowledge develop as the result of implementation of IBL activities.

The study will provide information and encouragement to Life Sciences teachers, encouraging them to recognise the value of IBL in consolidating knowledge and fostering critical-thinking abilities. The findings will also assist the Department of Education work with school administrators, subject advisor's, and provisional coordinators to encourage Life Sciences teachers to use IBL activities as a strategy to consolidate Life Sciences knowledge despite of the contextual factors. Furthermore, the findings may assist teachers in developing their teaching strategies in Life Sciences, which may help increase learners' interest and achievement in the subject. Finally, this research is vital in assisting teachers to understand what IBL is, how to implement IBL activities to improve their teaching strategies in Life Sciences and to develop teachers knowledge as a result of the implementation of IBL activities.

There are no known risks associated with this study, anonymity and confidentiality will be maintained by not disclosing the names of schools and participants. The data that will be collected form the participants will be kept confidential and will be strictly used for research purpose. Upon the completion of the qualification the participants will receive the summary of the findings for this study.

For more information with regard to this study contact me on: 0728260621 or email: 56845499@mylife.unisa.ac.za and my supervisor Mrs. M.M Ramulumo at email: ramulmm@unisa.ac.za.

Yours sincerely,

Ncamiso Mlipha	19 JULY 2022 Date

Cell: 072 826 0621

Email: 56845499@mylife.unisa.ac.za

CONSENT

In terms of ethical requirements of the University of South Africa, you are now requested to complete the following section:

I, ______________________________ have read this letter and understand that

- my participation in his research is *voluntary*, and that I can withdraw from the research at any time.
- in line with the regulations of the University of South Africa regarding the code of conduct for proper research practices for *safety in participation*, I will not be placed at risk or harmed in any way.
- my *privacy* with regard to confidentiality and anonymity as a human respondent will be protected at all times.
- as a research participant, I will always be *fully informed* about the research processes and purposes.
- research information will be used for the *purposes of this enquiry*.
- my trust will not be betrayed in the research processes and in dissemination of its published outcomes, and I will not be deceived in any way.

I hereby declare that I give my *informed consent* for participation in this research.

Signature: ____________________

Date: ____________________

Thank you for your time.

APPENDIX G: INQUIRY-BASED LEARNING ACTIVITY 1

TOPIC: PHOTOSYNTHESIS

TIME: 60 Minutes

AIM: To demonstrate that starch is produced in the green parts of variegated leaves during photosynthesis.

Apparatus and chemicals:

1. Glass beaker
2. Test tube
3. Bunsen burner
4. Test tube holder
5. Watch glass/ petri dish
6. Medicine dropper
7. Forceps
8. Water
9. Iodine solution
10. Alcohol/ ethanol/ methylated spirits
11. Variegated green leaf (exposed to sunlight)

Method:

1. De-starch a plant by placing it in a dark cupboard for 48 hours.
2. Then expose the plant to sunlight for a few hours.
3. Pick a leaf that has been exposed to sunlight.
   Feel the texture of the leaf before boiling and after boiling
4. Boil the leaf in water for about one minute.
5. Remove the boiled leaf, roll it into a test tube and place it in a test tube.
6. Pour ethanol/ alcohol into the test tube to cover the leaf.
7. Carefully place the test tube in a glass beaker containing boiling water and allow it to stand for a few minutes.
   Observe the colour change of the alcohol

8. Carefully remove the leaf and rinse it in hot water.
9. Spread the leaf in a watch glass/ petri dish and add a few drops of iodine solution.
10. Allow the leaf to stand for a few minutes.
(*Note the colour change of the leaf*)

QUESTIONS:

1. OBSERVATIONS

Complete the following table:

Criteria	Observation
The texture of the leaf before boiling	
The texture of the leaf after boiling	
The colour of the alcohol after boiling	
The colour of the leaf after rinsing	

2. RESULTS

Draw diagrams to illustrate the appearance of the leaf before and after the investigation.

3. DISCUSSIONS

Complete the following table on the precautions and steps

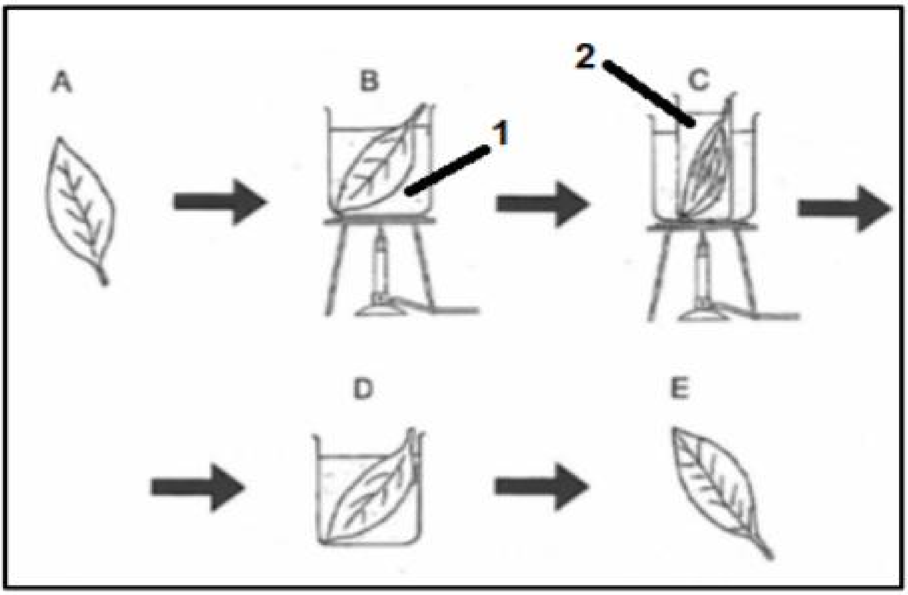
Step(s)	**Reason + Explanation**
Boiling the leaf in water	
Boiling the leaf in alcohol	
Rinsing the leaf in water	

4. CONCLUSION

ANSWER THE FOLLOWING QUESTIONS:

5. Study the experimental procedure below, to test for the presence of starch in a leaf.

Answer the questions that follow.



5.1 State the hypothesis for this investigation.

(2)

5.2 Explain why starch is tested for and not glucose.

(2)

5.3 Identify the liquids labelled **1** and **2**.

1:____

2:____(2)

5.4 Why do you have to turn off the Bunsen burner before you place the test tube in step **C** in the beaker?

____(1)

5.5 Give the name of the chemical reagent to be dropped on **E** to test for the presence of starch.

____(1)

5.6 What colour change would you expect to see of the test is positive for starch?

____(1)

5.7 How will you prepare leaf **A** for the investigation?

____

____

____(3)

APPENDIX H: INQUIRY-BASED LEARNING ACTIVITY 2

TOPIC: CELLULAR RESPIRATION

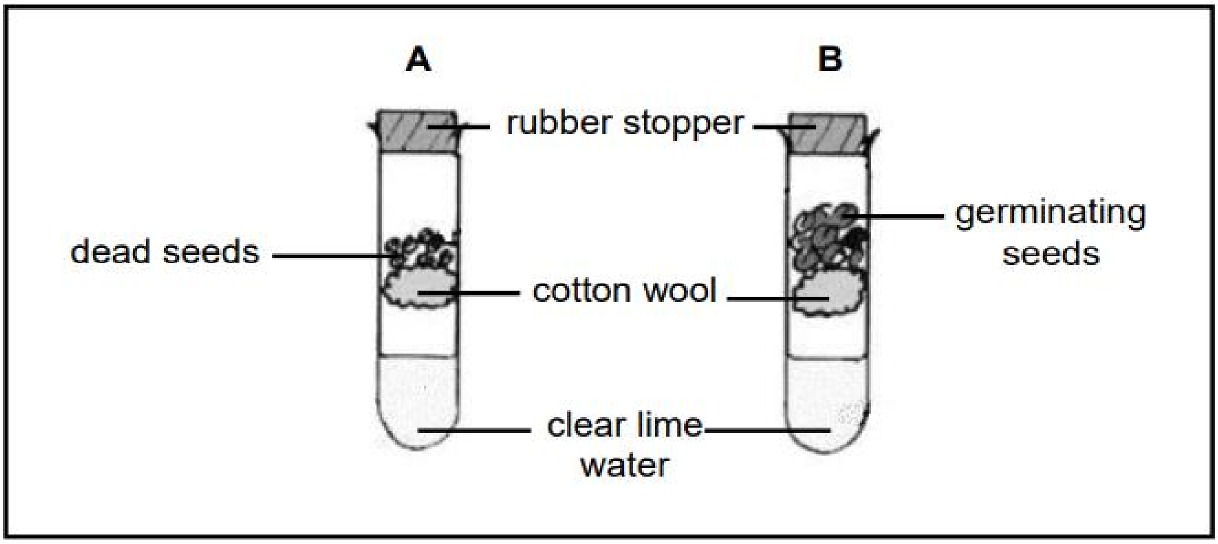
TIME: 60 MINUTES

QUESTION 1

1.1 To investigate if germination seeds release carbon dioxide during respiration.

The learners:

- Set up the investigation as indicated below
- Sterilised both sets of seeds before they placed it inside the test tubes
- Leave the apparatus in a safe place
- Record any colour change of the clear lime water in both test tubes after TWO days



1.1.1 Provide an investigative question for the experiment.

____

____

____

____ (2)

1.1.2 State the following for the investigation:

(a) Dependent variable

____

____

____ (1)

(b) Independent variable

____

____

____ (1)

(c) TWO fixed (controlled variables

____

____

____ (2)

1.1.3 Why were the seeds sterilised at the start of the investigation?

____

____ (1)

1.1.4 What colour change was observed in test tube:

A : ______________________________ (1)

B : ______________________________ (1)

1.1.5 Give a reason for the colour change in test tube **B.**

____

____ (1)

1.1.6 Why can experiment **A** serves as a control?

____

____(2)

1.2 The following table shows the relation between the amount of FOUR gasses present in exhaled air. Other gasses contribute to more or less than 1%.

Type of gas	**Average percentage of gas per volume of exhaled air (%)**
Water vapour	5
Nitrogen	78
Oxygen	12
Carbon dioxide	4

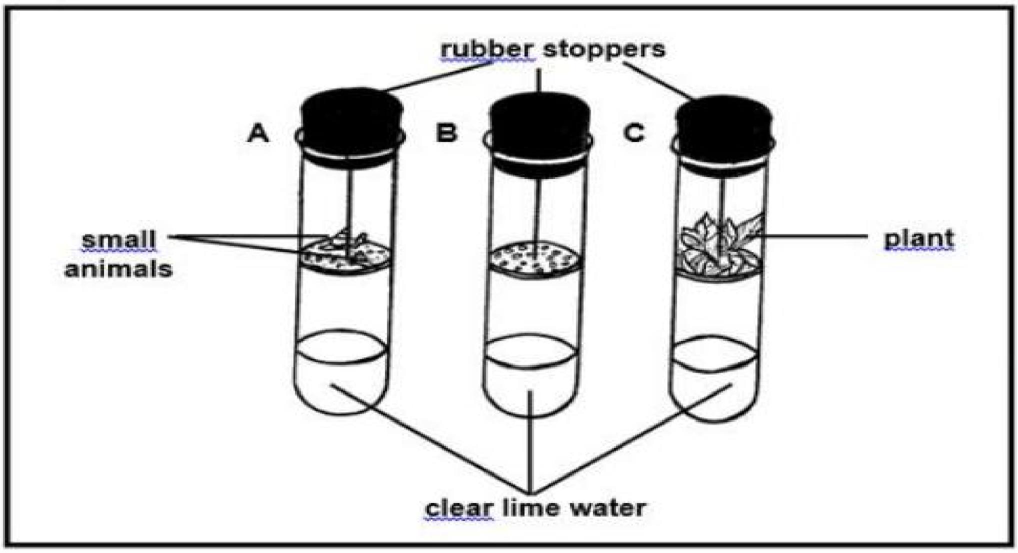
Draw a bar graph of the information in the table. (6)

QUESTION 2

2.1 Conducted an investigation after having gathered facts about cellular respiration and photosynthesis.

Set up the investigation as shown in the diagram.

- Place a small living animals and a healthy plant onto thin discs cut from a spongy material into two test tubes.
- Keep a third test tube without any living organisms
- Place all three test tubes in a room with bright, natural sunlight



2.1.1 What is the purpose of using:

(a) Rubber stoppers in each test tube

____

____ (1)

(b) The spongy disks

____

____(1)

2.1.2 State TWO ways in which the reliability of this investigation can be improved.

____

____

____(2)

2.1.3 Predict the results expected in the following test tubes after a few hours:

A : ____ (1)

C : ____(1)

2.1.4 Give a reason for your answers in QUESTION 2.1.3 - Test tube **C**

____

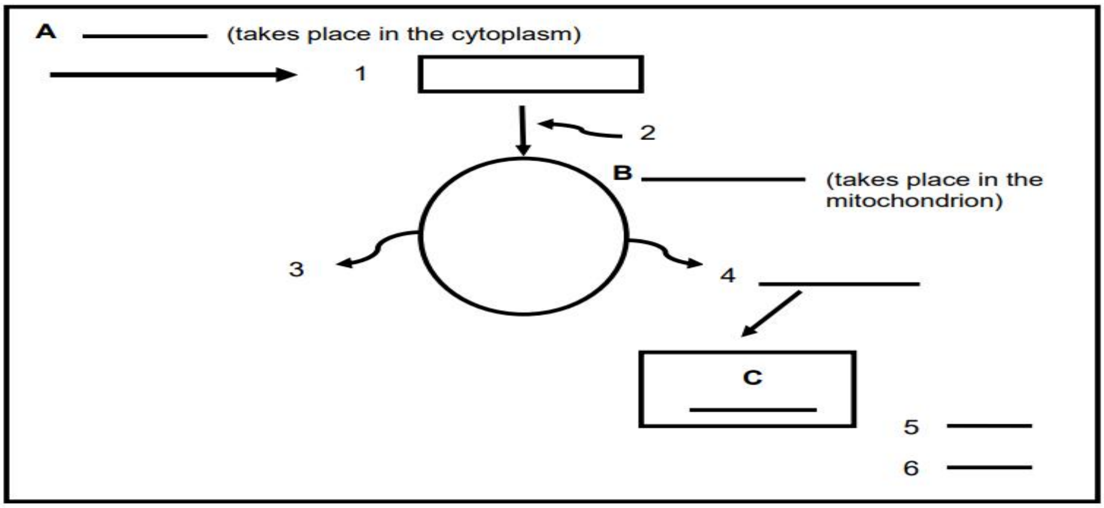
____

____

____ (2)

QUESTION 3

3.1 Answer the questions on the schematic presentation of the process of cellular respiration.



3.1.1 Name the following phases in the process of respiration:

A : ____(1)

B : ____ (1)

3.1.2 Name the gas:

2 : ____ (1)

3 : ____(1)

APPENDIX I: ALFRED INTERVIEW TRANSCRIPT

I: What do you understand about inquiry-based learning (IBL)?
Alfred: To my own understanding IBL it focus on teaching and learning of learners. Learners are active participants. The teacher is a facilitator. In summary it ensures that learners are active participants in learning not just taking instructions from the teacher. They are taking a huge role in their learning.

I: What are your thoughts and believes about teaching Life Sciences as inquiry?
Alfred: My thoughts are that for effective teaching and for learners to enjoy and capture or master the content easy, Life sciences should be taught using partial IBL because since learners are active participants they will bring their own experience and combine it with the content that is taught in the classroom. Life sciences will be enjoyable if IBL is used.

I: Do you have experience in incorporating IBL in you lessons? If yes,how? If not, what prevents you from incorporating it?
Alfred: I can not say yes or no, but I can say sometimes because the are some content where I use direct teaching and some content I use inquiry-base like during experiment investigation. I do have the experience in using inquiry-based. The reason for not using IBL is that it is time consuming.

I: What are the benefits of incorporating IBL?
Alfred: The benefits are very vast, number 1 we are building an independent learner. Learners are able to think on their own. Learners will be able to gain knowledge. It build self confidence and allow learners to think outside the box.

I: What is your role as a teacher when implementing IBL activities?
Alfred: Provide all the necessary resources needed in the class. Introduce the lesson start with the baseline assessment and act as a facilitator.

I: What limiting factors do you face when implementing IBL activities?
Alfred: Research, as a teacher you must do research to gain knowledge before the lesson, so our school does not have the resources to do the research which

limits the knowledge of the teacher. A teacher must have more knowledge. IBL activities needs more time, our annual teaching plan (ATP) is long, so if you can use IBL you will not finish teaching the content. Our classrooms are over crowded and IBL need learners to explore the resources, so in our situation it is difficult to implement IBL activities with the limited resources that we have. Our learners lack prior knowledge which make it difficult to teach using IBL.

I: Do you know that CAPS require IBL in Life Sciences? If yes, what CAPS says about IBL?
Alfred: Yes
I: What CAPS says?
Alfred: It requires us to perform and it allows teachers to perform experiments. It also want us to assess learners using the experiment activities in order to meet the demands of the cognitive levels.

I: Do you think CAPS places an emphasis on IBL? Why?
Alfred: it does
I: Why?
Susan: It gives us teachers an overview of what we have to teach. It allows learners to express themselves.

I: As a Life Sciences teacher, which instructional strategy do you think is best when you teach Life Sciences in your classroom and why?
Alfred: I don't have a direct strategy but I use a teaching strategy based on the lesson demands and focusing on the learners needs. I use direct teaching when introducing a lesson but mostly I use a learner-centred approach.

I: If limitation of resources was not a factor, which instructional strategies would be the best to use? Why?
Alfred: Learner-based learning. The reason I need my learners to be active participants. I need all my learners to be critical thinkers.

I: Do you sometimes use inquiry as an instructional strategy in your classroom? And if yes how often? If not, what limits you from using it?

Alfred: Yes I do, in a scale of 0-10 I can say is 5-6, most of the time I use it when conducting experiments work or investigation.

I: Do you think IBL activities have any contribution to the development of teaching strategies in Life Sciences?If yes, how?If not, why?

Alfred: Eish this question, yes, it because when teaching this learners the content of Life Sciences, Life sciences is all about the surroundings which they experience everyday, they are able to share what they experience everyday.

I: Thank you, that brings us to the end of our interview session.

APPENDIX J: NICO INTERVIEW TRANSCRIPT

I: What do you understand about inquiry-based learning (IBL)?

Nico: Ok, what I can say about inquiry-based learning is a teaching and learning methods that focuses more on learners in experiencing the processes of knowledge creation. I can add that it is a learner-centred that allows learners to learn on their own pace. It allows learners to be lifelong learners. The only thing that the teacher can do is to guide the learners.

I: What are your thoughts and believes about teaching Life Sciences as inquiry?

Nico: I believes teaching Life sciences as inquiry is a good idea since it enhance the Life Sciences teacher to gain competence, practices and also improve their conceptual understanding. I believes that in the learning space we learn from the books, we learn from our peers, so I believe teaching through inquiry will assist me and also the learners to gain more knowledge.

I: Do you have experience in incorporating IBL in you lessons? If yes, how? If not, what prevents you from incorporating it?

Nico: Aaah, since I started my teaching career I was using it but not noticing that I was using it. I was allowing learners to find information and in some cases I use to give learners activities which require them to go and search information or to ask to people outside the school, so I can say yes I am using inquiry-based learning.

I: What are the benefits of incorporating IBL?

Nico: It must allows my learners to be able to solve problems they come across in learning and also expose them to experimental learning. It allows them to questions ideas rather than being passive in their learning.

I: What is your role as a teacher when implementing IBL activities?

Nico: I believe that it is to help learners to generate content related questions and to guide them during an investigation. I think that that is my role. I can add by saying in controlled learning my role can be to provide several essential questions so that learners can unpack those questions.

I: What limiting factors do you face when implementing IBL activities?

Nico: Limiting factors, the first one is the absence of resources in the school, the absence of Wi-Fi in the school so it becomes difficult to give learners something to research on. There is shortage of textbooks so some learners relay on copies.

I: Do you know that CAPS require IBL in Life Sciences? If yes, what CAPS says about IBL?

Nico: CAPS allows active participation of learners. It allows learners to do more than the teachers that is why I make sure that I give learners room or space to do more. According to CAPS learners must be guided to be leaders in their learning.

I: Do you think CAPS places an emphasis on IBL? Why?

Nico: I think so, it does put an emphases. The document allows learners to do practical tasks and to give each practical task per term.

I: As a Life Sciences teacher, which instructional strategy do you think is best when you teach Life Sciences in your classroom and why?

Nico: The first one for me is hands-on learning, it involves the active participation of learners to experience scientific concepts rather than to be audience in their learning.

I: If limitation of resources was not a factor, which instructional strategies would be the best to use? Why?

Nico: I will say it is hands-on learning, I will allow my learners to explore scientific concepts rather than watching me as a teacher doing the practical task because now we will be have all the necessary resources.

I: Do you sometimes use inquiry as an instructional strategy in your classroom? And if yes how often? If not, what limits you from using it?

Nico: I use it when I give learners practical tasks, projects to be build. I use inquiry-based learning so that they will know how to do it, which resources, or apparatus to use so that they will know how the final product is produced.

I: Do you think IBL activities have any contribution to the development of teaching strategies in Life Sciences? If yes, how? If not, why?

Nico: Inquiry-based learning does contribute a lot because it allows teachers to learn from their learners and see their mistakes. It allows the teacher to develop and able to choose a strategy that is suitable for a particular lesson because of the mistakes that occurs when implementing the inquiry-based learning.

APPENDIX K: LIZZY'S INTERVIEW TRANSCRIPT

Researcher

What do you understand about inquiry-based learning?

Lizzy

Inquiry Based Learning I think it is a method of teaching and learning, it is an approach to learning that encourages learners to engage in solving the problem and experimental learning.

Researcher

What are your thoughts and believes about teaching Life Sciences as inquiry?

Lizzy

Life sciences is all about Life, Plants and animals and systems that are taking place in our bodies it is about making life and IBL fits well in Life Sciences because of all the practicals and investigation that we are doing, we get to learn the theory part and do practicals, we get to investigate physically, and we get to create our own questions sometimes and solve them

Researcher

Do you have experience in incorporating IBL in you lessons? If yes, how? If not, what prevents you from incorporating it?

Lizzy

In our classes it is very difficult to follow everything because of the high number of learners in our classes and to follow everything that IBL requires is difficult, classes are full, and the syllabus is too long, and we also don't have all the resources to do everything by the book so sometimes it more theory and less physical work done. We try but it is difficult hence I do not have much experience, instead we focus in using the traditional methods of teaching rather than IBL.

Researcher

What are the benefits of incorporating IBL?

Lizzy

If everything was done correctly like teaching and learning as well as practicals then IBL forces curiosity in learners and it teaches skills, encourages learning experience for learners and creates a well understanding of a topic for learners.

Researcher

What is your role as a teacher when implementing IBL activities?

Lizzy

The role as a teacher is to provide direct instructions to learners, help learners create questions about the topic and we guide learners into finding questions and solutions on their own, facilitating the teaching and learning. As a teacher we guide them into investigating and doing practical work. I believe that the learners should create their own questions and answer them along with the teacher.

Researcher

What limiting factors do you face when implementing IBL activities?

Lizzy

The common problem for learners even for the teachers is the inability to recognise when we are successful, we just jeep on teaching and learning if the work is done well, we are unable to recognise that and because of many learners in our classes we don’t usually work in groups, and it makes it difficult for the teacher to find a problem or identify learners who are in need. Mostly it is the lack of resources especially our schools we struggle to even do a simple practical, so the lack limits us from fully implementing IBL, we do have a laboratory, but it is lacking resources and there is also the lack of textbooks.

Researcher

Do you know that CAPS require IBL in Life Sciences? If yes, what CAPS says about IBL?

Lizzy

Yes, I am aware of that requirement

Researcher

Do you think CAPS places an emphasis on IBL? Why?

Lizzy

The CAPS document gives teachers detailed guidelines on what teach and what to assess but it does not emphasize on the issue of inquiry-based learning, so it does not emphasize it well or enough it just tells us and guides on what to teach and assess but nothing on how to teach the content.

Researcher

As a Life Sciences teacher, which instructional strategy do you think is best when you teach Life Sciences in your classroom and why?

Lizzy

In Life Sciences the strategy that works well in our classroom is teaching and learning because there are a lot of notes that need to be taught and explained before practical's. It has a lot of theory, so it is difficult to group them or allow them to do practical work. Direct teaching is the best strategy for me especially prior to doing practicals.

Researcher

If limitation of resources was not a factor, which instructional strategies would be the best to use? Why?

Lizzy

I think that if resources were not problem, then certainly, we need to give learners more work and more feedback, most of the time I focus on direct teaching and allocate time for revision, practicals and feedback.

Researcher

Do you sometimes use inquiry as an instructional strategy in your classroom? And if yes how often? If not, what limits you from using it?

Lizzy

I only do it sometimes due to lack of resources. I can only say twice in a term because most of the time my focus on direct teaching and drilling them with question papers. I am limited by the space and environment that I am teaching in. for example the largest class I teach is 75 learners making it impossible to implement IBL as often as I would like. The focus is not on learner development as envisioned by IBL but more on the assessment of the learners and the results reason being the lack of resources, the space and environment I teach in, so we are forced to focus on assessment than development.

Researcher

Do you think IBL activities have any contribution to the development of teaching strategies in Life Sciences? If yes, how? If not, why?

Lizzy

The practicals are working, and the learners are interested in them it is just that we are not doing them enough, IBL is a strategy that is working well with the learners as they are curious, they formulate their questions and participate in the activities compared to direct teaching. It assists in my strategies because I get to have a combination of both teaching directly and allow learners to be in groups doing their own activities.

APPENDIX L: ALFRED OBSERVATION TRANSCRIPTS

Lessons observation 1

TEACHER'S ACTIVITIES	YES/NO	NOTES/COMMENTS
Classroom environment		
Learners desks are arranged in pairs, in triples or quadruple groups.	**YES**	Learners are sitting in pairs, facing the front
The class is a learning centre for individual or group studies.		The class is an ordinary classroom which can accommodate both individual and group studies. Therefore in this lesson it is for individual learning.
Teacher's desk is not located in the centre or in front of the classroom; it is rather located on one side or at the back of the classroom		There is no desk for the teacher, the teacher is using one learners desk in the front raw of the classroom
The teachers' role in the inquiry-based learning environment		
The teacher identifies learners prior knowledge and integrates it with the new one before the lesson starts	**YES**	In the introduction the teacher explains the purpose of the lesson and reminds them of what they did in the last lesson on photosynthesis. In actual fact prior knowledge for the learners is not being identified by the teacher.

Teacher instruct learners to explain or write the rationale for their hypothesis.	**YES**	The is a question in the learners activity which requires learners to write their hypothesis. Some learners were not sure of how to come with the hypothesis. It is of the reason that the teacher explain what hypothesis is and how to write it. She even explain why it is important to have the hypothesis when doing an experiment or investigation.
The teacher activates learners so that they can develop a thorough understanding of science	**YES**	The teacher explains all the steps based on the method on doing the practical investigation. Some learners were following and asking question but others were not part of the lesson. The teachers explanation did activates learners even though some were not part of the whole process.
The teacher provides opportunities for learners to conduct the inquiry-based activity	**NO**	Due to limited resources the teacher assign two learners to conduct the activity while the others were assisting with the steps. The learners at the back of the classroom were not part of the activity. One learner was even busy with his work not the activity that was being done.
Teacher assists in the development of original learning by asking questions and facilitating the work with those questions.	**YES**	The teacher was mostly focusing on the activity that was being done by the two learners and asking the whole class some questions. Yes the teacher was facilitating the activity with the follow up questions.

The teacher has the ability to find different techniques of asking questions	**YES**	The teacher was having activity-based questions which the learners were to answer at the end of the practical investigation. While learners were busy with the practical the teacher was also asking questions to guide the learners in the process. Why are you boiling the leaf in alcohol? Why are you removing the flame when boiling the leaf in alcohol? How is the texture of the leaf after boiling it in alcohol? Those were some of the questions that the teacher was asking to guide the practical activity.
The teacher takes up the role of a facilitator in inquiry-based learning environment	**YES**	Yes the teacher was facilitating because she was not the one who was doing the practical but the learners and she was assisting them where possible.
Teacher initiates group activities	**NO**	No there were no groups because of the limited resource. The learners were working in pairs when they were answering the questions.
The teacher shows respect to different learners and different types of learning styles	**NO**	Not all learning style were accommodated in the lesson but the teacher shows respect to different learners because they were all given opportunity to be part of the lesson either through discussion or being hands-on.
The teacher ensures that the learners think further	**YES**	The questions were ensuring that the learners think further

The teacher contributes to increasing scientific literacy among learners	**YES**	Yes, in the discussions misconceptions were identified and the teacher was able to correct them. She was also able to explain some of the questions that the learners were asking and this contribute to learners scientific literacy.
The teacher contributes to learners' existing knowledge and examines the changes in their understanding	**YES**	Yes there was contribution because at first the learners observe the colour change in the leaf and the whole leaf turn blue-black even though it was a variegated leaf. The teacher pointed out that results in an investigation are not always positive and that is why it is important to do it more than once. The learners ask to repeat the investigation and the results were now positive. The teacher ask the learners what conclusion will they write now. One learner said they have to repeat it again in order to get reliable results. Some learners were aware of the term reliability but not in a practical sense. Through the investigation they examines the change in their understanding.
Teacher helps learners uncover their thoughts	**YES**	Yes, through the questions that were asked
The teacher contributes to learners' development of critical thinking, scientific processing, problem solving and high level thinking skills	**YES**	The activity was developmental in nature and it was promoting critical thinking, learners were following scientific process skills and it was promoting problem solving skills.

APPENDIX M: NICO OBSERVATION TRANSCRIPTS

Lessons observation 1

TEACHER'S ACTIVITIES	YES/NO	NOTES/COMMENTS
Classroom environment		
Learners desks are arranged in pairs, in triples or quadruple groups.		Learners were in groups or six, some were four and others were more but less than ten.
The class is a learning centre for individual or group studies.		The arrangement was for group work, therefore the class was a learning centre for group studies.
Teacher's desk is not located in the centre or in front of the classroom; it is rather located on one side or at the back of the classroom		The teachers desk was placed in the front position with the apparatus for the practical
The teachers' role in the inquiry-based learning environment		
The teacher identifies learners prior knowledge and integrates it with the new one before the lesson starts	**YES**	The teacher asked the learners the requirements for photosynthesis which was what they discussed in the previous lesson. The teacher identified learners prior

		knowledge and integrated it with the new knowledge which was to test for starch in a variegated leaf.
Teacher instruct learners to explain or write the rationale for their hypothesis.	**YES**	Teacher instructed learners to explain their hypothesis. Teacher asked learners what do they think the colour of the leaf will be at the end of the process. One learners “blue-black”.
The teacher activates learners so that they can develop a thorough understanding of science	**NO**	The teacher did not activate learners so that they can develop a thorough understanding of science. The expectation was to integrate theory to practical, therefore the learners view the practical and what they learned as separate entities which contributed to some learners not active participant. I hear the teacher making some remarks “where are the others, am I teaching one learner”.
The teacher provides opportunities for learners to conduct the inquiry-based activity	**NO**	The school is under-resourced and the teacher was having only the apparatus that were placed in his desk for demonstration. The teacher didn’t provide opportunities for learners to conduct the activity but he was the one who was doing the practical after reading the steps in the

		working manual.
Teacher assists in the development of original learning by asking questions and facilitating the work with those questions.	**YES**	“If you do not de-starch the plant what will be the colour change”, “why are we boiling the leaf in water”. The were so many question that the teacher asked and that assisted the teacher to facilitate the learning process.
The teacher has the ability to find different techniques of asking questions	**YES**	The teacher has the ability to find different techniques of asking questions but he was not making all the learners to answer. I believe that it was going to be proper to even direct the questions to all the learners even those that are non-participating.
The teacher takes up the role of a facilitator in inquiry-based learning environment	**NO**	The lesson was more teacher-centred, therefore he didn’t take up the role of a facilitator in the inquiry-based learning environment.
Teacher initiates group activities	**NO**	The groups were there but there was nothing that the learners were to work on because of the shortage of resources. The teacher did not initiate group activities.

The teacher shows respect to different learners and different types of learning styles	**NO**	The teacher did not show respect to different learners and different types of learning style because he was explaining, asking learners questions and do the demonstration. The learners were only listing and other answering the question. I believe that it was going to be proper to write in the chalkboard while explaining or having some poster.
The teacher ensures that the learners think further	**NO**	The teacher did not ensures that the learners think further by asking higher order questions.
The teacher contributes to increasing scientific literacy among learners	**YES**	The teacher contributed to increasing scientific literacy among learners because the practical activity makes the learners understand the process of photosynthesis better. Some learners were eager to do the practical by themselves which shows their interest of inquiry.
The teacher contributes to learners' existing knowledge and examines the changes in their understanding	**YES**	The teacher contributed to learners existing knowledge because by doing the demonstration that assisted some learners to change their understanding and some better

		understand the process of photosynthesis.
Teacher helps learners uncover their thoughts	**NO**	The lesson was more teacher-centred and it did not allow learners uncover their thoughts.
The teacher contributes to learners' development of critical thinking, scientific processing, problem solving and high level thinking skills	**NO**	The lesson was more of structured inquiry and it didn't develop learners critical thinking. As the lesson was more on the teacher demonstrating it didn't promote scientific processing, problem solving and high level thinking skills.

CLASSROOM OBSERVATION 2

TEACHER'S ACTIVITIES	**YES/NO**	**NOTES/COMMENTS**
Classroom environment		
Learners desks are arranged in pairs, in triples or quadruple groups.		Learners were sitting in groups. The numbers in the different groups was not the same as some were two, three and others four.
The class is a learning centre for individual or group		The teacher was using an ordinary classroom, which

studies.		means it is not a laboratory. The class was not promoting learners grouping because after the teacher has group the learners, there was no space for the teacher to move around during teaching and learning.
Teacher’s desk is not located in the centre or in front of the classroom; it is rather located on one side or at the back of the classroom		The teachers desk was placed in the front position with the apparatus for the practical.
The teachers' role in the inquiry-based learning environment		
The teacher identifies learners prior knowledge and integrates it with the new one before the lesson starts		The teacher asked the learners the requirements for photosynthesis and products for photosynthesis. Learners were answering in groups, giving the teacher the answers. It is noted that the teacher did a recap of the requirements and products for photosynthesis not actually identifying prior knowledge.
Teacher instruct learners to explain or write the rationale for their hypothesis.		As the teacher was explaining and following the method of the practical investigation, he was asking learners what

		will happen. Teacher: “what do you think will happen when we boil the leaf in water” Learner 1: “The leaf will change colour” Learner 2: “The leaf will be soft” Learner 3: “The leaf will be small” Teacher: “What is the reason for boiling the leaf in water” Learner 4: “To soften the tissues” Teacher: “yes, what else” Learner 1: “to stop the process like photosynthesis to happen” This shows that the teacher was instructing learners to predict what will happen but never explain to them what is a hypothesis and its importance in an experiment. The learners were given the opportunity to write their hypothesis as the first question in the worksheet requires learners to write their hypothesis.
The teacher activates learners so that they can develop a thorough understanding of science		Even though there were apparatus in the school, the teacher decided to demonstrate to learners. The teacher

		was picking each apparatus from his desk and show the learners. Teacher: “Here I have the apparatus which are used to test for the presence of starch, I have the test-tubes, the bicker, the Bunsen-burn which gives this light, the spirit which is inside this burn, water, the ethanol, the dishes and the iodine solution”. As the teacher was mentioning the apparatus, he was not even asking the learners what those apparatus are used for. He was explaining the use of other apparatus but not all of them. The teacher was the one who was doing the practical and the learners were watching. This means that the teacher did not activate learners understanding of sciences but he was telling them how things are done.
The teacher provides opportunities for learners to conduct the inquiry-based activity		In the box that the teacher was having in the floor there were other apparatus beside the ones that he was using but did not give them to learners. The learners were not given the opportunity to conduct the inquiry-based activity.

		The teacher was the one who was in change of everything in this classroom.
Teacher assists in the development of original learning by asking questions and facilitating the work with those questions.		The were question that the teacher was asking the learners. Teacher: “now we are boiling the leaf in alcohol, what will happen? And why are we boiling it in alcohol?” Learner 1: “the leaf will change colour” Learner 2: “the leaf will be hard” Teacher: “ok, yes the colour will change, that means chlorophyll is removed. Alcohol removes chlorophyll”. The teacher was not a facilitator of learning but was using the traditional approach of teaching. Even though he was asking questions but that does not mean he was facilitating learning.

The teacher has the ability to find different techniques of asking questions		The teacher has the ability to find different techniques of asking questions but he was not making all the learners to answer. I believe that it was going to be proper to even direct the questions to all the learners even those that are non-participating.
The teacher takes up the role of a facilitator in inquiry-based learning environment		The teacher was using the traditional way of teaching. The lesson was more teacher-centred and learners were passive participants in the learning process. The teacher was not a facilitator.
Teacher initiates group activities		The teacher did group the learners but they were only given the worksheet not the apparatus. Group work was not promoted because he even order the learner to answer the questions individual so that he will see if the had the understanding. Therefore, group activities were not initiated.
The teacher shows respect to different learners and different types of learning styles		The teacher did not show respect to different learners and different types of learning style because he was explaining, asking learners questions and do the

		demonstration. The learners were only listing and other answering the question. I believe that it was going to be proper to write in the chalkboard while explaining or having some poster.
The teacher ensures that the learners think further		The lesson was teacher-centred, therefore the teacher did not ensure that learners think further except when they were answering the questions. I did not even see any learners challenging the teacher in terms of asking questions for better understanding. The learners were in some cases talking amongst themselves as they were answering the questions.
The teacher contributes to increasing scientific literacy among learners		The teacher contributed to increasing scientific literacy among learners because the practical activity makes the learners understand the process of photosynthesis better. Some learners were eager to do the practical by themselves which shows their interest of inquiry.
The teacher contributes to learners' existing knowledge and examines the changes in their		The teacher contributed to learners existing knowledge because by doing the demonstration that assisted some

understanding		learners to change their understanding and some better understand the process of photosynthesis.
Teacher helps learners uncover their thoughts		The lesson was more teacher-centred and it did not allow learners uncover their thoughts.
The teacher contributes to learners' development of critical thinking, scientific processing, problem solving and high level thinking skills		The lesson was more of structured inquiry and it didn't develop learners critical thinking. As the lesson was more on the teacher demonstrating it didn't promote scientific processing, problem solving and high level thinking skills.

APPENDIX N: LIZZY OBSERVATION TRANSCRIPTS

LESSON OBSERVATION 1

TEACHER'S ACTIVITIES	YES/NO	NOTES/COMMENTS
Classroom environment		
Learners desks are arranged in pairs, in triples or quadruple groups.	**YES**	The learners were in groups of ten as the were limited resources.
The class is a learning centre for individual or group studies.		Learning centre for group studies
Teacher's desk is not located in the centre or in front of the classroom; it is rather located on one side or at the back of the classroom		The teachers desk is in front of the classroom as the teacher was to demonstrate what the learners was supposed to do.
The teachers' role in the inquiry-based learning environment		
The teacher identifies learners prior knowledge and integrates it with the new one before the lesson starts	**NO**	The teacher did not identify learners prior knowledge
Teacher instruct learners to explain or write the rationale for their hypothesis.	**NO**	The learners were passive and the teacher was the one who was explaining. So she did not instruct the learners to

		write the rationale for the their hypothesis.
The teacher activates learners so that they can develop a thorough understanding of science	**YES**	The teacher activates learners by explaining how to do the practical activity and why it was important. She also explain how the process of photosynthesis occur in plants.
The teacher provides opportunities for learners to conduct the inquiry-based activity	**YES**	Some learners were given the opportunity in the group to conduct the practical activity while others where watching as the process was done.
Teacher assists in the development of original learning by asking questions and facilitating the work with those questions.	**NO**	The teacher did not ask developmental questions or facilitate the work with the questions, even those which was in the learners worksheet.
The teacher has the ability to find different techniques of asking questions	**NO**	The teacher has no abilities to find different techniques of asking questions
The teacher takes up the role of a facilitator in inquiry-based learning environment	**NO**	The lesson was more teacher-centred, the teacher did not take up the role of a facilitator in the inquiry-based learning environment.

Teacher initiates group activities	**YES**	Learners were in groups but she did not facilitate the group activity and making sure that all the learners are part of the learning process.
The teacher shows respect to different learners and different types of learning styles	**NO**	Did not show respect to different learners and different types of learning styles. The teacher was using demonstration type of learning not allowing learners to inquire for themselves.
The teacher ensures that the learners think further	**NO**	The teacher did not allow critical-thinking and did not ensure that the learners think further.
The teacher contributes to increasing scientific literacy among learners	**YES**	The teacher was explaining while demonstrating to learners, with that I can say contributed to scientific literacy among learners as the learners were able to see the apparatus and how the process of starch test is done in a variegated leaf.
The teacher contributes to learners' existing knowledge and examines the changes in their understanding	**YES**	Less contribution to learners existing knowledge because some learners were not given the opportunity to handle the apparatus and perform the practical activity on their own. The second reason the learners were not exploring but the were following and looking what the teacher was

		doing as she reads the methods and demonstrate to them.
Teacher helps learners uncover their thoughts	**NO**	The teacher did not help the learners to uncover their thoughts because they were not exploring but they were following what the teacher was say they must do. Critical thinking was not developed, scientific processing was not developed and also no problem solving.
The teacher contributes to learners' development of critical thinking, scientific processing, problem solving and high level thinking skills	**NO**	The lesson of the teacher did not develop learners critical thinking, scientific processing, problem solving and high level thinking skills. The lesson was more teacher-centred and the was using more direct teaching. Overall the teacher demonstrated structured inquiry.

LESSON OBSERVATION 2

TEACHER'S ACTIVITIES	YES/NO	NOTES/COMMENTS
Classroom environment		
Learners desks are arranged in pairs, in triples or	**YES**	The learners were in groups of ten as the were limited

quadruple groups.		resources.
The class is a learning centre for individual or group studies.		The lesson was conducted in the laboratory which promotes group studies
Teacher’s desk is not located in the centre or in front of the classroom; it is rather located on one side or at the back of the classroom		The teachers desk is in front of the classroom as it is a build in from the laboratory. Even though the teachers desk was there but there was no apparatus on it except the teacher resources (books, chalk, duster and handouts).
The teachers' role in the inquiry-based learning environment		
The teacher identifies learners prior knowledge and integrates it with the new one before the lesson starts	**NO**	The teacher did not identify learners prior knowledge instead the teacher ask the learners to look on the worksheet as she was explaining the methods of carrying out the practical.
Teacher instruct learners to explain or write the rationale for their hypothesis.	**NO**	The learners were passive and the teacher was the one who was explaining. So she did not instruct the learners to write the rationale for their hypothesis. Even in the worksheet there was no question which was based on

		hypothesis.
The teacher activates learners so that they can develop a thorough understanding of science	**YES**	As the teacher was explaining the methods, she was also asking teacher some questions to make sure that they are within the lesson. It was an active exercise and you could tell that learners were used to the approach. From the teacher engagement with the learners I can say the teacher did activated learners so that they can develop understanding of science.
The teacher provides opportunities for learners to conduct the inquiry-based activity	**YES**	The learners were not given the opportunity to conduct the practical because they were not apparatus in this classroom. The teachers plan was not explained to the learners so that they will be able to answer the questions.
Teacher assists in the development of original learning by asking questions and facilitating the work with those questions.	**NO**	The teacher did not ask developmental questions or facilitate the work with the questions, even those which was in the learners worksheet.
The teacher has the ability to find different techniques of asking questions	**NO**	The teacher has no abilities to find different techniques of asking questions. The only way the teacher ask learner

		straight questions and the questions were not challenging learners to think further or to explain more.
The teacher takes up the role of a facilitator in inquiry-based learning environment	**NO**	The lesson was more teacher-centred, the teacher did not take up the role of a facilitator in the inquiry-based learning environment.
Teacher initiates group activities	**YES**	Learners were in groups but she did not facilitate the group activity and making sure that all the learners are part of the learning process.
The teacher shows respect to different learners and different types of learning styles	**NO**	Did not show respect to different learners and different types of learning styles. The teacher was using the traditional approach, which was talk and chalk or direct instruction.
The teacher ensures that the learners think further	**NO**	The teacher did not allow critical-thinking and did not ensure that the learners think further.
The teacher contributes to increasing scientific literacy among learners	**YES**	The lesson for the teacher did not contribute to increasing scientific literacy among learners because the lesson was more teacher-centred.

The teacher contributes to learners' existing knowledge and examines the changes in their understanding	**YES**	The teacher did not contributed to learner's existing knowledge and examines the changes in their understanding but the teacher was focusing more on learners finishing the activity and having good marks.
Teacher helps learners uncover their thoughts	**NO**	The teacher did not help the learners to uncover their thoughts because they were not exploring but they were following what the teacher was say they must do. Critical thinking was not developed, scientific processing was not developed and also no problem solving.
The teacher contributes to learners' development of critical thinking, scientific processing, problem solving and high level thinking skills	**NO**	The lesson of the teacher did not develop learners critical thinking, scientific processing, problem solving and high level thinking skills. The lesson was more teacher-centred and the was using more direct teaching. Overall the teacher demonstrated structured inquiry.

APPENDIX O: TRANSCRIPTS

ALFRED INTERVIEW TRANSCRIPT

Line	Description
1.	**Researcher**
2.	Good day
3.	**Alfred**
4.	Good day how are you?
5.	**Researcher**
6.	I am ok, so today were are going to have the interview, with me I am
8.	having twelve questions which I will be asking you. You are free to ask for
9.	clarity if you have any.
10.	**Alfred**
11.	Thank you I will do that
12.	**Researcher**
13.	What do you understand about inquiry-based learning?
14.	**Alfred**
15.	To my own understanding inquiry-based learning it focus on teaching and
16.	learning of learners. Learners are active participants. The teacher is a
17.	facilitator. In summary it ensures that learners are active participants in
18.	learning not just taking instructions from the teacher. They are taking a
19.	huge role in their learning.
20.	**Researcher**
21.	What are your thoughts and believes about teaching Life Sciences as
22.	inquiry?
23.	**Alfred**
24.	My thoughts are that for effective teaching and for learners to enjoy and
25.	capture or master the content easy, Life sciences should be taught using
26.	partial inquiry-based learning because since learners are active
27.	participants they will bring their own experience and combine it with the
28.	content that is taught in the classroom. Life sciences will be enjoyable if
29.	inquiry-based learning is used.
30.	**Researcher**

Do you have experience in incorporating IBL in you lessons? If yes,how? If not, what prevents you from incorporating it?

Alfred

I can not say yes or no, but I can say sometimes because the are some content where I use direct teaching and some content I use inquiry-base like during practical investigation. I do have the experience in using inquiry-based. The reason for not using IBL is that it is time consuming.

Researcher

What are the benefits of incorporating IBL?

Alfred

The benefits are very vast, number 1 we are building an independent learner. Learners are able to think on their own. Learners will be able to gain knowledge. It build self-confidence and allow learners to think outside the box.

Researcher

What is your role as a teacher when implementing IBL activities?

Alfred

Provide all the necessary resources needed in the class. Introduce the lesson start with the baseline assessment and act as a facilitator.

Researcher

What limiting factors do you face when implementing IBL activities?

Alfred

Research, as a teacher you must do research to gain knowledge before the lesson, so our school does not have the resources to do the research which limits the knowledge of the teacher. A teacher must have more knowledge. Inquiry-based learning activities needs more time, our annual teaching plan (ATP) is long, so if you can use IBL you will not finish teaching the content. Our classrooms are overcrowded and IBL need learners to explore the resources, so in our situation it is difficult to implement IBL activities with the limited resources that we have. Our learners lack prior knowledge which make it difficult to teach using IBL.

Researcher

Do you know that CAPS require IBL in Life Sciences? If yes, what CAPS says about IBL?

Alfred

Yes

Researcher

What CAPS says?

Alfred

It requires us to perform and it allows teachers to perform experiments. It also want us to assess learners using the practical activities in order to meet the demands of the cognitive levels.

Researcher

Do you think CAPS places an emphasis on IBL? Why?

Alfred

It does

Researcher

Why?

Alfred

It gives us teachers an overview of what we have to teach. It allows learners to express themselves.

Researcher

As a Life Sciences teacher, which instructional strategy do you think is best when you teach Life Sciences in your classroom and why?

Alfred

I don’t have a direct strategy but I use a teaching strategy based on the lesson demands and focusing on the learners needs. I use direct teaching when introducing a lesson but mostly I use a learner-centred approach.

Researcher

If limitation of resources was not a factor, which instructional strategies would be the best to use? Why?

Alfred

Learner-based learning. The reason I need my learners to be active participants. I need all my learners to be critical thinkers.

Researcher

Do you sometimes use inquiry as an instructional strategy in your

97.	classroom? And if yes how often? If not, what limits you from using it?
100.	**Alfred**
101.	Yes I do, in a scale of 0-10 I can say is 5-6, most of the time I use it when
102.	conducting practicals work or investigation.
103.	**Researcher**
104.	Do you think IBL activities have any contribution to the development of
105.	teaching strategies in Life Sciences? If yes, how? If not, why?
106.	**Alfred**
107.	Eish this question, yes, it because when teaching this learners the content
108.	of Life Sciences, Life sciences is all about the surroundings which they
109.	experience everyday, they are able to share what they experience
110.	everyday.
111.	**Researcher**
112.	Thank you, that brings us to the end of our interview session.

LIZZY INTERVIEW TRANSCRIPT

Line	Description
1.	**Researcher**
2.	What do you understand about inquiry-based learning?
3.	**Lizzy**
4.	Inquiry Based Learning I think it is a method of teaching and learning, it is
5.	an approach to learning that encourages learners to engage in solving the
6.	problem and experimental learning.
8.	**Researcher**
9.	What are your thoughts and believes about teaching Life Sciences as
10.	inquiry?
11.	**Lizzy**
12.	Life sciences is all about Life, Plants and animals and systems that are
13.	taking place in our bodies it is about making life and IBL fits well in Life
14.	Sciences because of all the practicals and investigation that we are doing,
15.	we get to learn the theory part and do practicals, we get to investigate

physically, and we get to create our own questions sometimes and solve them

Researcher

Do you have experience in incorporating IBL in you lessons? If yes, how? If not, what prevents you from incorporating it?

Lizzy

In our classes it is very difficult to follow everything because of the high number of learners in our classes and to follow everything that IBL requires is difficult, classes are full, and the syllabus is too long, and we also don't have all the resources to do everything by the book so sometimes it more theory and less physical work done. We try but it is difficult hence I do not have much experience, instead we focus in using the traditional methods of teaching rather than IBL.

Researcher

What are the benefits of incorporating IBL?

Lizzy

If everything was done correctly like teaching and learning as well as practicals then IBL forces curiosity in learners and it teaches skills, encourages learning experience for learners and creates a well understanding of a topic for learners.

Researcher

What is your role as a teacher when implementing IBL activities?

Lizzy

The role as a teacher is to provide direct instructions to learners, help learners create questions about the topic and we guide learners into finding questions and solutions on their own, facilitating the teaching and learning. As a teacher we guide them into investigating and doing practical work. I believe that the learners should create their own questions and answer them along with the teacher.

Researcher

What limiting factors do you face when implementing IBL activities?

Lizzy

The common problem for learners even for the teachers is the inability to recognise when we are successful, we just jeep on teaching and learning if the work is done well, we are unable to recognise that and because of many learners in our classes we don’t usually work in groups, and it makes it difficult for the teacher to find a problem or identify learners who are in need. Mostly it is the lack of resources especially our schools we struggle to even do a simple practical, so the lack limits us from fully implementing IBL, we do have a laboratory, but it is lacking resources and there is also the lack of textbooks.

Researcher

Do you know that CAPS require IBL in Life Sciences? If yes, what CAPS says about IBL?

Lizzy

Yes, I am aware of that requirement

Researcher

Do you think CAPS places an emphasis on IBL? Why?

Lizzy

The CAPS document gives teachers detailed guidelines on what teach and what to assess but it does not emphasize on the issue of inquiry-based learning, so it does not emphasize it well or enough it just tells us and guides on what to teach and assess but nothing on how to teach the content.

Researcher

As a Life Sciences teacher, which instructional strategy do you think is best when you teach Life Sciences in your classroom and why?

Lizzy

In Life Sciences the strategy that works well in our classroom is teaching and learning because there are a lot of notes that need to be taught and explained before practical’s. It has a lot of theory, so it is difficult to group them or allow them to do practical work. Direct teaching is the best strategy for me especially prior to doing practicals.

Researcher

If limitation of resources was not a factor, which instructional strategies would be the best to use? Why?

Lizzy

I think that if resources were not problem, then certainly, we need to give learners more work and more feedback, most of the time I focus on direct teaching and allocate time for revision, practicals and feedback.

Researcher

Do you sometimes use inquiry as an instructional strategy in your classroom? And if yes how often? If not, what limits you from using it?

Lizzy

I only do it sometimes due to lack of resources. I can only say twice in a term because most of the time my focus on direct teaching and drilling them with question papers. I am limited by the space and environment that I am teaching in. for example the largest class I teach is 75 learners making it impossible to implement IBL as often as I would like. The focus is not on learner development as envisioned by IBL but more on the assessment of the learners and the results reason being the lack of resources, the space and environment I teach in, so we are forced to focus on assessment than development.

Researcher

Do you think IBL activities have any contribution to the development of teaching strategies in Life Sciences? If yes, how? If not, why?

Lizzy

The practicals are working, and the learners are interested in them it is just that we are not doing them enough, IBL is a strategy that is working well with the learners as they are curious, they formulate their questions and participate in the activities compared to direct teaching. It assists in my strategies because I get to have a combination of both teaching directly and allow learners to be in groups doing their own activities.

NICO INTERVIEW TRANSCRIPT

Description

Researcher

What do you understand about inquiry-based learning?

Nico

Ok, what I can say about inquiry-based learning is a teaching and learning methods that focuses more on learners in experiencing the processes of knowledge creation. I can add that it is a learner-centred that allows learners to learn on their own pace. It allows learners to be lifelong learners. The only thing that the teacher can do is to guide the learners.

Researcher

What are your thoughts and believes about teaching Life Sciences as inquiry?

Nico

I believes teaching Life sciences as inquiry is a good idea since it enhance the Life Sciences teacher to gain competence, practices and also improve their conceptual understanding. I believes that in the learning space we learn from the books, we learn from our peers, so I believe teaching through inquiry will assist me and also the learners to gain more knowledge.

Researcher

Do you have experience in incorporating IBL in you lessons? If yes,how? If not, what prevents you from incorporating it?

Nico

Aaah, since I started my teaching career I was using it but not noticing that I was using it. I was allowing learners to find information and in some cases I use to give learners activities which require them to go and search information or to ask to people outside the school, so I can say yes I am using inquiry-based learning.

Researcher

What are the benefits of incorporating IBL?

Nico

It must allow my learners to be able to solve problems they come across in learning and also expose them to experimental learning. It allows them to questions ideas rather than being passive in their learning.

Researcher

What is your role as a teacher when implementing IBL activities?

Nico

I believe that it is to help learners to generate content related questions and to guide them during an investigation. I think that that is my role. I can add by saying in controlled learning my role can be to provide several essential questions so that learners can unpack those questions.

Researcher

What limiting factors do you face when implementing IBL activities?

Nico

Limiting factors, the first one is the absence of resources in the school, the absence of Wi-Fi in the school so it becomes difficult to give learners something to research on. There is shortage of textbooks so some learners relay on copies.

Researcher

Do you know that CAPS require IBL in Life Sciences? If yes, what CAPS says about IBL?

Nico

CAPS allows active participation of learners. It allows learners to do more than the teachers that is why I make sure that I give learners room or space to do more. According to CAPS learners must be guided to be leaders in their learning.

Researcher

Do you think CAPS places an emphasis on IBL? Why?

Nico

I think so, it does put an emphases. The document allows learners to do practical tasks and to give each practical task per term.

Researcher

As a Life Sciences teacher, which instructional strategy do you think is best when you teach Life Sciences in your classroom and why?

Nico

The first one for me is hands-on learning, it involves the active participation of learners to experience scientific concepts rather than to be audience in their learning.

Researcher

If limitation of resources was not a factor, which instructional strategies would be the best to use? Why?

Nico

I will say it is hands-on learning, I will allow my learners to explore scientific concepts rather than watching me as a teacher doing the practical task because now we will have all the necessary resources.

Researcher

Do you sometimes use inquiry as an instructional strategy in your classroom? And if yes how often? If not, what limits you from using it?

Nico

I use it when I give learners practical tasks, projects to be build. I use inquiry-based learning so that they will know how to do it, which resources, or apparatus to use so that they will know how the final product is produced.

Researcher

Do you think IBL activities have any contribution to the development of teaching strategies in Life Sciences? If yes, how? If not, why?

Nico

Inquiry-based learning does contribute a lot because it allows teachers to learn from their learners and see their mistakes. It allows the teacher to develop and able to choose a strategy that is suitable for a particular lesson because of the mistakes that occurs when implementing the inquiry-based learning.

NICO OBSERVATION TRANSCRIPT

Description

LESSON 1

Learners were in groups or six, some were four and others were more but less than ten. This arrangement indicates that the teacher had the preparation prior before my arrival. This arrangement indicates that the teacher was preparing for group work. The lesson was taking place in a classroom where the learners use for all the subjects. In short the teacher was not using a laboratory. The teachers desk was placed in the front position with the apparatus for the practical. The teacher greeted the learners.

Teacher: Good morning class

All learners: Good morning Sir

Teacher: How are you

All learners: We are fine how are you.

All the learners were sitting facing the teacher and waiting for the lesson to start.

Teacher: Today we will be doing a practical on how to test for starch. Do you still remember when we were learning about photosynthesis. I talk about the requirements for photosynthesis in the beginning. Can you remind me about the requirements, just give me three.

Vusi (pseudonym): Carbon dioxide

Bongi (pseudonym): Sunlight

Lwandi (pseudonym): temperature

Teacher: Aaah… temperature … is the same as sunlight can you give me other one.

Sihle (pseudonym): enzymes

Teacher: When we are testing for starch there are methods that we need to follow so that we can get the results. Yini okumele siyenze when testing for starch.

Amahle: we must use iodine solution

Teacher: Ok, the first thing that we need to do is to de-starch the leaf that we be using. In this case we will be using this leaf. The teacher pick the leaf in his table and was showing it to the learners. You distrach the leaf for how many hours? Without waiting for the answer. For 48 hours which is equivalent to two days. After that you take the plant out of the dark cupboard umangabe ubuyifake ku cupboard for de-starching then you place it in sunlight. This leaf has been de-starched for you. So now I will light up the Bunsen burner so that we will heat up the water. When you look on the leaf you can remember that the leaf is protected by the cell membrane, nani?

All learners: Cell wall

Teacher: I will put my leaf in this beaker so that the water break the cell wall so that the iodine solution will be able to penetrate so that you will see the results. When you are doing the testing you must have the hypothesis, prediction. What do you think will happen we testing for starch? What is you hypothesis? Predict the outcome what will happen?

Vusi (pseudonym): Colour change

Teacher: What colour are you expecting on this leaf when the leaf is de-starched?

Learners at the back: Blue black

Teacher: please raise up your hands, don't sing. Lapho Mandla (pseudonym)

Mandla (pseudonym): if the leaf is de-starched the colour change will be yellow brown.

Teacher: yes, that shows that the leaf has no starch. Let say there is starch, we didn't de-starch the plant. What will happen to the colour change, is it going to be yellow brown or change to blue black or pink. There is starch now on the leaf. Yes Mahle (pseudonym).

Mahle (pseudonym): It is going to change to blue-black

Teacher: Yes, it will change to blue-black indicating that starch is present, meaning photosynthesis has been taking place. What is gona happen now, you must observe the leaf the colour of the leaf is gonna change because the hot water is softening it up, breaking the cuticle and the cell membrane.

The teacher was stirring the leaf that was boiling in the water in the glass beaker.

Teacher: When the leaf is soft I will take it out and try to roll it in one of the test tubes. This are the test-tubes. The teacher was showing the tray with the test tubes to the learners.

Teacher: You know it angithi?

All learners: yes

Teacher: I will put it in the test tubes and pour this, picking up a bottle. What is this?

All learners:…ethanol

Teacher: we use ethanol, why we use ethanol?

Vusi (pseudonym): our aim is to remove chlorophyll

Teacher: we will put our leaf in alcohol. After removing the leaf what are we going to do? Are we going to put the iodine solution immediately?

All learners: No

Vusi (pseudonym): we will rinse the leaf in water.

Teacher: yes we will rinse it in water to remove the alcohol. i ethanol iyona I alcohol esiyisebenzisayo la **(The ethanol is the alcohol that we use**). Sizo remove le leaf bese si yi rinse kumanzi a clean **(we are going to remove the leaf and rinse it in clean water)**….clean water. Ok let me prepare leaf I think…you must try to be careful kulamanzi ashisayo (**in hot water)**. You must you a forceps. The teacher was rolling the leaf and putting it into the test tube. Pour the alcohol. Don't forget that ethanol is flammable, when doing this you must observe precautions. The teacher take test-tube with the leaf and put it into the boiling water. The burner was still burning. You can see the chlorophyll leaving the leaf. Those that are close can see bubbles. Can you see the bubbles?

Learners in the front: yes. Learners were observing.

Teacher: After few minutes, you take it off and rinse it then put it in the source plate. The ethanol is boiling, removing the chlorophyll. The teacher took the leaf out of the alcohol and put it directly into the boiling water. Remember your hypothesis, if there is starch the colour will be blue-black, if there is no starch the leaf will be yellow brown.

The teacher take out the leaf and place it in the table.

Teacher: I will put few drops of iodine solution on top of the leaf. If starch is present you will see the colour change. If there is no starch it will be yellow brown.

As they were waiting for the results the teacher was explaining all the steps from the beginning.

Teacher: those that are closer what is the colour change? Bongi (pseudonym) come and observe. What is the colour change?

Bongi: yellow brown

Teacher: the colour is yellow brown what does this mean?

Amahle (pseudonym): it means the plant was not receiving sunlight.

Teacher: is this correct?

Other learners: No

Bongi (pseudonym): it means that there is no starch on the leaf.

Vusi (pseudonym): instead of saying the is no starch on the leaf, we can say the leaf was not photosynthesising.

Teacher: if the leaf remain yellow brown it means there is no starch, the plant was not photosynthesising but if the colour change to blue black it means it was photosynthesising and receiving sunlight. Thank you that is the end of the lesson.

LESSON 2

The lesson was taking place in the classroom not in the laboratory. The learners were sitting in pair, some were three in the same desk. There were some groups formed. The teacher was placing his apparatus one of the learners desk which was in the front raw at the middle. The were other apparatus in some groups but in other groups the were no apparatus. The other groups were to look on the apparatus in front.

Teacher: Good afternoon class

All learners: Good afternoon teacher

Teacher: How are you.

All learners: we are fine

Teacher: I am also fine. I know you are all surprise why all this, pointing to the apparatus that were on top of the desk. Today I want us to test for starch. If you remember very well when I was teaching you about photosynthesis at the beginning. I said there are requirements for photosynthesis and also products for photosynthesis. Can you remind me of the requirement, just give me two.

Sipho (pseudonym): Sunlight

Buhle (pseudonym): Carbon dioxide

Teacher: and there are products, can you remind me of the products. Two products that we get from photosynthesis.

John (pseudonym): oxygen

Teacher: we refer oxygen as what?

All learners: by-product

Teacher: what is the other product?

All learners: glucose

Teacher: Glucose, plant photosynthesis and store glucose in a form of what?

Learners in the front raw: ATP

The teacher without considering the learners response answer the question.

Teacher: in a form of starch, right. They store the starch where in the leaf? In their leaves…angithi **(Is that right)** and they also store it in their roots angithi **(is that right).** Today I want us to test for starch with the apparatus here. The teacher was showing the learners the apparatus. We have the iodine solution which is our re-agent, the ethanol, the Bunsen burner as you can see it is burning, we will need fire, I have the beakers, which I will use to boil the water, I also have the stand (tri-pot stand). I have the cold water, I have the test-tubes. This is the spirit that is assisting us with the fire. Because of time I decided to boil the water. Here we are having the leaves that will be tested. Tell me, if we want to test for starch want are the method that we need to follow. Yini into okumele siyenze kuqala before sikhulume ngoku boiler uyenzani le leaf ozoyi tester **(what is the first thing we need to do before boiling the leaf?**).

Musa (pseudonym): destarch

Teacher: Uli destarch kanjani?**(How do we de-starch it?)** You can cover the leaf using a brown cover or a box. For how long?

All learners: 48 hours

Teacher: after de-starching you can place the leaf in sunlight. So here I will be boiling the leaf in water. The water is boiling. I will put the leaf in the water. What is the reason of boiling the leaf in what?

Sihle (pseudonym): to make it permeable, to break the cell membrane

Teacher: what else?

Musa (pseudonym): to remove the chlorophyll

Teacher: No, by boiling the leaf in water we are not removing the chlorophyll but breaking the cell wall, cell membrane and the cuticle. Ok, now we are going to boil the leaf in water. Ok, after boiling the leaf in water what next are we going to do? Senza njani, siyaliqoba njenge spinach?**(how do we do, we chop it like spinach?)** So what are we going to do? After boiling it we will take it off and put it in one of the test tubes. I will gonna add alcohol. Why are we going to add the alcohol?

All learners: to remove chlorophyll.

Teacher: what is the work of chlorophyll in the leaf?

Sizwe (pseudonym): Ngicela ukubuza Sir **(can I ask sir**), i alcohol ozoyi add izoba ngakanani?**(how much is the alcohol that you will add?)**

Teacher: it will depend on the size of the leaf. Any other question?

Zizi (pseudonym): what chlorophyll do in a plant?

Teacher: Oooh, who can answer that question?

Two girls with the first raw: To trap sunlight

Teacher: to trap sunlight which is one of the requirements for photosynthesis. Now I think the leaf has boil.

Learners: no, not enough.

Teacher: as we are still waiting for the leaf let me see in your groups. The teacher moved around, in different groups checking if everything is fine. That group over there, pointing the group at the back right corner you must observe everything that is happening. If the bubbles are formed around, or there is one bubble. Observe carefully because at the end I will give you questions to answer. So for us to make this investigation reliable what is it that we need to do at the end?

Learner talking to each other.

Teacher: at the end what colour are we expecting? When iodine solution changes colour to blue black, what does that tells you?

Learners: the leaf has starch

Teacher: removing the leaf from the water and pushing it to the test tube. Adding the iodine solution. When adding the alcohol you must observe the precaution. You must switch of the burner or remove it. The teacher put the test tube with the leaf inside alcohol into the beaker with boiling water. The bubbles tells you that the alcohol is removing the chlorophyll. The colour change of this alcohol is gonna be green, to show that chlorophyll has been removed.

Learners were observing but other were busy making noise until the teacher tells them to stop making noise.

Teacher: its changing colour to green, it means alcohol is removed. Those at the back you can come and observe. Once we are done boiling it in alcohol we will remove the leaf and rinse it. Are we going to rinse it in cold water or in hot water?

All learners: in hot water

Teacher: when we rinse it, are we rinsing chlorophyll or removing alcohol?

Learners: to remove alcohol

Teacher: yes, to remove chlorophyll so that the iodine solution will have an impact. When you see the leaf is it soft or hard?

Learners: hard

Teacher: hard, and the chlorophyll is removed. I will put my leaf on this plate and apply iodine solution. One learner was assisting with the material so that the other groups with apparatus will start boiling their leaf in alcohol.

Zinhle (pseudonym): Sir, so the iodine uzoyi **(will)** apply on top of the leaf?

Teacher; yes. Make sure that when you apply iodine solution it covers the whole leaf. Now we will apply the iodine solution. Let's observe the colour change. What is the colour change?

Learners in front: Blue black

	Teacher: What this colour change tells us?
	Bongi (pseudonym): The leaf has starch.
	Teacher: Alright let us see in the other groups, are you getting a blue-black colour? All the groups were having the blue black colour. Alright, now let us answer the questions in our worksheets.
	Learners were all answering their questions which was testing learners understanding of the whole process.

LIZZY OBSERVATION TRANSCRIPT

Line	**Description**
	LESSON 1
	The lesson was taking place in the classroom not in the laboratory. The teacher gets the learners set in groups, making sure that all the learners are able to see the set-up of apparatus at the centre of each group. She distributed the work-sheets/ hand out. There were three groups formed in the class. The learners were all set waiting for the lesson to start.
	Teacher: ok today I will be demonstrating that starch is produced in the green colour of the leaf during photosynthesis. After the process of photosynthesis the plant produces glucose and stored in the form of starch. The apparatus that we are going to use are: the glass beaker, the test tube, the Bunsen burner, test-tube holder, petri-dish, dropper, water, iodine solution, alcohol and the leaf. We are not going to use the variegated leaf but we will use the normal leaf.
	The teacher reads the method that they will follow from the working manual.
	Teacher: the method, number 1, de-starch the plant by placing it in a dark cupboard for 48 hour. The starch is not produced if the plant is in a dark place but is the plant is in the light that's where photosynthesis take place. You know the requirements of photosynthesis, which is light carbon dioxide and water. If you are taking in the plant for 48 hours, it means you are not exposing the plant to light and that means photosynthesis will not

take place. The plant will not produce the starch. Then number 2, expose the plant to sunlight for few hours. After placing the plant in a dark place you have to take the plant to sunlight. Do you understand?

All learners: Yes

Teacher: then number 3, you pick a leaf that was exposed to sunlight. From our potted plant we are going to pick a leaf that was exposed to sunlight then we feel the texture of the leaf before boiling it. Just feel the leaf, you have the leaf in front of you angithi?

Learners: yes

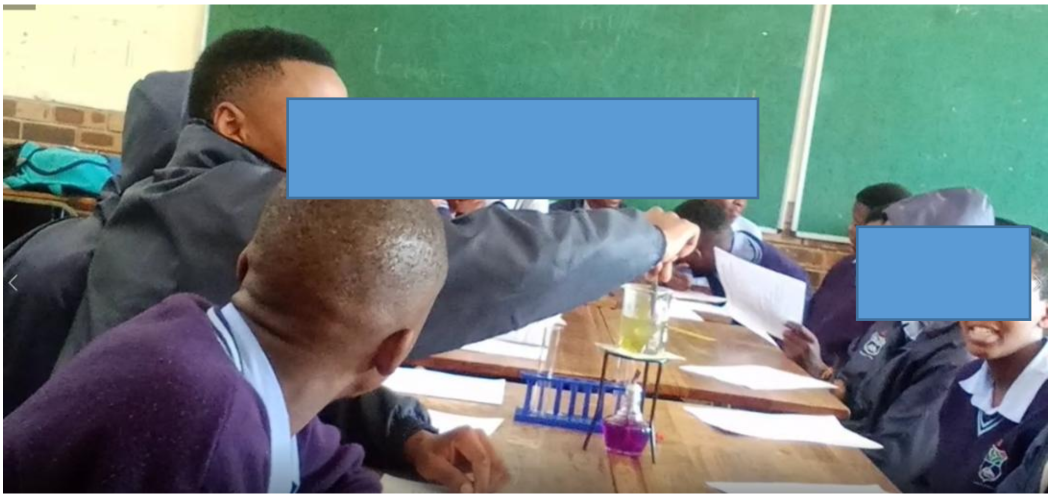
Learners were feeling the leaves, moving the leaf around in different groups.

Teacher: number 4, boil the leaf in water for about 1 minute.

Each group was boiling the leaf in water and observing the changes in the leaf.

Teacher: you observe the colour change. Any colour change?

Learners: they were talking to each other but not answering the teacher.



Teacher: Are you observing the colour change?

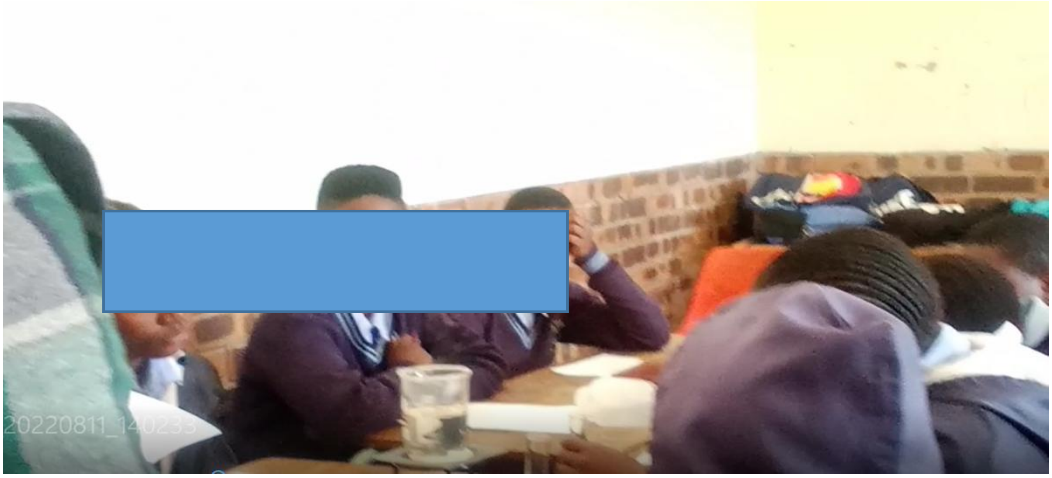
All learners: yes

Teacher: aah, is there any changes? Is it the same as before?

Sizwe (pseudonym): no, now is soft

Teacher: I think the minute is do. Let's go to number 5. don't take it out yet, talking to one group which was trying to take out the leaf. Ok number five remove the boiled leaf and roll it into the test-tube. Then number 6 pour the ethanol/alcohol in the test-tube

Learners:



Teacher: take the test-tube and put it into the boiling water.

The teacher was in one of the groups checking if they were doing okay. She then moved to the other groups checking.

Teacher: now we are observing the colour change in the test-tube, the colour change of the alcohol.

Teacher: okay, carefully remove the leaf in the test-tube

Learners:

Teacher: Rinse the leaf

The teacher was giving the learners cold water to rinse the leaf

Teacher: now you have raised the leaf, put it in the petri-dish

Learners: placed the leaf in the petri-dish.

The teacher was moving around checking the progress in all the groups.

Teacher: then number 9, apply few drops of iodine solution in the leaf using the dropper. If the colour changes to blue-black that indicates that the leaf has starch. Is the colour changing there.

Bongi (pseudonym): no

In all the groups there was no colour change on the leaf. The problem was that the teacher ordered learners to rinse the leaf in cold water instead of hot water. The leaf was still hard and the iodine solution was not penetrating the leaf membranes.

Teacher: if the colour change to blue black starch is present but if there is no colour change that means the leaf has no starch. Ok I want you to write your name outside the worksheet and write your observation. Answer all the questions in the worksheet.

Learners were answering the questions individually but in some other questions they were talking to each other.

LESSON 2

The teacher was using the laboratory in this lesson. Learners were sitting in groups.

There was no material/ apparatus. The teacher was having a box with hand-outs. She distributed the hand-out to all the learners.

Teacher: Good afternoon, today we will be looking on cellular respiration.

The teacher starts to read the aim of the investigation, the apparatus and the method from the worksheet.

Teacher: learners wanted to investigate if germinating seeds releases carbon dioxide during cellular respiration. What are the requirements for cellular respiration?

Zandi (pseudonym): carbon dioxide

Teacher: carbon dioxide is a product of cellular respiration. What are the requirements?

Andile (pseudonym): oxygen

Teacher: yes, and

Isaac (pseudonym): glucose

Teacher: yes. After the process of cellular respiration what do we get?

Bongi (pseudonym): carbon dioxide

Mahle (pseudonym): water

Teacher: so now we need to prove if cellular respiration has taking place. cellular can take place in both plant and animals unlike photosynthesis which take place only in plants. The investigation is about learners who wanted to investigate if carbon dioxide is produced during cellular respiration. The investigation take place as:

The teacher was reading the methods in the worksheet.

Teacher: we need to sterilised the test tubes, this means we must clear the test tubes. We are having two test-tubes.

The teacher was drawing on the chalkboard.

Teacher: in test-tube A we have test-tube with lime water, cotton wool and dead seeds. In test-tube B we have a germinating seed, cotton wool and lime water. In both test-tubes we have a stopper on top. Now what is the function of the rubber stopper on top?

Zinhle (pseudonym): to prevent the movement of in and out of air.

Teacher: okay, what is the function of the cotton wool?

Mazwi (pseudonym): to prevent the seed to have contact with the lime water.

Teacher: so in the dead seeds is cellular respiration going to take place?

All learners: no

Teacher: in the germinating seeds, is cellular respiration going to take place?

All learners: yes

Teacher: what are your prediction on this experiment?

Musa (pseudonym): in the germinating seed glucose is broken down to produce carbon dioxide.

Nhlanhla (pseudonym): the lime water will become milky.

Teacher: which apparatus will be milky between A and B?

All learners: B

Teacher: Right, what will be your investigative question for this experiment?

Peppy (pseudonym): which gas is released by living organisms during respiration?

Teacher: yes during an experiment you can ask yourself that question. Okay, which gas is released?

Musa (pseudonym): carbon dioxide.

Teacher: carbon dioxide is released during cellular respiration. 1.1.2 state the following for the investigation; dependent variable

Sizwe (pseudonym): carbon dioxide

Teacher: yes, its carbon dioxide. This means that for carbon dioxide to be there is depending on cellular respiration. The teacher was still standing in front and reading the questions from the worksheet. Learners were listing, responding and writing the answers. The teacher carry on with the questions. What is the independent variable?

Learners were raising up their hands to respond.

Mandla (pseudonym): the seeds

Teacher: aah, the seeds or the germinating seeds. Here (test-tube A) pointing on the drawing on the board there are seeds but they are not producing carbon dioxide. So the seeds are the independent variables. Do you understand?

Learners: yes

Teacher: two fixed or controlled variables?

Zipho: the amount of lime water

Teacher: the amount of lime water, you can check from the diagrams there is no lime water between the seeds. The lime water and the seeds are separated by what?

All learners: cotton wool

Teacher: yes, cotton wool. Now here in test-tube B cellular respiration is taking place. Carbon dioxide is released here (pointing in test-tube B in the chalkboard). the carbon dioxide is released into the lime water making the lime water to be milky. Do you understand.

All learners: yes

Teacher: are we done with the controlled variables?

Learners: yes

Teacher: which are?

Learners: they did not respond

Teacher: okay we said the amount of lime water, the type of seeds and size of cotton wool. Let’s go to the next question. Why were the seeds sterilised at the start of the investigation?

Sizwe (pseudonym): to kill all micro organisms

Teacher: we know that micro-organisms are so small and they are living organisms. So if we clear the test-tube we have to make sure that there are no living organisms that can produce carbon dioxide that is why we sterilise the test-tube. Let’s say in test tube A there is a bacteria in the test because we didn't sterilise. Our expectation is that in this test-tube the lime water will remain clear. Our expectation in B is that the lime water will be milky. Let's say there is a bacteria or virus (pointing inside test-tube A) the results will be the same because the test-tube was not sterilised and the micro-organism was releasing carbon dioxide. Now, so we have to make sure that everything is sterilised. Right where are we?

Learners: 1.1.4

Teacher: Right, what colour change was observed in test tube A

Musa (pseudonym): it remains clear

Teacher: yes, it means what?

Ben (pseudonym): there was no carbon dioxide

Teacher: no carbon dioxide means?

All learners: no cellular respiration take place. Test tube B?

Mazwi (pseudonym): Milky

Teacher: It means carbon dioxide has been produced and cellular respiration has taken place. 1.1.5 give the reason for the colour in test tube B. everyone can give me the reason. What is the reason?

All learners: presence of carbon dioxide

Teacher: Now, between A and B which one is a control?

Learners: A

Teacher: Okay now let's go to question number 2 and read the questions and write the answers. The teacher go out of the classroom. The learners were busy with the activity answering the questions. There was noise outside the lesson has extended until break time. The teacher comes back and she was moving around as the learners were busy answering the questions. In 2.1 there are now three test-tubes

ALFRED OBSERVATION TRANSCRIPT

Line	Description
	LESSON 1 The learners were sitting in pairs in the classroom. There were four rows

in total with 23 learners in the classroom. The teacher enters the class with a box. He open the box and take out the material which he was going to use. He then asked one learner to go and get boiling water in the staff room. The learner went out. He asked another learner to distribute the hand-out with the learning activity.

The teacher: Sanibonani bantwabami **(good morning my learners)**

All learners: yebo **(morning)**

Teacher: Today we are learning real science. Those who are wearing hats, please take them out. Okay let us look on the activity. When you look on the aim, the aim is to investigate that starch is produced in the green part in a variegated leaf during photosynthesis.

The teacher was reading from the activity that he distributed to the learners.

Teacher: we want to demonstrate that if there is a presence of starch that means photosynthesis yenzekile **(has happened).** we are having the following apparatus and chemicals, the glass beaker, the test-tube, the Bunsen burner, the test-tube holder, the petri-dish, the dropper and the forceps. We need to check the method, number 1 bathe **(they said)** we must de-starch the plant by placing it in a dark cupboard for 48 hours. Then expose the plant to sunlight for few hours. Then pick a leaf that has been exposed to sunlight. So we are having our leaves here, even though it was not de-starched. Number 4 then boil the leaf in water for about one minute. You remove the leaf then you put it in a test-tube. Number 5 pour the ethanol/alcohol in the test-tube to cover the leaf. Careful put the test-tube in the boiling water and allows it to boil for few minutes. This is our glass beaker niyayibona angithi? **(Do you see it right?)**

All learners: yes

Teacher: This is our test-tube sizoyifaka la **(we will put it here)**. putting the test-tube in the beaker. Then we need to observe the colour change. So le experiment lena kumele yeziwe nguwe as a learner **(this experiment must be done by you as a learner).** So we will assist each other so that all here we will be hands-on.

Learners: yes

Teacher: ngubani ofuna siyenze naye? **(Who want to do it with me?)**

Learners: they were raising hands so that the teacher will pick.

Teacher: Come Dlamini and Shongwe (pseudonyms). Let's go to the methods. We need to feel the texture before and after boiling.

The teacher and the two learners they were distributing the leaves to the other learners to feel the texture of the leaf.

Teacher: after boiling sizonika oyi one **(after boiling we will give one).**

The teacher was showing them how to feel the texture by rubbing the leaf between the fingers.

Learners: they were also doing the same. Feeling the texture.

Teacher: Dlamini (pseudonym) put the leaf. Who will be our time keep? We must boil for one minute.

Zinhle: Me

Teacher: we are now putting the ethanol/alcohol. How much it supposed to be?

So we are in number 7, we are boiling the leaf in alcohol and observing the colour change of the alcohol. We must observe the colour change.

Teacher: as were are still waiting for the leaf, let us look on the activity. Lets look on observation 1, the texture of the leaf before boiling. Uyizwe injani? **(how did you feel it?)**

Sizwe: rough

Teacher: write your observation. After boiling we will give it to one and will tell us the texture. What is the colour of the alcohol after boiling?

Learners: green

Teacher: we are taking the leaf out of the alcohol in the test-tube.

Teacher: what is the texture

Muzi (pseudonym): iqinile **(it is hard)**

Teacher: now let us rinse the leaf in water to remove the alcohol. What is the colour of the leaf?

Sipho: it is white.

Teacher: the reason we boil the leaf in alcohol we wanted to remove the chlorophyll and chlorophyll is green, right?

Learners: yes

Teacher: Now we are in number 9. Spread the leaf in the petri-dish. We are going to add the iodine solution and allow it to stay for few minutes and observe the colour change. And also in number 2 you must bear in mind that you have to draw the leaf before and after the investigation. Senze how many drops? **(How many drops we can add?)**

Zama (pseudonym): Three

Teacher: what is the colour change?

Zwandi (pseudonym): brown

Teacher: what is that means?

All learners: no starch present

Teacher: okay let us finish all the questions and submit.

All learners: they were answering the questions.

APPENDIX P: DATA ANALYSIS SCHEME (DAS)

Theme	Category	Characteristics
Teachers understanding	**The definition of IBL**	
	The characteristics of IBL	Connection - engage learners to the real world
		Foundation - establishes and develops background knowledge
		Exploration - learners deepen their knowledge to frame a deep question that directs their inquiry
		Examination - critical thinking, examining diverse and conflicting information to build knowledge
		Creation - meaningful representations of knowledge and understanding
	The stages of IBL	Developing a question
		Generating a hypothesis
		Developing an experiment design
		Collecting and recording data
		Analysing data
		Reaching conclusions, forming and extending generalisations
		Communicating results
The implementation of IBL activities	**The implementation process of IBL**	Identify learners prior knowledge
		Activates learners understanding
		Provide learners opportunity to conduct IBL activity
		Facilitating learners
		Initiates group work
		Assist in the development of original learning by asking questions
	The benefits of IBL	The development of conceptual understanding
		The development of higher-order thinking skills

		(analysis, synthesis, critical thinking and evaluation)
		To understand the nature of science
	The implementation issues	Lack of philosophy of the nature of scientific inquiry in Life Sciences policies
		Teachers lack of content knowledge
		Lack of resources in schools that supports IBL
		Lack of teacher professional development
		Learners who are less motivated to participate in IBL because they lack the necessary knowledge and abilities
Teachers practices of IBL	**Teaching method or approach**	Lecture
		Demonstrations
		Discussion
		Questioning
	The levels of inquiry applied	Structured inquiry
		Guided inquiry
		Open inquiry

APPENDIX Q: CODED INTERVIEW TRANSCRIPT

learning methods that focuses more on learners in experiencing the processes of knowledge creation. I can add that it is a learner-centred that allows learners to learn on their own pace. It allows learners to be life long learners. The only thing that the teacher can do is to guide the learners.

> Ncamiso Derrick ...
> Definition

Researcher

What are your thoughts and believes about teaching Life Sciences as inquiry?

Nico

I believes teaching Life sciences as inquiry is a good idea since it enhance the Life Sciences teacher to gain competence, practices and also improve their conceptual understanding. I believes that in the learning space we learn from the books, we learn from our peers, so I believe teaching through inquiry will assist me and also the learners to gain more knowledge.

> Ncamiso Derrick ...
> Characteristics (establis
> background knowledge

Researcher

Do you have experience in incorporating IBL in you lessons? If yes,how? If not, what prevents you from incorporating it?

Nico

[redacted]

> NCAMISO MLIPHA

APPENDIX R: CODED OBSERVATION TRANSCRIPT

Line	Description
1.	**LESSON 1**
2.	Learners were in groups or six, some were four and others were more but
3.	less than ten. This arrangement indicates that the teacher had the
4.	preparation prior before my arrival. This arrangement indicates that the

NCAMISO MLIPHA
Implementation process (initiates group work)

10

Line	Description
5.	teacher was preparing for group work. The lesson was taking place in a
6.	classroom where the learners use for all the subjects. In short the teacher
8.	was not using a laboratory. The teachers desk was placed in the front
9.	position with the apparatus for the practical. The teacher greeted the
10.	learners.
11.	**Teacher:** Good morning class
12.	**All learners:** Good morning Sir
13.	**Teacher:** How are you
14.	**All learners:** We are fine how are you.
15.	All the learners were sitting facing the teacher and waiting for the lesson
16.	to start.
17.	**Teacher:** Today we will be doing a practical on how to test for starch. Do

Ncamiso Derrick ...
Implementation (group work)

Ncamiso Derrick ...
Challenges (resources)

Ncamiso Derrick ...

APPENDIX S: ORIGINALITY REPORT

N.D MLIPHA CHAPTER 1-5

ORIGINALITY REPORT

17%	15%	2%	6%
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APPENDIX T: LANGUAGE EDITING CERTIFICATE

EDITING AND PROOFREADING CERTIFICATE

7542 Galangal Street

Lotus Gardens

Pretoria

0008

05 December 2022

TO WHOM IT MAY CONCERN

This certificate serves to confirm that I have language edited NE Mlipha' dissertation entitled, **"TEACHERS' IMPLEMENTATION OF INQUIRY-BASED LEARNING ACTIVITIES IN LIFE SCIENCES CLASSROOMS."**

I found the work easy and intriguing to read. Much of my editing basically dealt with obstructionist technical aspects of language, which could have otherwise compromised smooth reading as well as the sense of the information being conveyed. I hope that the work will be found to be of an acceptable standard. I am a member of Professional Editors' Guild.

Hereunder are my contact details:

Dr Jack Chokwe (PhD)

Contact numbers: 072 214 5489

jackchokwe@gmail.com

Professional EDITORS Guild

Jack Chokwe
Associate Member

Membership number: CHO001
Membership year: March 2022 to February 2023

076 471 6881 / 072 214 5489
012 429 3327
jackchokwe@gmail.com
www.academicproeditor.co.za

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