Implementation of Inquiry-Based Learning Strategies by Teachers for Practical Work in Physical Sciences: A Case Study in Tshwane South District

By

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DECLARATION

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''Implementation of Inquiry-Based Learning Strategies by Teachers for Practical Work in Physical Sciences: A case Study in Tshwane South District''

I, Lesiba Frans Phalane, student number 41471385, declare that this Master's dissertation is my work and that all the sources I have used or quoted have been indicated and acknowledged using complete references.

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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.

______________ January 2026

SIGNATURE DATE

DEDICATION

This work is dedicated to my children, Matsobane, Mahlako, Tebatso, and Ditabeng. May it serve as an encouragement to all of you to achieve all your dreams. This dissertation is also dedicated to my wife, Karabo, as a source of motivation and encouragement for her to further her studies.

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ABSTRACT

Inquiry-based learning (IBL) is a learner-centred approach that engages learners in authentic scientific investigation and problem-solving, fostering critical thinking and deeper understanding. However, although it has proven potential to enhance conceptual understanding and critical thinking, Physical Sciences teachers in South Africa continue to rely predominantly on traditional teacher-centred methods. Recent national examination reports show that learners consistently do poorly in the subject, indicating gaps in practical work facilitation. This study, therefore, investigated how teachers enact inquiry-based learning strategies during practical work to enhance learners' conceptual understanding, critical thinking skills, and active engagement in the learning process. The study further focused on the teachers' knowledge, lesson design, and the challenges they encounter when integrating inquiry during practical work. The conceptual framework of this study was based on Bybee's 5E learning model and the levels of inquiry-based learning. The models provide a structured approach for organising lessons into distinct phases that promote learner understanding and engagement. The frameworks were used to analyse the findings in this study. Additionally, an interpretive paradigm and qualitative case study approach, as outlined by Starman (2013), were used in this study. The researcher collected data from five Physical Sciences teachers selected from five secondary schools within the Tshwane South District. The data collection methods used were classroom observations, semi-structured interviews, and document analysis. The study used thematic analysis to analyse the collected data. The key findings of this study disclosed that inquiry-based learning strategies were inadequately utilised in practical work. However, teachers highlighted that during inquiry-based practical work, learners engage in hands-on activities that encourage active learning, skills development, and problem-solving. Their responses indicated that teachers viewed inquiry-based learning as a hands-on approach in which learners actively build knowledge through investigation, exploration, and problem-solving. Hence, they allowed learners to explore during their lessons independently.

Furthermore, the study found that a shortage of time and insufficient resources hindered teachers' ability to implement and manage inquiry-based learning activities effectively. These challenges collectively limited the effective integration of inquiry-based learning strategies during practical work. Moreover, some experienced difficulties in managing the classrooms and aligning inquiry-based practical work with curriculum principles. They demonstrated an inadequate usage of inquiry strategies. Therefore, there is a strong need for targeted professional development to help teachers understand and effectively implement inquiry-based learning strategies during practical work.

Keywords**:** Inquiry-based learning strategies, practical work, Physical Sciences, Secondary Schools, Professional development, active learning, problem solving

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ABBREVIATIONS

CAPS: Curriculum and Assessment Policy Statement

FET: Further Education and Training

DBE: Department of Basic Education

NSC: National Senior Certificate

POE: Predict-Observe-Explain

IBL: Inquiry-Based learning

GDE: Gauteng Department of Education

SMT: School Management Teams

PLC: Professional Learning Communities

ATP: Annual Teaching Plan

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Inquiry-based learning (IBL) is an instructional technique that places learners at the centre of the learning process by engaging them in authentic research (Santos et al., 2023). When appropriately implemented during practical work, inquiry-based strategies can help learners develop higher-order thinking skills, gain hands-on experience, and better understand scientific concepts (Culhane, 2020). According to Akuma and Callaghan (2019a), inquiry-based learning strategies involve experiences in which learners collaboratively engage with equipment and materials to gain insights into the environment, while also actively participating in scientific discovery through structured, directed, or open inquiry. Akuma and Callaghan (2019a) further emphasise that inquiry-based learning strategies promote scientific inquiry and align well with the social constructivist learning perspective. The above point of view highlights the idea that knowledge is constructed by the individual learner, rather than being passively received from a teacher. Recent studies continue to confirm that inquiry-based learning enhances learners' engagement, conceptual understanding, and scientific reasoning skills in science education contexts (Kraiwanit et al., 2023; Rahman, 2023). Studies further indicate that when teachers implement inquiry-based strategies in practical tasks, learners gain hands-on experience, deepen their understanding of scientific concepts, develop higher-order thinking skills, and grasp the essence of science (Rahmania, 2021).

The incorporation of inquiry-based learning strategies with practical work can be facilitated by the strategy of inquiry-based practical work (Tsakeni, 2021). Gudyanga and Jita (2019) note that learners gain authentic exposure to the natural world through actual laboratory practical work, which can best be realised through the implementation of inquiry-based learning strategies. Alneyadi (2019) describes practical work as assignments or intentional actions in which learners in science classes examine or handle actual objects or observe real, practical demonstrations. Tsakeni et al. (2019) state that inquiry-based learning, as a method for practical work, is essential in science classes for five reasons: (I) it captures the interest and motivation of learners; (ii) helps learners grasp scientific concepts; (iii) fosters scientific-practical skills and the ability to solve problems; (iv) enhances understanding about what science is; and finally, (v) nurtures scientific habits. Therefore, inquiry-based practical work strengthens learners' ability to transfer scientific knowledge to real-life contexts and improves their problem-solving and reasoning skills (Ozuem et al., 2022; Köhler et al., 2023).

The National Curriculum and Assessment Policy Statement (CAPS) for Physical Sciences, Further Education and Training (FET) Grade 10-12, promotes the incorporation of practical work to enhance the relevance of the content. Practical work in Physical Sciences focuses on improving knowledge and skills related to scientific inquiry and problem-solving. The Department of Basic Education (2011) states that practical work emphasises the construction and application of scientific and technological knowledge, as well as an understanding of the nature of science and its connections to technology, society, and the physical environment. Consequently, practical work plays a unique and pivotal role in the curriculum of the Physical Sciences. Therefore, teachers ought to implement practical work effectively, emphasising active learner participation and promoting scientific literacy (Department of Basic Education, 2011). As a result, integrating inquiry-based strategies into practical work positively influences learners' achievement, motivation, and self-efficacy in science learning (Nzomo et al., 2023; Köhler et al., 2023). When inquiry-based strategies are implemented in practical work, learners' learning in Physical Sciences, test scores, attitudes, and self-efficacy can be influenced (Nzomo et al., 2023).

Although teachers are ready to use inquiry-based learning approaches when teaching, many in South Africa and around the world face challenges with their implementation. Studies confirm that these challenges remain persistent and include limited time, large class sizes, safety concerns, and difficulties in assessing inquiry-based activities (Mkansi & Mkalipi, 2023; Khoa et al., 2023). According to Ibrahim et al. (2020), these challenges include issues related to learners' grading, safety, and time constraints. Strat et al. (2023) also state that some teachers lack competencies, the skills and knowledge related to implementing inquiry-based science lessons, and the need for their development to be realised. Kibirige and Maponya (2021) state that teachers conduct structured practical work once per term for recording purposes and do not incorporate it into their daily lessons. Thus, their knowledge and skills in inquiry-based learning strategies have not improved. Therefore, teachers encounter challenges related to classroom management, pedagogical decision-making, collaboration, and aligning practical work with learners' competencies when implementing inquiry-based learning (Photo, 2025). These reasons motivated the current study to explore how teachers in the Physical Sciences implement inquiry-based learning approaches during their practical work lessons

1.2. Problem Statement

The general learner achievement in Physical Sciences in South Africa's National Senior Certificate (NSC) matric exams has been low, alongside a significantly high enrolment of learners. The Department of Basic Education (DoE) reports that the percentage of learners who attained a 30% pass mark fell from 65.1% in 2020 to 63.6% in 2021 (DoE, 2020-2021). During the final exams of 2022, the percentage dropped further to 60.2% (Department of Education School Subject Report, 2022).

More recent data indicate that although the overall NSC pass rate has improved, challenges in gateway subjects such as Physical Sciences persist (Department of Education School Subject Report, 2025). The national pass rate increased from 82.9% in 2023 to 87.3% in 2024, reaching a record 88% in 2025 (Department of Education School Subject Report, 2022). However, Physical Sciences performance has shown only marginal improvement, with pass rates fluctuating from approximately 76.2% in 2023 to 75.6% in 2024 and increasing slightly to about 77% in 2025 (Department of Education School Subject Report, 2025). These trends suggest that despite overall gains in grade 12 performance, learners continue to experience challenges in Physical Sciences (Department of Education School Subject Report, 2025).

The DoE (2022) states that the challenging aspects observed include teachers' comprehension of how to facilitate science practical tasks. Experiments play a crucial role in the Physical Sciences and are consistently assessed at a higher cognitive level (DoE, 2022). Furthermore, the DoE (2022) asserts that teachers should apply appropriate teaching methods to enhance comprehension of Physical Sciences concepts through hands-on activities.

As a result, the findings call for investigations into elements that influence this performance to improve the Physical Sciences pass rate. Factors such as educational infrastructure (including access to science laboratories and resources for teaching and learning), teaching strategies (including the implementation of inquiry-based learning methods during hands-on activities), and teachers' experiences and perceptions concerning the use of inquiry-based methods for practical tasks require examination. Gudyanga and Jita (2019) suggest that learners’ success in Physical Sciences could be enhanced when teachers utilise inquiry-based learning strategies for practical work. Furthermore, Akuma and Callaghan (2019b) argue that applying inquiry-based learning techniques during hands-on activities in certain schools poses considerable difficulties, hindering its effectiveness as a pedagogical approach.

Studies indicate that the favoured teaching method among science teachers in some South African high schools is the expository teaching approach. The method remains prevalent even though increasing evidence suggests it fails to effectively teach the content knowledge, conceptual understanding, and science process skills essential for outstanding Physical Sciences instruction, especially when compared to the constructivist method (Ramnarain & Rudzirai, 2020). Although there is extensive research on IBL strategies for practical work, a notable gap persists in teachers’ knowledge of how to effectively apply these strategies in the Physical Sciences classrooms. Additionally, the ability of hands-on activities to enhance learner engagement, improve their capacity for critical thinking, and foster a deeper understanding of scientific ideas is hindered by problems such as the poor application of inquiry-oriented teaching methods (Akuma & Callaghan, 2019c). Thus, when teachers implement inquiry-based learning strategies in practical work, learners’ critical thinking and problem-solving abilities can be encouraged and enhanced. Therefore, this study aimed to explore how teachers apply IBL strategies during practical work in Physical Sciences classes within South African schools, specifically in the Tshwane South District, Pretoria.

1.3. Rationale of the Study

Research shows that inquiry-based learning strategies applied during practical work enable learners to develop a sincere interest, foster creative thinking, and improve their problem-solving abilities, together with critical reasoning skills (Fisowich, 2021). However, during my classroom visits for lesson observations as a Departmental Head, it became clear that many teachers structured their lessons in a reasonably conventional, direct way, concentrating on the fulfilment of particular facts and ideas, as described by Gericke et al. (2022). Most of their practical work could not be concluded within the allocated time as indicated in their lesson plans. Therefore, there was a need to investigate the strategies that teachers implement during practical work to promote inquiry-based learning. This might positively affect learners' performance in Physical Sciences.

The use of inquiry-based learning strategies during practical work is one of the best teaching skills that can improve learners' performance in Physical Sciences (Akuma & Callaghan, 2020). Hence, it was important to conduct this study to understand how teachers apply inquiry-based strategies in practical work. The findings of this study could encourage Physical Sciences teachers in my school, my district, and South Africa to plan practical work lessons using inquiry-based learning strategies. This study could also help identify challenges teachers face in schools and develop teaching strategies that promote inquiry-based learning. Furthermore, a better understanding of teachers' use of inquiry-based learning strategies in practical work could prompt curriculum developers to review policies for their implementation. The study also sensitised education officials to the need to consider skills development programmes that will improve teachers' professional development in the sciences and motivate them to teach Physical Sciences effectively.

1.4. Purpose of the Study

The purpose of the study was to explore how teachers apply IBL approaches during hands-on activities in Physical Sciences. The study focused on secondary schools in Pretoria, South Africa. It also sought to investigate teachers' knowledge of how to implement inquiry-based learning strategies during practical work, how they design practical activities to incorporate these strategies into their lessons, and the challenges they encounter, if any. Different from other scholars who primarily investigated IBL from a broader perspective, this study places specific emphasis on teachers' practical classroom implementation within a South African secondary school context.

1.5. Research Questions

The following research questions guided the investigation.

The Main Research Question

How do teachers implement inquiry-based learning strategies during practical work in Physical Sciences?

Sub-questions

1. How do teachers understand and apply inquiry-based learning strategies in practical Physical Sciences activities?
2. How do teachers design practical work activities to incorporate inquiry-based learning strategies in their lessons?
3. What challenges, if any, are experienced by teachers when implementing inquiry-based learning strategies during practical work in Physical Sciences?

1.6. Concept Clarification

1.6.1. Practical work

As referenced by Alneyadi (2019), practical work pertains to assignments or intentional actions where learners in science classes look at or handle actual objects or see real and practical demonstrations.

1.6.2. Inquiry-based learning

Inquiry-based learning is a guiding technique that places learners at the centre of the learning process by engaging them in authentic research (Santos et al., 2023).

1.6.3. Inquiry-based learning strategies

According to Akuma and Callaghan (2019a), inquiry-based learning strategies are experiences in which learners work together to manipulate tools and materials to learn about the environment while conducting scientific experiments using structured, directed, or open inquiry.

1.6.4. Inquiry-based practical work

They are learn-by-doing tasks structured to allow learners to engage in scientific practices related to inquiry (Akuma & Callaghan, 2019a).

1.7. Delimitations of the Study

This study focused on Secondary School teachers of Physical Sciences in Grades 10–12 (FET), in Pretoria, Tshwane South Education District, and included only five male teachers from schools within a reasonable distance from the researcher. The study examined Bybee's 5E instructional model (Engage, Explore, Explain, Elaborate, and Evaluate) and the various levels of inquiry, ranging from confirmation and structured inquiry to guided and open inquiry, which allowed learners to exercise autonomy during practical work.

1.8. Structure of the Study

This section provides an overview and structure of the chapters in this study.

Chapter 1: Introduction

This chapter outlines the research background, problem statement, rationale, purpose, research questions, objectives, clarification of key concepts, delimitations of the study, research design, and concluding remarks.

Chapter 2: Literature Review and Theoretical Framework

This chapter reviews the literature regarding definitions of inquiry-based learning and practical work, the advantages of inquiry-based learning strategies in practical work, the challenges associated with implementing these strategies, and what teachers do to support inquiry-based learning during practical activities. Bybee’s 5E Learning Cycle Model, along with the various levels of inquiry, served as the conceptual framework guiding the study, providing a structured lens for analysing teachers' implementation of inquiry-based learning during practical work.

Chapter 3: Research Methodology

This chapter gave a complete description of how the study was conducted. This includes an overview of the method adopted for this research, together with the research paradigm, research approach, research design, population and sampling techniques, data acquisition methods, data analysis techniques, the study’s trustworthiness, and ethical requirements.

Chapter 4: Data presentation, discussion, and findings

This chapter presented data, engaged in discussion, and presented findings from the Physical Sciences teachers, obtained through interviews, their lesson presentations, and the documents used during lessons, including their lesson plans and practical worksheets.

Chapter 5: Summary of Findings and Recommendations

This chapter summarised the study's research findings, contributions, limitations, recommendations, and conclusions.

1.9. Conclusion

This chapter laid the groundwork for the study by outlining the primary themes and the research process. It also provided background information on how teachers conduct inquiry-based learning in practical settings. In addition, the chapter described the study's research questions, goals, objectives, and purpose. The following chapter presents a survey of relevant literature, concentrating on the theoretical framework that informed the research and assesses how prior studies relate to the ongoing topic.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

This chapter reviews literature regarding the implementation of inquiry-based learning (IBL) methodologies as reformed approaches to teaching Physical Sciences through practical activities. The review draws on key definitions, theoretical perspectives, and empirical evidence to clarify the connection between IBL approaches and practical activities in Physical Sciences education. It also examines existing research on teachers' knowledge, challenges, and practices associated with the application of IBL (Akuma & Callaghan, 2019c). Furthermore, the chapter situates IBL within broader discussions of effective science education pedagogy and the improvement of learners' scientific skills and understanding. However, there is limited research that specifically explores how teachers present IBL strategies in real classroom contexts, particularly within under-resourced South African schools (Lesetja, 2025). Additionally, existing studies tend to focus more on theoretical perspectives or reported challenges rather than providing detailed insights into teachers' actual classroom practices and experiences (Lesetja, 2025).

2.2. Definition of IBL

Multiple definitions of IBL are presented within the reviewed literature. According to Shah-Ph and Kumar (2020), IBL is a learner-centred approach to teaching that emphasises active engagement, critical analysis, and problem-solving skills. Tsakeni (2021) indicates that IBL is regarded as the most effective methodology for teaching learners in the Physical Sciences. Similarly, Aparicio-Ting et al. (2019) argue that IBL is a hands-on teaching approach that empowers learners to take charge of their learning. In addition, Aparicio-Ting et al. (2019) explain that inquiry-based strategies are rooted in a constructivist approach, focusing on experimental procedures that allow learners to participate in knowledge construction and gain knowledge, resulting in greater engagement and deeper learning than traditional teaching practices.

The IBL is an efficient way to combine prior understanding with scientific explanations of how things work in nature (Paseka et al., 2023). Gholam (2019) emphasises that IBL is a dynamic, ongoing learning process in which learners are actively engaged, highlighting that it is an activity performed by learners rather than an experience imposed upon them. According to Li et al. (2023), during an inquiry-based lesson, both the teacher and learners actively participate in constructing reality. Li et al. (2023) further emphasise that the process of constructing reality begins with genuine inquiries arising from learners' lived experiences about concepts, ideas, and information they encounter and seek to incorporate into their constantly developing knowledge.

Although the definition of IBL varies, there is also a shared understanding of its key components (Archer-Kuhn & MacKinnon, 2020). Authors such as Archer-Kuhn and MacKinnon (2020), Ramnarain (2020), and Gajić et al. (2021) argue that during an inquiry-based lesson, the following components should be included:

- A question that is based on science encourages learners to learn.
- Learners prioritise evidence, enabling them to develop and evaluate explanations related to scientific questions. Consequently, learning is founded on the development of knowledge and comprehension.
- Learners construct descriptions based on facts to answer inquiries focused on science. Therefore, IBL constitutes an engaging methodology for learning.
- Learners consider alternative explanations, especially those that support scientific understanding. The teacher facilitates this learner-centred approach.
- Learners talk to each other about their ideas and give reasons for them. They are in charge of their own learning and are responsible for it.

However, there are several agreements on the main components of IBL. Researchers such as Archer-Kuhn and MacKinnon (2020), Ramnarain (2020), and Gajić et al. (2021) all agree that IBL includes asking questions, using evidence to make decisions, making explanations, looking at different ideas, and sharing what you find. These essential elements of IBL highlight how learners are actively involved in their education, and learning is experiential (Ramnarain, 2020). Chu et al. (2021) emphasise that IBL can provide learners with the understanding, expertise, and beliefs needed for them to learn to think for themselves and keep learning for life. In other words, Chu et al. (2021) argue that IBL is primarily defined by learners' discourse, collaborative group activities, and teachers' scaffolding. Thomas (2021) indicates that, within the dialogue, learners are prompted to articulate their encounters with a natural phenomenon, facilitating comparisons of their experiences with those of their peers in the group and with established scientific perspectives. Thomas (2021) further believes that with the gained experience, learners develop the ability to debate, argue, formulate, and clearly present their concepts. Furthermore, it assists them in turning their attention towards what they understand, how they acquire that understanding, and how what they know fits in with what others in the group, in other fields, and in the world outside of school know (An & Thomas, 2021).

Therefore, learning mostly occurs when learners reflect on what they have learned before and build their mental models or plans, using their past experiences to create new ways of thinking (Gunawan et al., 2020). This study adopted the definition of IBL by Akuma and Callaghan (2019a). According to Akuma and Callaghan (2019a), IBL is an experiential process in which learners collectively engage with equipment and materials to understand the world around them while participating in scientific procedures through structured, directed, or open inquiry.

2.3. Implementing IBL through hands-on activities

Hands-on activities are practical activities that include experiments or tasks primarily linked to a specific field of study, profession, or skills development (Makhubele, 2016; Tsakeni, 2021). However, hands-on activities in Physical Sciences refer to practical demonstrations, experiments, or projects that expand understanding of concepts (DoE, 2011). Tsakeni et al. (2019) argue that practical activities are a fundamental aspect of the Physical Sciences curriculum, offering learners hands-on opportunities to investigate scientific phenomena. Additionally, Cossa and Uamusse (2015) emphasise that hands-on activities pertain to any form of knowledge acquisition in which individuals engage with and interact with objects through observation and manipulation. Equally important, hands-on activities also bridge the gap between theoretical concepts and learners' real-world applications, providing context for the subject matter and making it more relevant and engaging (Kilag et al., 2023). This indicates that practical work provides a natural context for IBL, as it allows learners to pose questions, investigate phenomena, and construct evidence-based explanations through direct engagement with scientific materials.

Additionally, Alneyadi (2019) acknowledges hands-on activities as activities best supported by IBL strategies that promote the social constructivist learning perception. Therefore, the implementation of IBL strategies during practical work assists learners to actively generate knowledge rather than receiving it directly from the teacher (Shana & Abulibdeh, 2020). According to Alneyadi (2019), practical work pertains to assignments or designed engagements in which individuals in science lessons view or interact with real items or experience genuine presentations. The current study adopted Alneyadi's (2019) explanation of practical work with IBL strategies serving as a key approach to support its delivery. Practical work in science education can take various forms, each of which can be effectively supported through the use of IBL strategies. These include hands-on activities, investigations, demonstrations, experiments, and simulations, all of which encourage active learner participation, as discussed below.

2.3.1. Types of Practical Work and the Role of IBL Strategies in Their Implementation

Practical work, which includes a wide range of activities, is a fundamental element in the Physical Sciences curriculum. Ko (2021) identifies several practical activities commonly used in Physical Sciences classrooms, including experiments, simulations, demonstrations, and exploratory tasks. Similarly, Thomas et al. (2022) categorise practical activities into distinct types, highlighting their varied purposes in supporting learning. Significantly, these practical activities are aligned with an IBL approach, which emphasises learners' active involvement in questioning, investigating, and constructing knowledge (Thomas et al., 2022). Furthermore, IBL provides a pedagogical framework that connects practical work to meaningful learning. In this regard, encouraging learners to explore phenomena, formulate hypotheses, conduct investigations, and reflect on their findings (Utomo et al., 2023). However, not all types of practical work equally support IBL.

Among the different forms of practical work, investigations and exploratory tasks are considered the most effective for IBL, as they require learners to engage in open-ended inquiry, analyse relationships between variables, and construct their own explanations (Utomo et al., 2023; Ladosz et al., 2022). These activities promote higher-order thinking and align closely with the core principles of inquiry. In contrast, illustrative experiments and demonstrations tend to be more teacher-directed, often limiting opportunities for learner autonomy and reducing the depth of inquiry, although they may be useful for introducing concepts or modelling procedures (Evans, 2020; Gericke et al., 2023).

Similarly, while skill-based practical tasks and observation activities contribute to the development of foundational scientific skills, they are generally more structured and may not fully support inquiry unless intentionally designed to include questioning, reasoning, and interpretation (Tredennick et al., 2021; Rumjaun & Narod, 2020). Therefore, their effectiveness within an IBL framework depends largely on how teachers scaffold and extend these activities beyond procedural engagement. Therefore, all forms of practical work have pedagogical value; their effectiveness for IBL varies depending on the level of learner autonomy, the extent of cognitive engagement required, and the opportunities provided for investigation and explanation (Rumjaun & Narod, 2020; Strom & Viesca, 2021). This suggests that the successful implementation of IBL in Physical Sciences is not dependent on practical work alone, but on how such activities are structured and facilitated in the classroom.

Table 2.1: *Different types of practical work and their descriptions (Carroll et al., 2022)*

Types of Practical Work	Description
Demonstration	The teacher experiments, while learners analyse and deliberate on the results. Furthermore, learners may need to predict outcomes and draw conclusions.
Laboratory experiments/closed inquiry	To demonstrate a scientific principle or fact, the teacher assigns learners a laboratory worksheet to follow. Learners thoroughly rewrite the objectives, materials, and processes in a comprehensive scientific report.
Directed activity	In addition to asking pre-planned questions, the teacher provides clear directions. In addition to following instructions and responding to questions, learners also learn the content through hands-on activities.
Undirected activity	The teacher offers learners the opportunity to examine a topic that appeals to them. Learners are allowed to utilise trial-and-error, equipment experimentation, and simple problem-solving methods. A common reason for this is to

	familiarise them with the types of equipment. The teacher cannot teach a lesson until the learners have become comfortable using the apparatus.
Skill-development	The teacher gives learners many opportunities to use basic scientific tools. The learner uses the equipment alone and out of context to learn how to manipulate objects.
Guided inquiry	Through questioning, the teacher leads the inquiry, while the learners are in charge of organising, conducting, and analysing the investigation. The learner's imagination directs how to approach the present challenge.
Open-inquiry	The teacher asks no questions. Learners ask questions, organise and carry out the investigation, and then evaluate the results.

As shown in Table 2.1, practical work that is supported by inquiry-based activities offers outstanding opportunities for learners to engage with scientific topics and improve their learning (Idris et al., 2022; Khishfe, 2023). Demonstrations enable learners to explore scientific phenomena and participate in dialogues with their peers and teachers, encouraging analytical reasoning and investigative questioning (Idris et al., 2022). Therefore, inquiry-based practical work offers a systematic method for exploring scientific concepts, requiring learners to adhere to procedures, gather data, and prepare reports, thereby enhancing scientific literacy and communication skills.

Guided activities, in addition, are structured learning tasks in which the teacher provides direction, support, and scaffolding while learners engage in the learning process. According to Bunag (2024), they help learners learn to solve problems and gain real-world experience with their teachers' support. On the contrary, undirected activities are learning experiences in which learners are given a task or problem to explore with minimal teacher guidance or explicit instructions (Blackburn & Stair, 2022). According to Blackburn and Stair (2022), they inspire learners to investigate and test scientific ideas, fostering their creativity and independence. Above all, Blackburn and Stair (2022) argue that skill-development activities, within an IBL approach, focus on enhancing learners' ability to use scientific apparatus, a crucial aspect of conducting lessons and experiments. These various forms of practical work reflect the principles of IBL by promoting learner engagement, critical thinking, and the development of scientific knowledge through both guided support and independent exploration.

Finally, open-minded inquiry refers to an approach to learning and investigation where learners are willing to consider multiple perspectives, question their own assumptions, and remain open to new ideas and evidence (Adnan et al., 2021). Open-minded inquiry fosters creativity and independent thinking (Adnan et al., 2021). Further, it allows learners to create and execute their research by guiding the teacher to help them engage in scientific inquiry (Adnan et al., 2021). Open-minded inquiry, as a form of practical work, is closely aligned with IBL strategies as it encourages learners to actively construct knowledge through exploration, reflection, and the evaluation of evidence. Hence, using a variety of inquiry-based practical activities in Physical Sciences teaching ultimately helps learners acquire a wide range of scientific competencies and gets them ready for future studies in science (Pols & Dekkers, 2024). Therefore, from the distinct types of inquiry-based practical work, this study sought to investigate which type or what types of practical work teachers implement during Physical Sciences lessons.

2.3.2. The Objectives of Practical Work in Physical Sciences

Practical work in Physical Sciences is meant to provide learners with practical experience through which they can gain knowledge by observing and experimenting (Tsakeni et al., 2019). Sutiani (2021) suggests that practical work is one of the major components of learning since it teaches learners to think critically, solve problems, and ask questions. In addition, hands-on work helps learners understand the concepts they are learning more clearly (Sutiani, 2021). The practical activities also assist learners in building scientific skills, including observation, measurement, experimentation, and data interpretation (Darmaji et al., 2019). Such skills are required to conduct a scientific study and comprehend scientific principles (Darmaji et al., 2019). Van-Driel (2021) compiled a comprehensive list of practical work objectives for the Sciences, which are mentioned below:

Improving Understanding

Through practical work, learners can witness scientific concepts in action (Russell & Martin, 2023). Utecht and Keller (2019) argue that learners do not acquire practical experience that improves their ability to solve abstract problems accurately when they merely read ideas and principles from textbooks. Engaging in practical work can lead to deeper, more significant learning experiences (Uy et al., 2023).

Fostering Curiosity

The goals of practical work are to impart scientific knowledge and skills while also stimulating learners' inquisitiveness and enthusiasm for understanding the natural world (Tursunova, 2023). Moreover, practical work helps learners develop a sense of astonishment and curiosity by allowing them to explore scientific phenomena in greater detail and ask questions; thus, it helps them explore scientific concepts in a more concrete and meaningful way (Lombardi et al., 2021).

Encourages Scientific Thinking

Scientific thought is a critical activity and entails observation, inquiry, prediction, analysis, and evidence-based conclusion-making (Sutiani, 2021). Thus, doing actual, practical work encourages scientific reasoning. Furthermore, hands-on practice will enable learners to participate in such processes and develop their analytical skills in the field of Science (Alsaleh, 2020). Practical activities allow learners to examine and investigate the natural environment, thereby promoting scientific thinking, according to Oliveira and Bonito (2023). With their minds, learners can witness and gather information about scientific phenomena, which they can subsequently utilise to formulate theories and forecasts (Kitto et al., 2023). By using the data to support their scientific theories, learners are prompted to engage in scientific thinking through hands-on activities (Russell & Martin, 2023).

Developing Teamwork and Collaboration Skills

Practical work typically involves group work, which can help improve cooperation and collaboration skills, which are needed in numerous careers (Tang et al., 2020). Additionally, practical work teaches teamwork, collaboration, and problem-solving skills, essential for success in science and life (Hazapoa, 2021).

According to Gillies (2019), learners can learn to collaborate with their peers to work towards a common goal, share resources and ideas, and communicate effectively by encouraging academically useful learner conversations. Most importantly, the procedure helps develop collaborative skills, which are critical to scientific inquiry

(Suparno et al., 2023). Furthermore, cooperation and teamwork are often required to achieve significant advances and resolve challenging issues (Suparno et al., 2023).

The objectives of science education, as articulated by researchers in Physical Sciences education, encompass the development of conceptual knowledge, the acquisition of procedural skills, and an understanding of the fundamental nature of science (Höttecke & Allchin, 2020). As a result, the goals for Physical Sciences learning through hands-on activities depend on how much attention scientists and teachers give to various components of science education (Demirhan & Şahin, 2021). Although practical work is a broad term that includes a wide range of hands-on activities, not all practical work constitutes IBL. According to Utete and Ilukena (2019), basic practical activities, such as learning to handle laboratory equipment, such as a pipette, are primarily focused on developing technical skills and following prescribed procedures and therefore do not necessarily involve inquiry. In contrast, Çilekrenkli and Kaya (2023) pointed out that IBL is characterised by learners engaging in questioning, investigating, and constructing knowledge, often with varying levels of teacher guidance. Therefore, inquiry-based practical work goes beyond procedural skill development by requiring learners to explore scientific phenomena, interpret results, and draw evidence-based conclusions

In the teaching of Physical Sciences, Çilekrenkli and Kaya (2023) argue that practical activity serves several purposes. These include encouraging the acquisition of knowledge about scientific models, theories, and terminology, as well as the comprehension of significant problems in science, technique, philosophy, and history. In particular, practical work provides learners with opportunities to engage in activities that help build their scientific knowledge. Learners can perform inquiry-based tasks that help them think more critically and solve problems better (Oyewo et al., 2022). Hence, this chapter reviewed how teachers incorporate IBL strategies into their classes to achieve practical work objectives.

2.3.3. Importance of Practical Work in Physical Sciences Teaching and Learning

The importance of practical work and its role in scientific fields such as chemistry and physics have been researched by different scholars since the beginning of the 18th century (Peluso & Chankvetadze, 2022). According to Agustian et al. (2022), several studies reveal several advantages of practical work. Among these benefits are improving laboratory work, learning more about science, and gaining knowledge of scientific concepts and ideas (Agustian et al., 2022).

Jesionkowska et al. (2020) advocate for practical work in Physical Sciences, arguing that learners learn most effectively through individual engagement, which encourages active interaction with the materials. Jesionkowska et al. (2020) assert that experiential learning promotes deeper thinking and the creation of connections between the material being studied. Jesionkowska et al. (2020) further assert that learners retain information more effectively when actively engaged in the learning process. Therefore, practical work requires action and contemplation, in addition to manipulating materials to comprehend the fundamentals of science and the methods used by scientists (Russell & Martin, 2023).

In the Physical Sciences, hands-on activities are crucial. They are important for learning in the Physical Sciences because they help learners understand scientific concepts and become interested in science topics (Ramnarain, 2020). Additionally, according to Lawson et al. (2019), learners can use their practical work experience to construct scientific notation and create models to test hypotheses during the educational process. Moreover, practical experience makes it easier to grasp the difference between data presentation and data observation (Gumilar & Ismail, 2023). As a result, it is an effective instrument for teaching and building knowledge in Physical Sciences.

According to Oliveira and Bonito (2023), Practical work offers learners a foundational platform for actively engaging with scientific standards and laws. Several authors, including Martin and Borup (2022), highlight the importance of practical work in helping learners bridge theoretical and practical concepts, thereby enhancing their engagement and coordination. The aim is to enhance learners' understanding, refine their analytical skills, and recognise the fundamental principles of science by emulating the approaches of scientists (Mayer, 2023).

According to Ramzan et al. (2023), practical work is an effective strategy for fostering learners' positive attitudes, boosting their motivation to study, and enhancing their communication skills, all of which help them solve Science problems. Furthermore, Jesionkowska et al. (2020) argue that doing hands-on activities might increase learners' interest in Science and make it a more appealing subject. Learners' autonomy is fostered through practical work, which pushes them to become self-sufficient investigators able to analyse data, think critically, and solve problems (Kelly, 2023). In addition, practical work plays an essential role in the curriculum of the Physical Sciences because it not only helps learners develop their knowledge and skills but also encourages a positive attitude towards the subject (Gericke et al., 2023).

In summary, the significance of practical work in the Physical Sciences is acknowledged, as it enhances learner engagement, stimulates excitement, and develops scientific knowledge and conceptual understanding. In addition, well-structured practical activities strengthen a range of learner skills and promote meaningful scientific-practical engagement (Zulyusri et al., 2023). When effectively implemented, practical work can support learners at different levels of inquiry by presenting both mental and physical challenges that are difficult to achieve through other instructional approaches (Agustian et al., 2022). However, some Physical Sciences teachers tend to lead practical activities in a teacher-centred manner rather than incorporating inquiry-based learning (IBL) strategies. To fully realise the benefits of practical work, it must be carefully planned and effectively executed (Mukhamedov et al., 2020). Therefore, teachers are encouraged to integrate IBL-oriented strategies during practical activities, such as open-ended questioning, hands-on experimentation, and collaborative problem-solving, to enhance learner participation and deepen understanding.

2.4. Inquiry-based Learning Strategies for Practical Work

IBL strategies are learner-centred instructional techniques that emphasise learner autonomy and place less emphasis on teacher-led, procedural instruction (Soysal, 2021). According to Soysal (2021), the IBL strategy is based on the central inquiry into real questions generated from learners' experiences. During the inquiry-based lesson, teachers become facilitators, helping learners process information and communicate in groups, coach their actions, facilitate their thinking, and model their learning (Archer-Kuhn & MacKinnon, 2020). According to Al-Mamun et al. (2020), the primary function of the teacher in IBL is to serve as a guide by providing sufficient external support to enable learners to achieve successful learning outcomes. Rather than overwhelming learners with excessive information, the teacher facilitates and assists learners to independently discover information and construct an understanding of natural phenomena (Jazby, 2023).

According to Meulenbroeks et al. (2023), scaffolding used by teachers during inquiry-based classes entails providing additional external support at the start of the lesson. Meulenbroeks et al. (2023) further specify that support for learners must be gradually removed as the lesson proceeds, until they can work and learn independently. Consequently, as instructional support diminishes, learners assume greater responsibility and independence (Meulenbroeks et al., 2023). Gholam (2019) suggests that IBL strategies can encourage learners to expand their content knowledge beyond their current understanding. Gholam (2019) further argues that to effectively assist learners in advancing through the levels of inquiry, teachers should follow these principles: ensure that science is readily available, make thinking transparent, facilitate peer learning, and encourage the development of autonomous learning skills. According to Strat et al. (2023), important pedagogical strategies to be considered in IBL include how the teacher sets up the classroom, how they craft and ask questions, how they recognise what the learners already know, how they set up and lead group discussions, and how they help learners improve their ability to solve problems.

In the context of South African Physical Sciences classrooms, IBL strategies are particularly relevant as they support the development of critical thinking and problem-solving skills outlined in the national curriculum, as explained by Gholam (2019). On the other hand, it also addresses diverse learner backgrounds and varying levels of prior knowledge (Jazby, 2023). These strategies are especially valuable in practical work settings, where learners often require guided support to connect theoretical concepts with real-world scientific investigations (Jazby, 2023). By incorporating IBL, teachers in South Africa can promote active participation, improve conceptual understanding, and better prepare learners for scientific inquiry in both academic and real-life contexts. Therefore, this study investigated the application of IBL strategies during practical work by focusing on the ways in which teachers design, guide, and implement practical activities.

2.5. Teachers' Understanding of Inquiry-based Learning Strategies in Science education

A significant number of teachers lack familiarity with constructivism, leading to limited understanding of inquiry-based learning (IBL) methodologies (Camci & Buyuksahin, 2023). Wartono et al. (2019) assert that a lack of knowledge and understanding leads to teachers' confusion about IBL methodologies, with some perceiving them as suitable only for high-ability learners. Machado and Nahar (2023) assert that, despite participating in a three-year teacher development programme, teachers frequently abstained from implementing IBL methodologies in practice. This reluctance was primarily due to their misunderstanding of the notion of inquiry. Machado and Nahar (2023) further conclude that teachers are underprepared in terms of inquiry techniques and find it challenging to adopt inquiry-based strategies. In the absence of information and guidance on implementing inquiry-based methods, teachers will not be able to identify the advantages and opportunities these strategies offer (Baroudi & Rodjan-Helder, 2021). Consequently, teachers will continue to instruct learners using the conventional pedagogical methods they themselves experienced (Machado & Nahar, 2023).

Central to the questions regarding the application of IBL strategies and learning strategies are, according to Akuma and Callaghan (2019c),

- Questions about teachers' ability to design their practical work that integrates an IBL strategy as an educational technique.
- Teachers' knowledge of implementing IBL strategies during practical work, and
- The challenges teachers face in implementing IBL strategies during practical work.

Furthermore, the expertise and insight that teachers possess regarding the application of IBL methodologies in practical contexts are crucial for understanding their responsibilities (Akuma & Callaghan, 2019c). The successful execution of IBL methodologies requires teachers who not only hold the conviction that these strategies are the most effective pedagogical approaches for improving learner engagement (Hofer & Lembens, 2019). Nonetheless, the effective implementation of these strategies requires teachers who have a strong sense of confidence in their ability to apply IBL methodologies (Hofer & Lembens, 2019). Therefore, this study aimed to explore not only the methodologies teachers employ in planning and designing practical work but also their understanding of how to effectively implement IBL strategies within these contexts.

In spite of the existing research highlighting teachers' lack of knowledge, confidence, and preparedness in implementing IBL, there remains limited context-specific research on how Physical Sciences teachers in South African classrooms design and implement IBL during practical work, as well as the specific challenges they encounter in doing so. This study sought to address this gap by investigating teachers' knowledge, practices, and challenges in applying IBL strategies within South African Physical Sciences practical work contexts.

2.6. Challenges Regarding the Implementation of IBL Strategies During Practical work

Despite explaining the advantages of IBL, applying this approach during practical work poses particular challenges that cannot be ignored (Moseley & Connolly, 2021). Effendi-Hasibuan and Mukminin (2019) argue that time constraints and curriculum demand often limit the scope for open-ended inquiry, requiring careful planning and integration of inquiry-based strategies within existing lesson structures. Furthermore, a lack of resources, especially in resource-constrained schools, is another challenge that delays the implementation of hands-on activities (Shohel et al., 2022). Shohel et al. (2022) further explain that teachers also face challenges in effectively scaffolding lessons to strike a balance between providing supervision and allowing learners to be self-sufficient. Moreover, managing a classroom where learners are actively engaged in IBL can be demanding for most teachers (Nzomo et al., 2023).

Baroudi and Rodjan-Helder (2021) argue that teachers apply IBL methodologies without possessing a comprehensive knowledge of the subject matter and the necessary abilities to support learning. Baroudi and Rodjan-Helder (2021) further maintain that the teachers' insufficient expertise ultimately contributes to a decrease in learners' interest in Physical Sciences. Furthermore, teachers' expertise and pedagogical knowledge of conducting practical work remain a challenge (Van-Graan, 2020). Their content knowledge and pedagogical skills affect the implementation of IBL strategies and deteriorate the value of teaching and learning of Physical Sciences (Van-Graan, 2020).

Although inquiry-based approaches are widely accepted worldwide as the best ways to teach and understand science, many teachers still do not want to use this method when teaching Physical Sciences (Adigun, 2022). The obstacles to the adoption of inquiry-based techniques in practical work stem from aspects linked to Physical Sciences teachers' pedagogical skills and the prevailing culture within school sciences

(Xaba & Sondlo, 2023). Bergmark (2023) believes that challenges encountered by teachers in implementing IBL methodologies during practical activities can be categorised into three distinct groups: issues related to the educational system, issues related to resources, and issues related to the individual teacher. Hence, to promote the successful execution of strategies during practical work, teachers ought to possess a systematic understanding of IBL (Spernes & Afdal, 2023). They also need to know enough about how scientific information is put together and how to use IBL methods (Spernes & Afdal, 2023). Consequently, this chapter examines the difficulties encountered by teachers throughout their preparation of inquiry-based practical work. Therefore, these challenges were fundamental to this study, as they informed the research into how Physical Sciences teachers in the South African perspective understand, plan, and implement IBL strategies during practical work.

2.7. Benefits of Inquiry-based Learning Strategies in Practical Work

Inquiry-based learning (IBL) strategies are some of the most effective teachings and learning techniques in Physical Sciences (Pabón-Galán et al., 2022). In IBL, learners are presented with the process of knowledge generation and expression, as well as the means by which they can acquire the knowledge and abilities necessary to become lifelong learners (Radu & Schneider, 2019). Incorporating IBL strategies during practical work promotes learners' enthusiasm and willingness for learning about the Physical Sciences, increasing their participation and influencing their academic achievement (Xaba & Sondlo, 2023). Furthermore, implementing IBL strategies during practical work encourages learners to ask questions, develop hypotheses, and design investigations (Singh, 2020). According to Arabacioglu (2022), inquiry-based strategies foster a rooted understanding of scientific concepts.

Through IBL strategies, practical work allows learners to connect theory to real-world applications, enhancing their appreciation for the scientific method and its relevance to their lives (Rafiq et al., 2023). Gholam (2019) further argues that inquiry-based strategies inspire critical thinking, increase learner participation, foster learner independence, build curiosity, enhance problem-solving skills, promote collaboration, and develop communication skills. Gholam (2019) further notes that IBL strategies help learners connect real-life experiences to theory, to put theory into practice.

IBL strategies help learners acquire scientific ways of thinking and enhance their considerable science abilities. (Gizaw & Sota, 2023). Considerable science abilities are habits of mind that people create to organise and package their thoughts (Nykyporets et al., 2023). Among them, as stated by Nykyporets et al. (2023), are critical thinking, evidence-based reasoning, problem-solving, communication and decision-making, and metacognitive processes. Furthermore, engaging learners with IBL strategies during practical work improves their interpretive, scientific reasoning, questioning, and critical thinking proficiencies, towards a more profound understanding (Alsaleh, 2020). According to Sahintepe et al. (2020), IBL strategies significantly improve learners' problem-solving and Science process techniques. This resulted in enhanced practical work experience for learners and increased enthusiasm for Physical Sciences (Sahintepe et al., 2020). Furthermore, Sahintepe et al. (2020) opine that active learner engagement in hands-on activities, such as describing objects and events, posing questions, and constructing explanations, enhances their understanding of Physical Sciences. Furthermore, when learners evaluate explanations in relation to existing scientific knowledge and talk about their views with other learners, they enhance their capacity to understand concepts in Physical Science (Sahintepe et al., 2020).

According to Xaba and Sondlo (2023), learners' strong proficiency in practical work contributes to their knowledge acquisition and provides a meaningful context for learning. In addition, strong proficiencies enhance the comprehension of Physical Sciences content (Xaba & Sondlo, 2023). The values of employing IBL strategies during practical activities are most effectively summarised by the eight key components of inquiry-based science instruction outlined by Akuma and Callaghan (2019a): IBL strategies enhance learners' comprehension of fundamental Science concepts, encourage the development of process and critical thinking skills, and cultivate a sense of the connections between Physical Sciences, technology, and society. They provide learners with experiences that help them understand, change, or improve how they see the world. Additionally, these strategies accommodate a variety of learning approaches, offer multiple means for learners to demonstrate their understanding, and actively involve learners in an ongoing learning cycle. This chapter, in summary, endorses the advantages of IBL for practical work as articulated by Akuma and Callaghan (2019a). Consequently, this study aimed to examine the challenges, if any, encountered by teachers in implementing IBL strategies during practical work.

2.8. Comparison of the Literature on IBL in Physical Sciences Practical Work

Across studies in Physical Sciences education, IBL is consistently framed as a learner-centred approach that shifts practical work from following instructions to doing science. However, the literature differs in emphasis, depth of implementation, and reported outcomes.

2.8.1. Focus of IBL implementation

Conceptual understanding against procedural skills

Studies such as Arabacıoğlu (2022) and Rafiq et al. (2023) emphasise conceptual understanding, showing that learners develop scientific meaning when they actively construct knowledge through experiments. In contrast, Sahintepe et al. (2020) highlight improvements in science process skills (observing, hypothesising, experimenting, interpreting data), suggesting that IBL strengthens procedural competence in laboratory settings. Therefore, some literature prioritises knowing science (conceptual understanding), while others prioritise doing science (process skills), but few integrate both equally.

Level of learner autonomy

Gholam (2019) and Singh (2020) describe IBL as promoting high learner autonomy, where learners generate questions, design investigations, and construct explanations. However, Xaba and Sondlo (2023) and Alsaleh (2020) show that in many classroom realities, IBL is implemented as guided inquiry, where teachers still heavily structure tasks due to curriculum constraints and learner readiness. Therefore, there is a gap between the ideal open inquiry model and the actual guided/structured inquiry practices used in classrooms.

Teacher role and pedagogical shift

Pabón-Galán et al. (2022) and Radu and Schneider (2019) present teachers as facilitators of knowledge construction, guiding learners through inquiry cycles. However, several studies, including Xaba and Sondlo (2023), note that teachers often struggle to shift from traditional recipe-style practicals to facilitative roles due to a lack of training, time pressure, and large class sizes. In contrast, literature supports a facilitative role, but implementation studies reveal persistent teacher-centred practices.

Learner engagement and affective outcomes

Studies such as Gholam (2019) and Sahintepe et al. (2020) agree that IBL increases motivation, curiosity, participation, and collaboration. However, researchers such as Xaba and Sondlo (2023) critically examine sustained engagement over time, instead focusing on short-term intervention effects. Therefore, there is strong evidence for immediate engagement, but limited evidence for long-term affective impact.

Contextual and infrastructural influence

Studies in well-resourced contexts, for example, some Asian settings in Sahintepe et al. (2020), report successful implementation with structured laboratory environments. In contrast, studies in developing contexts, for example, Xaba and Sondlo (2023), in their African classroom-based research, highlight constraints such as a lack of laboratory equipment, overcrowded classrooms, and limited time for inquiry cycles. Thus, the effectiveness of IBL is highly context-dependent, especially on resource availability.

Assessment practices in IBL

Rafiq et al. (2023) and Alsaleh (2020) suggest that IBL improves reasoning and interpretation skills. However, most studies note a disparity between IBL goals and traditional assessment methods, which still focus on recall and procedural correctness rather than inquiry processes. On the contrary, teaching approaches are inquiry-based, but assessment systems remain traditional.

2.9. Practical Work in the South African Physical Sciences Curriculum

The South African Physical Sciences Curriculum and Assessment Policy Statement (CAPS) promote a scientific inquiry approach that emphasises the use of hands-on practical activities to develop explanations and predictions of natural phenomena (Department of Basic Education [DoE], 2011). The CAPS necessitate the cultivation of investigative and procedural abilities in learners, including classification, measurement, model formulation, hypothesis generation, communication, conclusion analysis, and variable recognition and monitoring (Langa, 2021). Therefore, teachers who facilitate practical activities enhance learners' development of investigative and procedural skills.

The DoE (2011) states that the CAPS curriculum for Physical Sciences mandates formal assessments for the Further Education and Training (FET) band (Grades 10–12), allowing learners to engage in one or more practical tasks each term. Practical work prescribed by the curriculum is required in each grade per term. As a result, the curriculum does not oblige teachers to conduct practical work during their daily teaching (Bertram, 2021). For instance, within the 10th and 11th grade cohort, there are two required experiments each year: one in Physics and one in Chemistry, as formal assessments, with one experiment scheduled per term for Terms 1 and 2 (Department of Basic Education, [DoE], 2011). For Grade 12, on the other hand, three mandatory experiments are done every year. These include one or two Physics experiments and one or two Chemistry experiments as formal tasks. These assessments include one experiment per term across Terms 1, 2, and 3 (Department of Basic Education, [DoE], 2011).

The DoE (2011) argues that the CAPS curriculum stipulates that the instruction of practical and inquiry skills should remain an uncomplicated directive for teachers in all situations. Nonetheless, the circumstances in South Africa, characterised by constrained classroom resources, pose significant challenges to the execution of practical work within educational settings (Du Plessis, 2020). Moreover, the shift in curriculum focus, as reflected in CAPS's prioritisation of problem-based practical activities, presents a novel challenge for numerous teachers in South Africa who may be accustomed to a curriculum rich in content and information (Sebatana & Dudu, 2022). The researcher of this study posits that these teachers may possess a constrained background in practical application during their teacher training programmes. Numerous teachers are consequently inclined to express a range of concerns regarding the recent emphasis on increasing practical work within the Physical Science CAPS curriculum, even as they attempt to implement it as mandated by the authorities.

Teachers predominantly function within the realms of systematic and habitual practices because the CAPS curriculum is not seen to support them in their proper advocacy (Damoah et al., 2024). According to Damoah et al. (2024), this may result in a teacher-centred methodology during practical work and limit learner engagement. As a result, with less advocating for the CAPS curriculum, learners may merely observe what their teachers do, with no active engagement (Ngobeni et al., 2023). For this purpose, teachers may not be seen to be carrying out the CAPS practical task as policymakers planned. Furthermore, teachers may be low on time and resources because the weekly instruction time is four hours, which includes practical work (Ngobeni et al., 2023). Limited content and pedagogical understanding of the subject may also contribute to the nominal execution of CAPS practical work, as noted by Naidoo (2022). Furthermore, teachers may use traditional teaching strategies when conducting practical work. As a result, they have little potential to stimulate learners' interaction with practical tasks.

The reviewed literature, therefore, reveals that although IBL is generally recognised for refining learners' understanding of Physical Sciences, its implementation in practical work remains limited. Many teachers still rely on traditional, teacher-centred approaches, reducing opportunities for meaningful inquiry. Persistent challenges include limited understanding of IBL, insufficient skills development, and systemic constraints within schools.

2.10. Conceptual Framework

This study used Bybee's 5E Learning Cycle Model and the levels of IBL strategies as its conceptual framework. The 5E learning cycle model is an educational framework that emphasises effective learning, inquiry-based teaching, and collaborative knowledge-acquiring procedures to improve understanding and retention of concepts (Bybee, 2002). It involves five stages: Engage, Explore, Explain, Elaborate, and Evaluate. On the one hand, the IBL approach involves various levels of investigation in scaffolding a lesson (Tiaradipa et al., 2020). They are confirmatory, structured, guided, and open inquiry. In this study, the frameworks provided a clear, structured model for guiding inquiry-based practical work through its sequential phases, while also aligning with different levels of inquiry. Additionally, they allowed the study to systematically examine how teachers design and implement IBL in classroom practice

(Husni, 2020). Therefore, supporting the analysis of both teacher facilitation and learner engagement, which are central to understanding effective IBL implementation in Physical Sciences.

According to Wale and Bishaw (2020), Inquiry instruction is the core of IBL. It is a type of active learning that focuses on asking questions, analysing evidence, and thinking critically (Wale & Bishaw, 2020). Saad (2020) supposes that inquiry instruction emphasises the teaching methodology and the level of inquiry, thereby fostering learners' active participation in making them hands-on. Inquiry instruction focuses on learners' capacity to investigate questions derived from their lived experiences and to pursue answers that describe natural occurrences (Husni, 2020). For these reasons, the two frameworks used in this study helped the researcher investigate how much information is provided to learners as the lesson progresses and how much guidance and support the teacher provides during practical work.

For this study, the two frameworks were seen to be complementary, with each other serving a distinct yet interrelated function in the design and analysis of practical work. The 5E model provided a structured sequence for instructional delivery, while the levels of IBL indicated the degree of learner autonomy within each phase. Additionally, these frameworks were systematically integrated by aligning specific levels of inquiry with the phase of the 5E model to guide both pedagogical implementation and analytical procedures. Furthermore, the frameworks informed the data presentation and analysis. The two frameworks are explained in detail in the sections below.

2.10.1 The 5E Learning Model

The 5E learning cycle model provides a structured framework for IBL that teachers can effectively utilise (Bybee, 2002). This model complements IBL at various levels. Bybee (2002) indicates that when learners participate in IBL at various levels during practical work, they are expected to navigate through various stages of learning. Bybee (2002) provides a detailed explanation of the 5E learning cycle model, which organises learning events to facilitate learners' construction of knowledge about a subject. Furthermore, Bybee (2002) asserts that teachers' application of the 5E model during practical activities can effectively guide learners through five distinct stages of learning, each clearly articulated with terms beginning with the letter E: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Figure 2.1 below illustrates Bybee's 5E Learning Cycle Model.

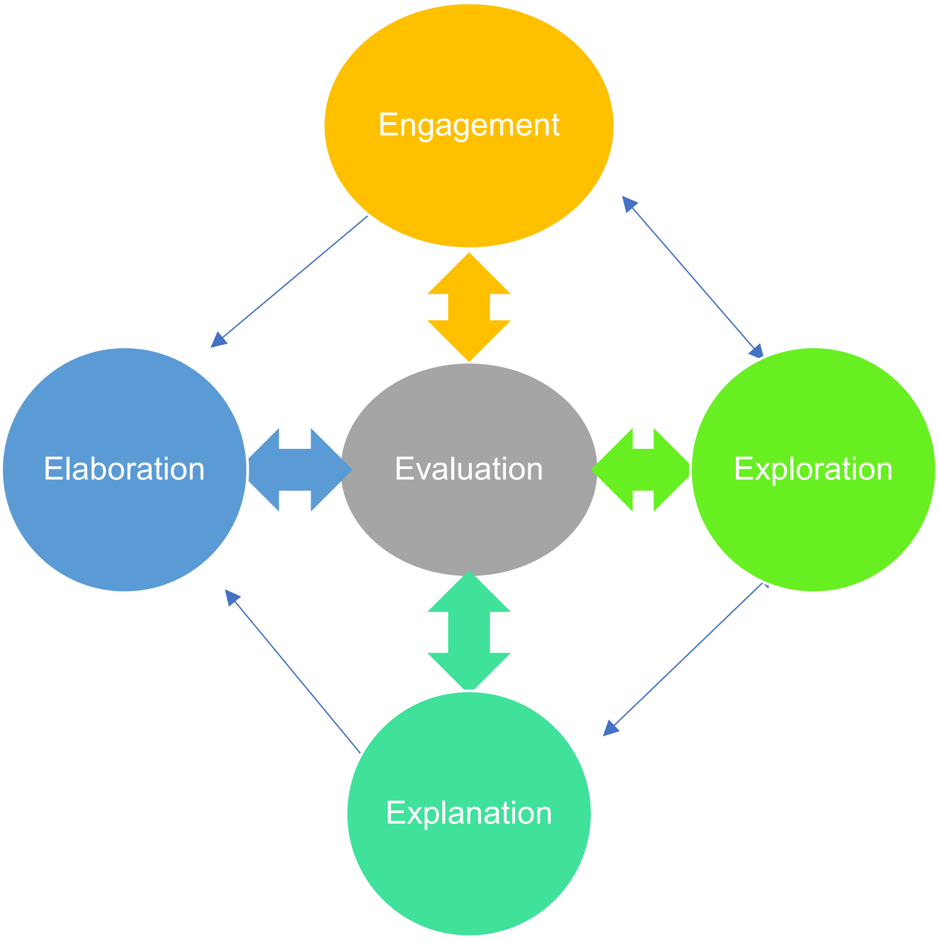


Figure 2.1: *Bybee's 5E Learning Cycle Model (Bybee, 2002)*

Engagement Phase

In the first phase, the teacher draws learners' attention and sparks their interest in the topic or topics to be studied (Bybee, 2002). Bybee (2002) argues that the phase allows a teacher to determine what learners already know or feel they know about the topic and the ideas that will be taught. At this phase, teachers use an interesting, engaging, or challenging question or demonstration to pique learners' interest, curiosity, and focus on the topic or idea (Bybee, 2002). Consequently, the teacher involves learners in the learning process by encouraging them to reflect on the problem, situation, or event and how it relates to things they have done in the past, and things they will do in the future (Ergin, 2012).

Exploration Phase

The subsequent phase entails a teacher facilitating opportunities for learners to engage with materials and concepts through experiential learning and collaborative small-group discussions (Hsiao et al., 2022). Bybee (2002) suggests that this phase facilitates the acquisition of a shared set of experiences among learners, enabling them to engage in comparative analysis of results and ideas with their peers. Learners acquire experience and a deep understanding of concepts through hands-on activities (Bybee, 2002). Tsakeni (2022) elaborates that during this phase, the teacher directs and supports learners as they engage in hands-on or problem-solving exercises and practical work intended to help them learn more about the topic. The main goal of the exploration phase is to create experiences that both the teacher and learners may use to effectively develop a skill, process, or idea (Rahman, 2023). Hence, learners frequently engage in learning by collaborating in groups and exchanging shared experiences.

Explanation Phase

The third phase involves learners linking their previous experiences to their current learning and conceptualising the key concepts (Bybee, 2002). The phase offers an opportunity to present scientific terminology and content that can enhance learners' comprehension of their prior experiences. During the explanation phase, the teacher directs learners to specific parts of the engagement and discovery phase and helps them clearly and thoroughly explain ideas, processes, and skills (Pfende et al., 2022). The teacher then explains important words and helps learners identify patterns, examine outcomes, and draw conclusions based on their performance (Bybee, 2002).

Elaboration Phase

The fourth phase involves learners applying introduced concepts to new situations (Whittle et al., 2020). Bybee (2002) suggests that the introduced concepts enable learners to establish conceptual links between new and existing knowledge, integrate ideas, and enhance their comprehension of concepts and processes. Learners subsequently expand upon previously acquired concepts or ideas, establishing relationships with other relevant ideas and novel situations (Bybee, 2002). During this phase, learners participate in additional activities that enhance or explain the ideas, steps, or abilities previously acquired (Jesionkowska et al., 2020).

Evaluation Phase

Bybee (2002) points out that the phase is essential to the paradigm and is present at nearly every stage of the 5E learning cycle model, enabling teachers to prepare a summative evaluation of learners' expertise. Furthermore, the assessment phase is considered crucial because it allows teachers to measure learners' attention during subject presentation through practical activities (Bybee, 2002). In this phase, the teacher will formally evaluate learners' understanding of the concepts learned (Admiraal et al.,2021). Learners are also permitted to assess their comprehension by applying the skills they have acquired (AlAli et al., 2023).

In the 5E learning model, learners' progression from one phase to the next is predominantly contingent on the teacher's support. According to Assem et al. (2022), questioning is a core support strategy that is consistent with the constructivist learning principle (Assem et al., 2022). Hence, Zain et al. (2022) contend that in an inquiry-based classroom, teachers must pose creative questions that necessitate thought and analysis, hence motivating learners to seek solutions and rationalise their actions. Teacher worksheets, during practical work, are essential for helping learners feel a sense of order and purpose in their research and for giving them a way to become more independent learners (Yıldız-Feyzioğlu & Demirci, 2021).

Tawfik et al. (2020) assert that teachers may pose four categories of questions based on the required assistance and the learners' level of inquiry: clarifying, focusing, probing, and prompting inquiries. During practical work, teachers pose clarifying questions to help learners articulate their thoughts and comprehension more explicitly, emphasising questions that promote specificity rather than vagueness. Probing questions prompt learners to clarify, justify, or expand on their initial responses while guiding them towards a specific focus (Chen, 2022).

Zain et al. (2022) deem that in an inquiry-driven classroom, teachers must pose creative questions that require analysis and reflection, thereby prompting learners to seek solutions and rationalise their practices. Tawfik et al. (2020) assert that teachers may employ four categories of questions during learner assessment, contingent on the required assistance and learners' levels of inquiry: clarifying, focusing, probing, and provoking inquiries. The purpose of using probing questions is to guide learners in a specific direction while also encouraging them to elaborate, justify, or supplement their initial responses (Chen, 2022).

2.10.2 Levels of inquiry-based learning strategies for practical work

Inquiry-based learning (IBL) techniques for practical work include confirmatory, structured, guided, and open inquiry (Schiering et al., 2023). Table 2.2 outlines the levels of IBL techniques employed in the study, as stated by Lederman (2009).

Table 2.2: *Levels of IBL and their descriptions (Lederman, 2009)*

Level	Description
Level 1 ***(Confirmation Inquiry)***	• Learners confirm existing knowledge • Follow prescribed procedures • Answers are provided
Level 2 ***(Structured Inquiry)***	• Learners formulate questions based on given data or problems • Teacher provides guidelines and procedures • Answers are not predetermined
Level 3 ***(Guided Inquiry)***	• Learners formulate questions independently • Teacher provides guidance and resources • Learners formulate investigations and design experiments
Level 4 ***(Open Inquiry)***	• Learners formulate questions, design, and execute investigations. • The teacher serves as a facilitator, offering support and resources. • Learners formulate conclusions derived from their findings.

As shown in Table 2.2 above, IBL methodologies can be used at different levels (Singh, 2020). Hence, Mackenzie et al. (2021) studied the four distinct levels of learner-inquiry applicable during hands-on instruction. These authors went on to say that teachers typically start the class with a structured inquiry model, then move on to confirmation inquiry, then guided inquiry, and, if everything goes well, end with open inquiry. As a result, this study adopted the four levels of IBL as explained by Mackenzie et al.

(2021). Therefore, the learner-inquiry levels that can be implemented during practical work are summarised below.

Confirmation Inquiry

A confirmation inquiry represents the most basic level of inquiry, in which learners validate a theory through an activity with predetermined outcomes (Sotakova et al., 2020). Furthermore, this form of inquiry is employed by teachers to instruct and exemplify a concept that is already understood (Sotakova et al., 2020). At this stage, the teacher introduces learners to the investigation's questions, aims and objectives, the research questions, methodology, and data collection sheet (Dita et al., 2021). The inquiry is primarily centred around the teacher, with learners serving mainly as respondents to teacher-led activities (Dema & Yuden, 2022). According to Gericke et al. (2023), confirmation inquiry is most effectively employed to instruct and familiarise learners with practical procedures, specifically to help them understand what constitutes a well-formulated testable question, methods for secure experiment design to investigate a research question, and how to gather and analyse data to come to conclusions based on facts.

To actively engage learners in hands-on activities linked to confirmation inquiry, teachers should use techniques such as discrepant occurrences and the Predict-Observe-Explain (POE) method (Kahraman, 2023). However, in discrepant events, learners must observe and recognise unforeseen results that conflict with their typical experiences or anticipations (Potvin, 2023). Compared with discrepant events, the POE technique requires learners to use basic skills, including predicting what will happen, observing the consequences, and providing an explanation or inference (Dogan et al., 2023). The POE technique is an outstanding example of interactive learning in the field of educational approaches, helping learners and teachers navigate the complex web of comprehension to enhance understanding of scientific concepts (Wang & Wang, 2023).

Structured Inquiry

This level of inquiry involves learners examining the teacher's questions through a defined procedure while remaining unaware of the outcomes (Spernes & Afdal, 2023). During practical work, the teacher articulates the investigative question, outlines the procedure, and specifies the method for data recording, while learners adhere to the provided instructions (Tsakeni et al., 2019). Learners are actively involved in analysing and interpreting the results, while the teacher facilitates their understanding through targeted questions to reach the necessary conclusions (States et al., 2023). This form of inquiry is regarded as low because it has limited autonomy, is memorisation-focused, is prone to recipe-following, overemphasises confirmation, and is perceived as lacking authenticity (Baccarella et al., 2021).

Guided Inquiry

In a guided inquiry, learners explore a question posed by their teacher, while independently determining the methods of investigation, with the outcomes remaining unknown to them (Bui et al., 2020). The teacher selects the question for investigation during practical work, while learners, with the teacher's assistance, develop the procedure for conducting the investigation (Peel, 2020). Peel (2020) further notes that at this stage of inquiry, the teacher instructs learners in the specific skills required for open inquiry investigations. Guided inquiry is an instructional strategy that falls between open and structured inquiry on the IBL spectrum (Oliver et al., 2021). Compared to structured inquiry, guided inquiry offers learners greater freedom and flexibility while maintaining some structure and supervision to support the learning process (Trask & Cowie, 2022). This form of inquiry might be suitable for the study, as it will provide learners with an opportunity to approach the open inquiry with a thorough understanding of the procedures they have acquired.

Open Inquiry

According to Lederman (2009), open inquiry is the most advanced form of inquiry. Open inquiry is entirely focused on the learner, who starts by formulating questions about a given topic to be researched and then decides on the steps to take (Jegstad, 2023). Learners ask questions based on what they already know about the subject (Sakata et al., 2023). Additionally, learners take on the function of autonomous learners, during which they design their own activities and collect information, come up with hypotheses, make sense of the data they have, describe their ideas on a specific natural event, and share the power to find the answers (MacLeod et al., 2022). According to Akuma and Callaghan (2019c), as learners engage in the inquiry process, teachers provide increased support and autonomy, progressively diminishing their assistance over time. Therefore, learners need to be able to think critically to do practical work well in open inquiry. This study follows an open inquiry approach, a type of IBL that fosters learner autonomy in exploring scientific concepts.

In summary, various IBL strategies are employed for different types of lessons and cater to specific requirements within Physical Sciences classrooms (Akuma & Callaghan, 2019a). Therefore, IBL strategies are more learner-focused and assist teachers in diversifying teaching and learning experiences in the Physical Sciences classroom to address learners' needs more effectively (Mkandla, 2021). An inquiry-based Physical Sciences classroom, therefore, provides learners and teachers with the opportunity to engage in practical work in Physical Sciences in an engaging and dynamic manner (Chen, 2020). Therefore, this study employed the four levels of IBL as strategies that teachers can implement during practical activities.

2.11. Conclusion

This chapter began with definitions of IBL and practical work. The discussion addressed the types and objectives of practical work, as well as its significance in the teaching of Physical Sciences. This chapter further examined the implementation of IBL strategies in practical work and the teachers' comprehension of IBL within the context of Science education. This chapter also emphasised the advantages and difficulties of implementing IBL strategies in practical work. This chapter also notes that successful practical work can be conducted through appropriate pedagogical strategies (Anthony & Walshaw, 2023). Furthermore, science curriculum and teaching depend primarily on the strategies that engage learners and improve their ability to learn independently (Lombardi et al., 2021). Finally, the conceptual framework for the phases of learning and the levels of the IBL approach, as included in the 5E model, was reviewed.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1. Introduction

The previous chapter provided a literature review regarding the implementation of inquiry-based learning (IBL) strategies by teachers during practical work. To examine their implementation of the techniques, the preceding chapter addressed the following: Teachers' knowledge of IBL strategies, obstacles in executing these approaches during practical activities, and the benefits of IBL strategies in practical contexts. In addition, the chapter addressed the conceptual structure guiding the study. This chapter is intended to provide details on how this study was carried out. These involve the sampling strategy, the study's paradigm and methodology, sampling techniques, and data collection techniques. The chapter continues to address the data analysis, trustworthiness, and ethical issues that emerged in this research project. Table 3.1 below offers a synopsis of the research approach used in this study.

Table 3.1: *Summary of the research methodology*

Components	Categories
Research questions of the study	**The main research question** How do teachers implement IBL strategies during practical work in Physical Sciences? **Sub-questions:** • How well do teachers understand and apply IBL strategies in practical Physical Sciences activities? • How do teachers design practical work activities to incorporate IBL strategies into their lessons? • What challenges, if any, are experienced by teachers when implementing IBL strategies during practical work in Physical Sciences?
Research paradigm	Interpretivist paradigm
Research approach	Qualitative approach
Research design	Case study
Sampling methods	Purposive sampling
Data collection tools	Semi-structured interviews, Observations, and Document analysis
Data analysis	Thematic analysis

3.2. Research Paradigm

Kotlarsky and Oshri (2023) describe research paradigms as frameworks of hypotheses and beliefs designed to enhance knowledge and comprehension. The research paradigm shapes the way one perceives and understands the world (Pervin & Mokhtar, 2022). The same approach affects how study data are analysed and how research methodologies are chosen (Pervin & Mokhtar, 2022). Carcary (2020) states that research paradigms represent the comprehensive and prevailing framework that guides the conceptual perspective, methodological approach, and foundational assumptions that support a research inquiry. Additionally, Mkansi and Mkalipi (2023) describe paradigms as foundational principles that help refine a specific area of study, shape the methodology for developing research questions, collecting and analysing data, and deriving significant conclusions.

The concept of 'research paradigm' includes four related ideas: ontology, epistemology, axiology, and methodology (Gannon et al., 2022). These assumptions influence all facets of the research, encompassing data collection and analysis. Ontology analyses the essence of reality, epistemology evaluates the acquisition of information regarding it, axiology investigates ethical issues, and methodology addresses the methods of quantifying reality (Setiawan & Syamsuddin, 2022). Qualitative research is based on five main ideas: interpretivism/constructivism, advocacy/participatory, pragmatism, critical theory, and phenomenology (Tumoce-Tulele, 2019).

This research utilised the interpretivist paradigm, founded on the premise that reality necessitates interpretation because there is no singular reality (Panya & Nyarwath, 2022). The interpretivist paradigm endeavours to comprehend the subject's viewpoint, whereas the researcher seeks to understand others' opinions on reality better (Pervin & Mokhtar, 2022). This paradigm emphasises the ability of humans to extract meanings from their experiences (Pervin & Mokhtar, 2022). Pervin and Mokhtar (2022) further assert that researchers ought to analyse these meanings, acknowledging that reality is not a static entity, but a construct established by the research participants. Additionally, the researcher must acknowledge that reality is context-dependent, allowing for multiple interpretations (Pervin & Mokhtar, 2022). The interpretive paradigm was especially appropriate for this investigation for the following fundamental reasons:

Subjectivity and Contextual Understanding

According to Pervin and Mokhtar (2022), the interpretive paradigm recognises that subjective interpretations of the world influence human behaviour. In this study, the interpretive paradigm acknowledges that teachers' actions and decisions are shaped by their pedagogical knowledge, teaching experience, and the context in which they teach. The paradigm enabled the researcher to explore teachers' understandings of inquiry-based learning (IBL) strategies and how they interpret and implement them in their lessons.

Qualitative Inquiry

The interpretive paradigm is closely related to qualitative research methods, such as interviews, observations, and ethnography (Pervin & Mokhtar, 2022). In this study, these methods were well-suited for exploring the complex and significant nature of teaching practices, including the application of IBL strategies. A qualitative study enabled the researcher to collect rich information on teachers' experiences and knowledge, perceptions, and classroom interactions. Furthermore, it provided a deeper insight into their decision-making processes and teaching methodologies.

Meaning-Making and Constructivism

The interpretive research paradigm, according to Chuang (2021), emphasises the importance of understanding how learners make meaning of their experiences and construct knowledge within specific social contexts. In this study, this paradigm enabled the researcher to explore how teachers make sense of IBL approaches, how they perceive their role during practical work, and how they encounter and address the challenges and opportunities associated with implementing IBL strategies in their teaching.

Contextual Factors

According to Rahman (2023), the interpretive paradigm acknowledges the significance of contextual factors in shaping human behaviour. In the context of this dissertation, this paradigm enabled consideration of numerous related influences, including school policies, teaching and learning resources, curriculum frameworks, and societal expectations. Hence, understanding these contextual factors was essential for interpreting teachers' practices and effectiveness in supporting IBL strategies in science education. Furthermore, the interpretive paradigm offered a complete and important approach to this study, emphasising the importance of individual interpretations, qualitative inquiry, meaning-making, constructivism, and contextual understanding. By adopting this paradigm, the researcher gained a deeper understanding of the difficulties of teaching and learning processes in science education, ultimately informing the development of more effective pedagogical approaches and teacher professional development initiatives.

3.3. Research Approach

To investigate how Physical Science teachers employ IBL strategies in practical work, the researcher employed a qualitative methodology after a comprehensive assessment of the merits of both qualitative and quantitative research approaches. Kraiwanit et al. (2023) characterise qualitative research as a methodological approach including the methodical examination and study of written, spoken, or visual texts to reveal their intrinsic meanings and interpretations. Qualitative research integrates several data collection methods and analytical instruments to establish a conceptual framework and theoretical contribution through the analysis of participants' experiences and their interconnections (Ozuem et al., 2022). Langley and Meziani (2020) argue that qualitative research aims to explore the intricate nature of human perceptions, attitudes, and social phenomena as they manifest in their authentic contexts.

A qualitative methodological approach collects, examines, and evaluates information on visual and oral history through open-ended questionnaires, participant observation, interviews, and document analysis (Ayala & Koch, 2019). A variety of qualitative approach elements were effective in addressing the questions guiding this study. The qualitative approach was appropriate for this study, as it provided a thorough insight into beliefs, actions, experiences, and points of view (Pandey & Pandey, 2021). This method mainly focused on understanding how people make sense of their life events. This method was appropriate for this investigation due to the following:

- It could offer an opportunity to analyse and elaborate on the topic under investigation.

- The researcher, as the primary instrument, was the primary instrument for obtaining and interpreting data.
- The researcher drew upon rich descriptions and meanings, not numbers. For instance, instead of numbers, more descriptive words and images were utilised to convey outcomes. In this context, the participants were discussed. Therefore, the extracted data were incorporated to substantiate the findings.
- The approach emphasised the significance of context. The location, participants, and subject matter were significant in the study. The analysed data and produced interpretations were acknowledged not as biases to be eliminated, but as subjectivities to be integrated.

3.4. Research Design

Research designs serve as systematic approaches for gathering, analysing, interpreting, and presenting data within research studies (Nneoma et al., 2023). The process involves conceiving and executing the study, as well as synthesising the findings (Nneoma et al., 2023). Hendren et al. (2023) articulate that research design encompasses the plans and procedures for conducting research, transitioning from overarching assumptions to specific methodologies for data collection and analysis. Muzari et al. (2022) elaborate on a research design as a strategic guiding structure that directs the investigator in the processes of data acquisition, quantification, and evaluation. A research design must be specifically crafted to tackle questions guiding the research, ensuring an effective investigation that yields significant insights into the topic at hand (Hendren et al., 2023). Various qualitative research designs are available for selection when conducting qualitative research studies (Muzari et al., 2022). For instance: ethnography, phenomenology, grounded theory, narrative research, and case study (Muzari et al., 2022).

This research employed a case study design to gather qualitative data. Schoch (2020) characterises case study research design as a strategy that involves a comprehensive analysis of a specific case, which may include a group of individuals, an organisation, an event, or a phenomenon within its real-world setting. A case study is designed to achieve a thorough and in-depth comprehension of the subject being examined by analysing a small number of cases critically (Starman, 2013). A case study provides researchers with a comprehensive examination of a specific group, enhancing their knowledge and understanding of current circumstances (Starman, 2013).

This research employed an exploratory case study methodology, following Yin (2014). Yin (2014) suggests that an exploratory case study is used when a researcher investigates a phenomenon that is not yet clearly defined or has been insufficiently studied. Therefore, in this study, an exploratory case study entails a thorough, systematic examination of one or more cases to achieve an initial understanding of a specific phenomenon (Patnaik & Pandey, 2019). Notably, an exploratory case study was conducted to gain preliminary insight into teachers' implementation of IBL strategies in practical work, offering detailed accounts of their experiences and challenges. The exploratory case study was appropriate for this research, facilitating an examination of the phenomenon within its context through multiple data-generating sources, as outlined by Schoch (2020). In addition, the exploratory case study employed in this research provided an accurate portrayal of teachers' knowledge of implementing IBL strategies during practical work and of their design of practical work activities to incorporate these strategies.

3.5. Population and Sampling

The term population refers to the complete set of individuals a researcher seeks to examine and from which conclusions are derived (Pandey & Pandey, 2021). The research population comprised Physical Sciences teachers in Gauteng, South Africa. Sampling is the method of selecting subjects for a research study, including individuals, events, objects, or behaviours (Obilor, 2023). This research adopted purposive sampling as its methodological approach. Rahman (2023) defines purposive sampling as a non-probability sampling technique used in research and data collection. According to Rahman (2023), purposive sampling involves the intentional selection of specific individuals or groups from a population based on characteristics or attributes relevant to the objectives of the research project.

The application of purposive sampling was suitable for this study, as it facilitated the researcher to carefully select participants who could help the researcher understand how Physical Science teachers implement IBL strategies within the Tshwane South District and ensure rich, appropriate data for analysis. Although the sample comprised only five teachers, this size is considered appropriate for qualitative research of this nature, where the emphasis is on depth rather than breadth of understanding (Rahman, 2023).

The adequacy of the sample size is supported by the concept of data saturation, which refers to the point at which no new themes, patterns, or insights emerge from the data (Pandey & Pandey, 2021). During data collection and analysis, it became evident that responses from the participants began to converge, with recurring themes and shared experiences across the different schools. This indicated that sufficient depth had been achieved and that additional participants were unlikely to yield significantly new information (Obilor, 2023). Therefore, the sample size of five teachers was deemed sufficient to reach data saturation and to provide a comprehensive understanding of the phenomenon under investigation, while still allowing for in-depth exploration of each participant's perspectives.

The participants were intentionally chosen since only individuals capable of providing insights into the study's primary phenomenon were required. The researcher employed purposive sampling in this study, guided by the aim of observing, understanding, and deriving insights from the sample (Sukmawati et al., 2023). Consequently, the sample must exhibit most, if not all, of the characteristics desired by the researcher. Participants were selected based on the objectives of this study.

The criteria specified below were used to determine the sample of participants for this investigation.

- The participants had to teach in the Tshwane South District.
- They should be teaching Physical Sciences within the Further Education and Training (FET) phase.

3.5.1. Cases

The research involved five male participants who volunteered to take part in the study: Tshepo, John, Willy, Mpho and Lebo (pseudonyms) from five secondary schools. The cases are detailed below:

Case 1: Tshepo from School A

School A is a public institution situated in the eastern suburbs of Pretoria. The facility includes 43 classrooms, five active laboratories, two computer labs, three art studios, and a library. The organisation is structured with a principal at the top, who is supported by two Deputy Principals and ten Heads of Departments. The institution has a faculty of 58 teachers and serves an instructional body of 1,183 learners. The institution provides education for learners in Grades 8 to 12. Tshepo has dedicated 11 years to educating learners on Physical Sciences at this institution. While collecting data, Tshepo taught Physical Sciences for Grades 10-12 and Natural Sciences for Grade 9. Tshepo holds a Master of Science (M.Sc.) in Applied Radiation Science and a Postgraduate Certificate in Education (PGCE), specialising in Physical and Natural Sciences.

Case 2: John from School B

School B is situated in the North-Eastern Township of Pretoria. The school lacks adequate teaching resources and infrastructure. The school is overseen by a Principal and a Deputy Principal, catering to a total of 960 learners. The school has two science laboratories that are presently unused. The Physical Sciences curriculum is designated 4.5 hours of instructional time weekly, structured as 60 minutes per day across four days. The primary language of instruction at the school is English, with Afrikaans offered as a home language option. During data collection, John taught Physical Sciences for Grades 10-12 and Natural Sciences for Grade 8. He has been teaching the subjects for 8 years. John holds a Bachelor of Science degree with specialisations in Geology and Chemistry, as well as a Postgraduate Certificate in Education (PGCE) that encompasses specialisations in Physical Sciences and Natural Sciences. John is the head of the Sciences department at his school.

Case 3: Willy from School C

School C is a public institution located on the Western industrial side of Pretoria. The institution comprises 43 teachers and 1240 learners. There are 46 classrooms along with two Science laboratories. The ratio in the classroom is 1 to 35. Willy became a member of the school community in 2006. He offers classes in Physical Sciences and Natural Sciences. Willy has been teaching Physical Sciences for a decade. While collecting data, Willy taught Physical Sciences for Grades 10 to 12 and Natural Sciences for Grade 9. Willy possesses a three-year Teacher’s Diploma with a focus on Physical Sciences and Mathematics.

Case 4: Mpho from School D

School D, like C, is a fee-paying school that is located in the centre of Pretoria City. The school lacks sufficient educational resources and facilities. There are 520 learners and 20 teachers at School D. The school has one Principal, one Deputy Principal, and five Heads of Department. There are approximately twenty learners in each class. The school uses a regular classroom as a science laboratory. When data were collected, Mpho was teaching Natural Sciences in Grades 8-9 and Physical Sciences in Grades 10-12. He has been teaching for the past 14 years. Mpho earned a four-year Bachelor of Education degree with specialisation in Physical Sciences and Natural Sciences. He also heads his school's Science department.

Case 5: Lebo from School E

School E is a state school that is located in the Eastern Township of Pretoria. The facility has a total of 50 classrooms, four functioning laboratories, two computer laboratories and a library. The school has a principal, two Deputy Principals and 13 Departmental Heads as the school leadership. It has 68 teachers who attend to 1,950 learners. The school offers Grades 8-12. Lebo is one of the teachers who teaches Physical Sciences, and he has five years of experience teaching in this school. During data collection, Lebo taught Physical Sciences from Grade 10 to Grade 12 and Grade 9 Mathematics. He received a four-year Bachelor of Education (Senior and FET) degree, majoring in Physical Sciences and Mathematics, and an honours degree in Mathematics Education. He has been teaching Physical Sciences to learners over the past five years.

3.6. Data Collection

The data used in this research were collected through interviews, observations, and document analysis. The procedure used in collecting the data is outlined as follows:

3.6.1. Interviews

Swain and King (2022) assert that interviews are among the most prevalent methods for conducting qualitative research. An interview is a structured or semi-structured conversation between two or more people, usually with a specific goal in mind (Ruslin et al., 2022). Reissner and Whittle (2022) distinguish two main types of interviews: the standardised conventional interview and the discursive, constructionist interview.

The standardised interview provides somewhat accurate data based upon the interviewee's responses and must be conducted objectively and without bias (Reissner & Whittle, 2022). The standardised, conventional interview is characterised by limited interference or discussion from the interviewer, enabling the respondent to deliver a genuine, subjective narrative of facts, views, and feelings as experienced (Reissner & Whittle, 2022). However, discursive-oriented interviews are characterised by conversation as a mode of social contact between the interviewer and the responder (Reissner & Whittle, 2022). Hence, discursive-oriented interviews were used in this study to engage the interviewee in making meaning of the experiences under discussion.

Semi-structured interviews, as a form of discursive-oriented interviews, were used in this study to allow participants to freely express themselves, encourage two-way communication, and allow themes and ideas to emerge gradually (Kostera & Modzelewska, 2021). A semi-structured interview is a type of qualitative research interview that includes a list of topics to discuss and allows the interviewer to ask follow-up questions and provide more information (Conrad & Tucker, 2019). Bearman (2019) claims that a semi-structured interview helps the researcher pose questions without predetermined answers. In semi-structured interviews, participants' responses are unrestricted, providing comprehensive and nuanced data for the researcher (Chapman, 2023).

A semi-structured interview guide with a list of interview questions was used to gather data on the participants (see Appendix C). According to Halvorsen et al. (2020), this tool is an interactive one in which questions are asked, and participants respond by sharing their experiences. The questions were intended to help answer the research questions (Chen et al., 2023). Interviews were conducted at the participants' schools, with each individual being interviewed twice: prior to and after the classes. One-on-one interviews, each lasting approximately 30 to 40 minutes, were carried out. Executing a one-on-one interview facilitated comprehensive data collection and provided a better understanding of how teachers implement IBL strategies for practical work.

Every interview was recorded, and the recordings were stored on the researcher's laptop in a password-protected folder for transcription. Each interview was recorded with an audio recorder, and participants provided consent. Every participant was informed that the interviews would be recorded. Participants were asked if they agreed to have their audio comments recorded during the interviews. The researcher used field notes and audio recordings to help with data transcription before analysis (Fearnley, 2022). The researcher used a smartphone to record an audio clip, which was then moved to a password-protected folder for privacy reasons. Verbatim (word-for-word) transcriptions of the interviews were made.

3.6.2 Observation

In addition to interviews, the researcher conducted classroom observations to explore Physical Sciences teachers' understanding of the implementation of IBL strategies for practical work. The researcher employed an observational technique to examine the sessions. An observational approach is a research method used to systematically collect information and data about individuals, objects, events, or phenomena through direct observation and documentation of their behaviours, activities, characteristics, or interactions (Mezmir, 2020). FitzGerald and Mills (2022) state that observations are usually conducted in existing rather than prearranged settings. Five male participants from various secondary schools were observed. All the participants taught Physical Sciences in the Further Education and Training (FET) phase, and the researcher observed each teacher's lesson. The researcher observed participants in the classrooms to capture incidents and learn more about some of the research questions (Awasthy, 2019). An observation template was used to observe the lessons. Each participant was observed once and taught a different topic in a 60-minute lesson.

3.6.3. Document Analysis

In a qualitative study, documents can provide significant insights (Natow, 2020). Documents can be examined for their historical significance, as they serve as valuable sources of information (Wang et al., 2020). For this study, each teacher provided one lesson plan and one worksheet. The analysis of these documents supported answering the primary research question and the study's sub-questions.

3.7. Data Analysis

The process of analysing data involves manipulating the collected data through processes such as coding, indexing, sorting, and retrieval, commonly referred to as data handling (Mezmir, 2020). Eakin and Gladstone (2020) note that data analysis is fundamentally a process of imaginative interpretation, involving the manipulation of data through ordering and sorting techniques. In this study, thematic analysis served as the systematic approach for interpreting the collected data.

Thematic analysis is a method for identifying, examining, and presenting patterns or themes within data (Lochmiller, 2021). Thematic analysis consists of six distinct stages: becoming familiar with the data, coding, searching for and reviewing themes, defining and naming themes, and finally, writing up and articulating the findings (Humble & Mozelis, 2022). However, Wiltshire and Ronkainen (2021) differentiate between inductive and deductive thematic approaches. The inductive thematic approach suggests that theme development progresses concurrently with the ongoing research process. In contrast, when the researcher codes in alignment with a particular topic of study, the thematic analysis applied is inductive. Additionally, inductive thematic analysis is a data-driven, open-ended approach that does not begin with predetermined themes; instead, themes emerge naturally from the data (Braun & Clark, 2022).

The researcher employed an inductive thematic analysis approach, generating codes directly from the raw data to address the research questions. The researcher did not establish predetermined themes; instead, selective colour-coding was employed to present the evidence in a narrative format aligned with the identified themes (Zammit, 2023). By doing so, the researcher sought to understand participants' knowledge and understanding in analysing the qualitative data (Zammit, 2023). The inductive thematic analysis was complemented by the study's conceptual framework, namely Bybee's 5E model and the levels of inquiry-based learning, which served during the interpretation phase. Even though codes were generated inductively from the raw data, their development and organisation into themes were guided by the stages of the Bybee 5E model and the varying levels of inquiry-based learning (Braun & Clark, 2022).

Therefore, the data were examined and organised according to the 5E stages, with each stage being used as a framework for grouping relevant codes and identifying patterns in the data (Lochmiller, 2021). In addition, the level of inquiry present in participants' practices was used as a perspective to categorise the extent of teacher guidance and learner autonomy reflected in the data (Lochmiller, 2021). This investigation employed thematic analysis to uncover themes from data gathered through interviews, lesson observations, and document analysis.

3.7.1. The coding process

The coding process was conducted systematically as shown in Table 3.2 below.

Table 3.2: *The coding process*

Coding step	Key activity
Familiarisation with the data	The researcher transcribed interview recordings verbatim and repeatedly read through the transcripts, observation notes, and documents to gain a complete understanding of the data.
Initial code generation	During the first cycle of coding, the researcher identified meaningful segments of data such as phrases, sentences, and paragraphs relevant to the research questions. These segments were assigned initial codes that captured their key ideas.
Inductive coding using colour-coding	Codes were generated inductively from the raw data without predetermined categories. Selective colour-coding was used to label similar ideas across different data sources, allowing the researcher to organise patterns and recurring concepts visually.
Code comparison and refinement	The researcher compared codes across interviews, observations, and documents to identify similarities and differences. Redundant codes were merged, while unclear codes were refined to improve clarity and consistency.
Categorisation of codes	Related codes were grouped into broader categories based on shared meanings. At this stage, the researcher began identifying connections between codes and emerging patterns.
Alignment with the conceptual framework	Although coding was inductive, the grouped codes were organised according to the stages of Bybee's 5E model and the levels of inquiry-based learning. This provided a structured lens for interpreting the data without imposing predetermined themes during the initial coding phase.

Table 3.2 presents the initial codes generated inductively from the interview, observation, and document analysis data. These codes emerged directly from the raw data during the early stages of analysis and were subsequently refined and organised into broader themes.

Table 3.3: *Inductive Codes used during data analysis*

Prior Code	Code Description	Data Source
Teachers' understanding of IBL	Teachers' conceptual understanding of IBL principles, levels (confirmation, structured, guided, open inquiry), and educational purpose.	Interviews, lesson observations
Practical work design	How teachers design and prepare inquiry-based practical work (lesson plans, objectives, procedures, activities, teaching methods, and instructional strategies).	Document analysis, Interviews, 'lesson observation
Challenges in Implementing IBL Strategies	Constraints and issues that delay effective IBL implementation (time, class size, curriculum demands, resources, and professional development).	Interviews, lesson observation

3.8. Trustworthiness

The study adhered to Lincoln and Guba's (1985) methodology to guarantee trustworthiness. These authors used four criteria to illustrate what trustworthiness entails: credibility, transferability, confirmability, and dependability, as described by Lemon and Hayes (2020).

3.8.1. Credibility

Credibility relates to the practical relevance and real-world applicability of research outcomes (Wood et al., 2020). Credibility ensures that participants' experiences are accurately perceived and accurately reflect their intended meaning (Shufutinsky, 2020). It ensures that study results are complete, robust, and well-conducted by including members who review the data and conduct triangulation (Johnson et al., 2020). Triangulation, member checks, peer review, and ongoing observation are just a few ways to ensure reliability (Hamilton, 2020).

Triangulation involves utilising several individuals to code, analyse, and interpret data (Aguilar Solano, 2020). Member verification, validity checks, and reflective engagement were conducted after each interview to ensure the study's legitimacy. The researcher utilised prolonged engagement by asking questions that required detailed responses and were relevant to the participants' knowledge and experiences.

The researcher employed probing questions to elicit further information and enhance comprehension of the reported experience. The researcher utilised continuous observation to develop codes and themes (Williams & Moser, 2019). This research enhanced trustworthiness by employing multiple data collection methods, including interviews, observations, and document analysis.

3.8.2. Transferability

Transferability refers to the degree to which research findings can be utilised in various contexts (Daniel, 2019). Transferability also refers to how well the research's results can be used in situations other than the one they were meant for (Fischer & Guzel, 2023). Moreover, transferability highlights the researcher's dedication to providing adequate background information to readers, enabling them to contextualise the conclusions within their own experiences (Köhler et al., 2023).

This study presented a comprehensive understanding of the collected data through a detailed description of the research questions, objectives, background, findings, and interpretations (Köhler et al., 2023). These descriptions engage readers in the scene and foster a sense of collective experience (Englander & Morley, 2021). This technique was employed to assist the reader in determining, understanding, and comprehending the probability of the findings in relation to their circumstances (Englander & Morley, 2021). The accounts of the participants' experiences and processes, along with select direct quotes, were incorporated. Additionally, transferability was addressed by providing a rich, detailed description of the research background, participants, and procedures, enabling readers and other researchers to determine whether the findings apply to their own settings.

3.8.3. Dependability

Dependability denotes the probability of achieving consistent outcomes when an identical study is repeated (Kyngäs et al., 2020). Kyngäs et al. (2020) suppose that in qualitative research, dependability refers to the consistency of the data gathered by a researcher and the subsequent findings, rather than the likelihood of reproducing such findings. In other words, dependability indicates that the research findings are consistent and can be replicated in an identical situation (Sürücü & Maslakci, 2020). To guarantee the study's reliability, the researcher employed rigorous data-gathering methods and well-documented data analysis approaches (Carcary, 2020). The researcher documented sampling selections, data administration details, coding decisions, and all theories used throughout the study. An interview guide, member checking, a co-coder, audio recordings of the interviews, and verbatim transcriptions were utilised and documented. To enhance reliability, all interview questions, lesson observation instruments, and document analysis tools were carefully captured, and participants' comments during interviews were audio-recorded.

3.8.4. Confirmability

Confirmability denotes the degree to which findings are corroborated or validated by peers within the same research domain (Chung et al., 2020). Khoa et al. (2023) indicate that the researcher meticulously documents all outcomes and evaluations throughout the investigation. The constructed audit trail ensured confirmability, alleviating concerns that the data had been fabricated by the researcher rather than based on participant reports. Furthermore, confirmability refers to the degree to which the data are considered valid (Liu et al., 2023). This study provides a comprehensive account of the methods and processes employed in data generation and analysis to enhance confirmability. In other words, complete transparency was maintained by thoroughly documenting and disclosing all methods and processes used for data generation and analysis. The researcher correctly documented and reported every step of data collection and analysis, including the specific IBL strategies implemented during the lesson and how teachers implemented them.

3.9. Ethical Considerations

The research committee of the Department of Science and Technology at the University of South Africa provided ethical clearance and permission for this study to be conducted. The ethical clearance certificate was used to obtain approval from the Gauteng Department of Education, the Tshwane South District, school principals, and teachers. The purpose of this study was communicated to participants to help them understand the nature of the investigation and maintain transparency. To protect confidentiality and anonymity in this study, pseudonyms were employed instead of school and participant identities.

The researcher ensured the study adhered to research ethics. The researcher ensured that the individuals were not harmed in any manner, whether physically, emotionally, or spiritually. The researcher complied with the prescribed code of conduct and ethics to prevent violations of participants' rights. These codes of conduct and ethics are rules that guide researchers in conducting research without violating the rights of the people taking part (Ibbett & Brittain, 2020). Below are the main ethical criteria that the researcher followed:

3.9.1 Protecting the Rights of the Institutions Involved

An ethics committee is tasked with reviewing the ethical dimensions of a study, including its general quality and adherence to principles safeguarding the dignity, rights, integrity, and well-being of participants (Vlckova et al., 2023). This study was conducted in schools and included teachers. The researcher received permission and authorisation to conduct this research from the University of South Africa (Annexure A) and the Department of Education, Tshwane South District (Annexure B). Both bodies confirmed their approval of the researcher’s adherence to all ethical requirements. Participants were informed of their rights and were assured that they could express their views freely, provided that doing so did not place them at any risk or cause them harm.

3.9.2 Confidentiality and Anonymity

Confidentiality, on the one hand, refers to the protection of participants' data privacy and sensitivity to keep their information private and separate from unauthorised parties, and to sustain trust in the research process (Kanekar & Otundo, 2023). Anonymity, on the other hand, is a circumstance or scenario in which a person's identity is unknown or concealed (Maloney et al., 2020). Confidentiality is maintained when all information received about the participant is kept strictly private (Oey-Gardiner et al., 2023). All identifying information related to participants was withheld from publication. To ensure confidentiality and anonymity, the researcher informed participants that the data collected would remain confidential and would not be disclosed to any third parties not directly involved in the study. All information was securely stored on a password-protected laptop. The findings were reported in a manner that prevents any linkage to individual participants (Heylen, 2023). To further protect participants’ identities, the researcher assigned pseudonyms to each individual. Both the original transcripts and the anonymised data were stored in the supervisor’s secure, password-protected laptop (Heylen, 2023).

3.9.3 Autonomy

The researcher clarified to participants that participation in the study was entirely voluntary, with no obligations imposed, and that there was no pressure to participate. Participants made a conscious decision to participate in the study. The information gathered during interviews regarding personal and job details was not classified as sensitive, suggesting a lower likelihood of inducing psychological distress among participants (Azad et al., 2021). The researcher clarified to the participants that their involvement in the study was entirely voluntary; they could withdraw at any time during the interview if any questions caused discomfort. Efforts were made to obtain consent or willingness to participate. Before conducting the interviews, the researcher provided participants with a comprehensive explanation of the study. To minimise the potential for distress, all participants were provided with an information sheet outlining the study's purpose, procedures, and expectations. The informed consent and information sheet provided a comprehensive overview of the study's nature, participant requirements, the implications of participation, and participants' rights. It also outlined the use of collected data and the reporting methods, as well as contact information for raising any concerns or questions regarding the research (Jawa et al., 2023).

The researcher clarified to the participants that their involvement in the study was entirely voluntary, indicating that they were not obligated to answer any specific questions or any portion of the questionnaire if they felt uneasy. Participants were asked to provide written permission (Mollen, 2023). Before the interview sessions, the researcher informed participants that the interviews would be audio-recorded and that they retained the right to withdraw from the study at any time (Yip et al., 2023).

3.10. Conclusion

This chapter outlined the research strategy and methodology, as well as the data-gathering and analysis protocols. The chapter discussed the rationale for using a case study design. Following the interpretivist paradigm, the researcher selected participants through purposive sampling and conducted semi-structured interviews, observations, and document analysis. The qualitative approaches utilised to collect data were thoroughly explained and justified.

CHAPTER FOUR

DATA PRESENTATION AND DISCUSSION

4.1 Introduction

The previous chapter discussed the research design and methodology utilised to collect data for this study. This chapter presents data acquired through semi-structured interviews, document analysis, and observation. Five participants from different schools were subjected to the same interview questions and observation techniques to gain a better understanding of how they utilise inquiry-based learning methodologies in practice. Data were gathered and analysed in response to the following research questions:

Main Research Question

- How do teachers implement inquiry-based learning strategies during practical work in Physical Sciences?

Sub-questions:

- How do teachers understand and apply inquiry-based learning strategies in practical Physical Sciences activities?
- How do teachers design practical work activities to incorporate inquiry-based learning strategies in their lessons?
- What challenges, if any, are experienced by teachers when implementing inquiry-based learning strategies during practical work in Physical Sciences?

4.2 Presentation of Themes

The collected data were analysed using an inductive thematic analysis method. Inductive thematic analysis involves coding data without imposing an existing coding framework or the researcher's prior analytical assumptions (Naudé, 2025). This section outlines the themes derived from the data analysis obtained through interviews, observations, and documents, as presented in Table 4.1 below.

Table 4.1: *Emerged themes and sub-themes*

Themes	Sub-themes
Teachers' knowledge of implementing inquiry-based learning strategies	• Teachers' understanding of inquiry-based learning in practical work
	• Teachers' application of inquiry strategies in practical work
How teachers design their practical work	• Alignment of practical work with inquiry-based learning objectives
	• Structure and sequencing of practical activities
Challenges when implementing inquiry-based learning strategies for practical work	• Constraints in designing inquiry-based learning practical work
	• Issues when implementing inquiry-based learning strategies

The key themes and sub-themes identified in the study through thematic analysis are presented in Table 4.1 above. The themes illustrate the primary areas of inquiry, whereas the sub-themes offer a more detailed understanding of particular elements within each category. The findings from the interviews, observations, and document analysis involving the five participants, that is, Tshepo, John, Willy, Mpho, and Lebo (pseudonyms), who took part in this study, are detailed in Sections 4.3 to 4.5 below. The findings outlined in the following sections represent teachers' understanding of implementing inquiry-based learning, the strategies they employ in designing practical activities, and the difficulties they face when applying inquiry-based learning techniques in their practical work.

4.3 Theme 1: Teachers' Knowledge of Implementing Inquiry-based Learning Strategies

4.3.1 Teachers' understanding of inquiry-based learning in practical work

To facilitate comparison across cases, Table 4.2 below summarises the participating teachers' understandings of inquiry-based learning in practical work, with particular attention to their views on learner engagement, teacher roles, and the emphasis placed on inquiry processes.

Table 4.2: *Summary Table of Teachers' Perspectives on IBL in Practical Work*

Teacher	Key Focus	Role of the Teacher	Role of Learners	Notable Emphasis
Tshepo	Learner-centred learning	Facilitator	Take charge of one's own learning	Active engagement, autonomy
John	Hands-on exploration	Guides through questions & procedures	Engage with structured activities	Balance between structure and inquiry
Willy	Learner autonomy	Minimal direct instruction	Construct your own understanding	Self-discovery of concepts
Mpho	Investigation/problem-solving	Presents problems	Explore and think critically	"Finding out" through inquiry
Lebo	Guided inquiry	Provides guiding questions	Engage through exploration	Critical thinking development

4.3.1.1. Cross-case findings

Across all five cases, teachers consistently conceptualised inquiry-based learning as a learner-centred approach that promotes active engagement in practical work. This suggests a shared foundational understanding of inquiry as a shift in focus from teacher-dominated instruction toward learner participation.

However, slight differences emerge in how teachers interpret the balance between guidance and autonomy. For example, Tshepo and Willy strongly emphasised learner autonomy, showing learners as responsible for constructing their own understanding with minimal teacher intervention. Similarly, Mpho highlighted independent investigation, particularly through problem-solving and critical thinking. In contrast, John and Lebo leaned toward a more structured form of inquiry, where a teacher plays an active role in scaffolding learning through guiding questions and procedures. This indicates a preference for guided inquiry rather than open inquiry. These differences suggest that while all teachers align with the principles of inquiry-based learning, they differ in implementation orientation, ranging from Open inquiry (high learner autonomy) by Tshepo, Willy, Guided inquiry (teacher-supported exploration) by John, Lebo and Problem-based inquiry (investigative focus) implemented by Mpho

Case 1: Tshepo

During the interview, Tshepo described inquiry-based learning as a learner-centred teaching approach in which learners are actively engaged in the learning process and take charge of their learning. He further stated that, during an inquiry-based learning practical work, the role of a teacher is primarily that of a facilitator rather than a direct teacher. Tshepo's verbatim definition of inquiry-based learning is stated below in italics:

> "*I think this is a learner-centred approach to learning where learners have to be the ones doing the work and the teacher is just an instructor."*

The observation data supported Tshepo's statement that inquiry-based learning is a learner-centred approach. During the classroom observation, Tshepo introduced the practical lesson by going through some concepts related to the titration topic with the learners, including safety precautions. He then facilitated a lesson in which learners conducted titration experiments. Tshepo grouped learners, and each group assembled the materials they would use for the titrations practical work. Figure 4.1 below illustrates the materials that the learners assembled in preparation for the practical work session.

Figure 4.1: *Prepared materials by learners in Tshepo's class*

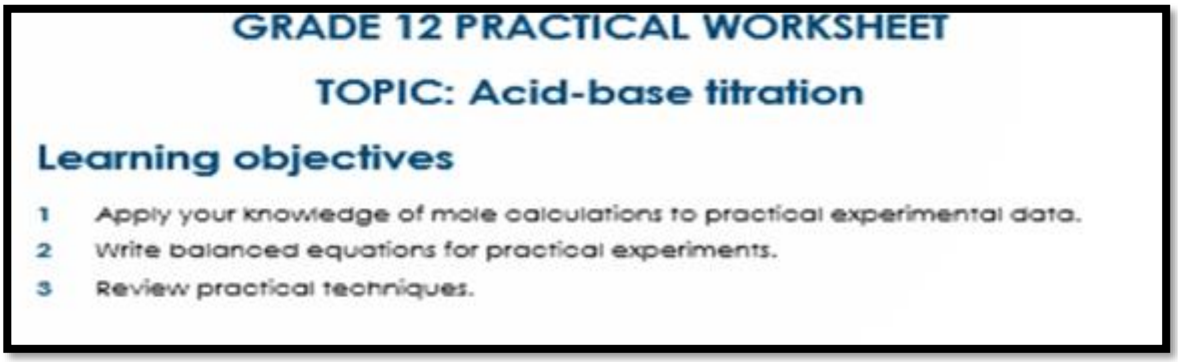
Case 2: John

During the interview, John expressed his understanding of inquiry-based learning in the context of practical work as an approach that actively encourages learners to explore scientific concepts through hands-on activities. He described it as a teaching approach he uses in the classroom, characterised by guiding questions, structured procedures, and the resulting data, which together create a learner-centred environment. He emphasised that this approach enables learners to engage actively with investigative questions, allowing them to explore and formulate responses independently. He further mentioned that he provides learners with results, which serve as a tool for assessing and reinforcing their understanding after they have completed their practical work. Below is John's definition of inquiry-based learning for practical work:

> *"Inquiry-based learning in teaching Physical Sciences is the approach that I would take in a class as the teacher. For example, I can go with question, method, and results, whereby it becomes a learner-centred learning in such a way that if I provide them with questions, they can go through the questions and answer, and when they are done, I will be able to give them the results to check if they understood…"*

During the lesson observation, it was noted that John spent more time on the theoretical aspects, which did not align with his interview response. During the interview, he mentioned that during an inquiry-based practical work, he provides learners with questions, methods, and results. Instead, the lesson observation revealed that he provided learners only with the learning objectives, not the investigative questions, as he mentioned during the interviews.

The observation data further revealed that John focused on teaching the main concepts of the topic, such as defining acid-base titrations, standard solutions, endpoints, and equivalence points. This contradicts his interview response when he was defining inquiry-based learning for practical work. In his definition, he mentioned that an inquiry-based learning strategy is a teaching approach in which the teacher provides learners with questions, methods, and results, and learners explore the investigative process independently through hands-on, practical work. Towards the end of the lesson, John demonstrated to the learners how the practical experiment would work and allowed them to work independently. Figure 4.2 below indicates the worksheet with the learning objectives that John aimed to achieve during the practical lesson.


GRADE 12 PRACTICAL WORKSHEET

TOPIC: Acid-base titration

Learning objectives

1 Apply your knowledge of mole calculations to practical experimental data.
2 Write balanced equations for practical experiments.
3 Review practical techniques.

Figure 4.2*: Practical worksheet used during John's inquiry-based learning lesson*

Case 3: Willy

The interview data revealed that Willy places significant emphasis on learner autonomy in defining inquiry-based learning in practical work. He pointed out that inquiry-based learning for practical work requires learners to investigate and construct their understanding of concepts actively. Willy further highlighted that learners are not only dependent on traditional teaching methods but also on self-discovery of concepts. Additionally, he expressed his understanding of inquiry-based learning strategies as a learner-centred approach that prioritises exploration and independent engagement with content. He defined inquiry-based learning for practical work as follows:

> *''…I think to some extent, it involves the learners investigating some things and coming to conclusions about some concepts without me as the teacher necessarily having to sit them down, bring up a question, and explain everything to them. Without me being the teacher having to bring up a concept, explaining everything to them…"*

The lesson observation supported Willy's perception of inquiry-based learning for practical work as expressed in the interview. However, during the lesson observation, Willy did not directly teach the content; instead, he created an environment where learners could explore by posing questions that required them to perform the practical work before providing possible answers. He further created an atmosphere where learners were to investigate and draw conclusions independently. This was evident when learners prepared a standard solution, conducted the entire titration experiment, and performed the molar calculation by themselves.

Figure 4.3 below presents the calculation questions Willy used to assess learners' understanding of concepts during his lesson presentation. Willy used the calculation questions to support the inquiry-based learning approach observed during the lesson. He did not give learners direct answers to the questions. Instead, he guided them to explore and think critically through tasks that reflect on the worksheet. Learners used the experimental data they obtained during their hands-on practical work to respond to the calculation questions. Willy's role was that of a facilitator. Willy had learners use the provided document, as shown in Figure 4.3, to analyse their results and draw conclusions as they answered the given calculation questions.

Calculations

1. Write a balanced equation for the reaction of hydrochloric acid and calcium carbonate.
2. Using your measured mass and volume, calculate the number of moles of hydrochloric acid and calcium carbonate used and whether the hydrochloric acid or calcium carbonate is limiting.
3. Using your answer to question 2, calculate the mass of gas that should form and the moles of acid that should be left over.
4. Write a balanced equation for the reaction of hydrochloric acid and sodium hydroxide.
5. Using your answer to question 4 and your titration data, calculate the moles of hydrochloric acid in your sample (remember this is 10 ml from the total 50 ml)

Figure 4.3: *Learner's assessment from Willy's practical worksheet*

The observation data further revealed that Willy was using the calculation questions above to cascade the practical work lesson, as he was seen trying to encourage his learners to discover, investigate, and create their understanding by providing answers to the questions. He also avoided using guiding questions and explanations during the practical lesson. He stood by his belief from the definition of inquiry-based learning, as he believed that learners should *"come to conclusions without him as the teacher having to explain everything to them."*

Case 4: Mpho

During the interview, Mpho defined inquiry-based learning in practical work as an approach primarily focused on "finding out" and "investigating." He further described it as a learner-centred teaching approach that emphasises active learner engagement. According to Mpho, inquiry-based learning involves presenting learners with a problem and prompting them to independently seek solutions through exploration and critical thinking. He articulated his definition of inquiry-based learning as follows:

> *''Well, I think in terms of inquiry-based learning, inquiry to me we unpack this word; the inquiry is all about finding out, investigating, that's your inquiry, actually, a learner-centred approach in terms of a lesson. Well, in terms of teaching Physical Sciences, it's like when you give learners a problem, and then learners start to find out the solutions, like we are doing in practical investigations and so on, where we have investigative questions…"*

The lesson observation data revealed that Mpho contradicted his understanding of inquiry-based learning for practical work when he was teaching, as he mentioned during the interviews. During the interviews, he said that the inquiry-based learning strategy is a learner-centred teaching approach. On the contrary, Mpho started his lesson by teaching titration theoretically. He spent more time on traditional teaching methodologies than on allowing his learners to engage in hands-on practical work. Only towards the end of the lesson did he allow learners to titrate on their own, analyse their results, and check whether their conclusions aligned with the lesson objectives. With the little time remaining, Mpho allowed the learners to conduct the practical step by step, from preparing a standard solution to the endpoint of the titration. Learners were able to answer the question through his guidance. Figure 4.4 below shows the classroom environment during Mpho's practical lesson. The figure shows that Mpho made learners explore and investigate scientific concepts independently. Within this context, Mpho facilitated the learning process and scaffolded learner understanding.

Figure 4.4: *Learners engaging in a practical activity during Mpho's IBL lesson.*

Case 5: Lebo

During the interview, Lebo initially defined inquiry-based learning strategies as a learner-centred teaching approach. He further elaborated that such strategies involve the teacher formulating a set of guiding questions, with learners actively engaging with these questions through exploration and investigation. This process, according to Lebo, fosters critical thinking and promotes deeper understanding through learner participation. This is what he said:

> *''So, for us essentially, it's just a teaching approach, or using education terms, it will be a teaching instruction which is learner-centred, and it is where a teacher comes up with maybe a set of questions, and then the learners get to engage in some of the questions and try to explore…"*

The lesson observation aligned with Lebo's interview response, as he said that an inquiry-based learning strategy is a learner-centred teaching approach. Lebo supported his interview response by introducing his lesson through questions. He provided learners with a worksheet that already included an investigative question and instructed them to answer it through experimentation. He further allowed learners to take charge of their learning by interacting with the learning materials independently. Thereafter, he was seen walking around, clarifying to learners who needed help during the lesson. Figure 4.5 below shows learners conducting a titration experiment during Lebo's inquiry-based learning lesson.

Figure 4.5*: Learners conducting a titration experiment during Lebo's lesson*

During the lesson, Lebo also allowed learners to work independently by assigning roles within groups and providing support and guidance. He was observed reducing support as learners became more engaged, as shown in Figure 4.5 above. Lebo encouraged the learners to observe and analyse the results.

4.3.2 Teachers' applications of inquiry strategies in practical work

Table 4.3 below summarises how the five teachers applied inquiry-based learning strategies during practical work, emphasising the different teaching approaches they use in their classroom.

Table 4.3: *Summary Table of Inquiry Strategies*

Teacher	Inquiry Strategies Used	Level of Inquiry	Teacher Role	Notable Practice
Tshepo	Hypothesis generation, testing, collaboration, guided inquiry	Guided inquiry	Facilitator	Learners test hypotheses during titration
John	Collaborative, scaffolded, guided inquiry	Highly structured/guided	Strong guidance	Provides results beforehand; uses structured worksheets

Willy	Collaboration, hypothesis generation and testing	Guided inquiry (with prior teaching)	Demonstrator + facilitator	Performs an experiment with learners after teaching the theory
Mpho	Collaboration	Guided inquiry	Organiser	Group work with worksheets for results
Lebo	Collaboration, guided inquiry	Guided inquiry	Facilitator	Provides questions and procedures for learners

4.3.2.1. Cross-case findings

Across all five cases, teachers (Tshepo, John, Willy, Mpho, and Lebo) reported using inquiry-based strategies during practical work, with learner collaboration emerging as the most common approach. This suggests a shared understanding that inquiry learning is fundamentally social and benefits from peer interaction. However, differences become evident in the degree of inquiry and teacher control. Most teachers (Tshepo, Willy, Mpho, and Lebo) implemented forms of guided inquiry, where the teacher provides some structure, such as procedures, questions, or prior content knowledge, while allowing learners to engage actively in the process. For example, Lebo provided both the investigative question and procedure, while Tshepo incorporated hypothesis testing within a guided framework.

In contrast, John's approach reflected a more highly scaffolded form of inquiry, where learner exploration is more tightly controlled. Providing experimental results beforehand and using structured worksheets indicated a stronger emphasis on concept reinforcement rather than open investigation. Additionally, while Willy and Tshepo included hypothesis generation and testing, indicating an engagement with scientific inquiry processes, Mpho's approach focused primarily on collaborative learning, with less emphasis on other inquiry components.

Case 1: Tshepo

During the interview, Tshepo explained how he uses inquiry-based strategies during practical work. He stated that when performing practical activities, especially titration experiments, he employs various teaching strategies. These include hypothesis generation and testing, learner collaboration, and guided inquiry as effective methods for inquiry-based learning. For instance, in a titration task he planned, he mentioned that he would ask learners to predict outcomes when the solution concentration was incorrect and to justify the steps they take during preparation. He also added that he would encourage learners to record observations, identify potential sources of error, discuss ways to improve accuracy in groups, and reflect on their conclusions. The excerpt below illustrates this:

> *"… I will therefore encourage learners to predict what might happen if the concentration is incorrect and ask them questions about why certain steps were necessary. This will help them to think critically about the procedure rather than follow my instructions. In the second half, while conducting the titration, I will encourage learners to record their observations, suggest possible causes of error, if any, and discuss in groups how to improve accuracy so that they can reflect on their conclusions and explain them. This will make the practical more interactive and help learners to understand the fundamental concepts."*

The observational data largely supported Tshepo's explanation of his instructional approach during practical work. In the observed lesson, he organised learners into groups and provided them with practical worksheets that included the investigative question, procedural steps, and formative assessment questions. While the methodology was provided, Tshepo allowed learners to engage with some aspects of the task with limited guidance, thereby fostering opportunities for independent decision-making. He facilitated the lesson by moving between groups, offering support primarily through guiding questions and clarification rather than direct instruction. Tshepo maintained a balance between structured oversight and opportunities for learners to take initiative. He consistently questioned learners' techniques and understanding of the equipment, and he permitted multiple trials of the experiment. These observed practices aligned with his earlier claims, particularly regarding his efforts to encourage learner collaboration and participation during the scientific inquiry process.

Case 2: John

During the interview, John explained how he implements inquiry-based learning strategies during practical lessons. John explained that when doing practical work, he prefers different teaching approaches. His teaching strategies include collaborative, scaffolded, and guided inquiry. For example, in the titration practical work he planned, he mentioned that he would provide learners with the results of the experiment before they perform it, allowing them to apply the theory they learned. John also mentioned that he would use a worksheet designed to target different levels of learners' thinking. Additionally, he said he would group learners by thinking level, ensuring each group includes learners at different levels to promote collaborative learning. Within the groups, some learners would generate results and conclusions based on the experiments, demonstrating independent learning. Lastly, he said that the strategies to be implemented during the practical include guided inquiry, confirmation, and structured inquiry. John said the following:

> *" …I also designed a worksheet that covers all the cognitive levels. When putting them in groups, you cannot have all the level seven type of learners in one group. The group must include all cognitive levels so they can learn from each other. During practical work, it's all about what they contribute. You provide some learners with results, and others have to generate their own results and conclusions. There are different types of inquiry-based learning strategies, ranging from guided inquiry to confirmation, structured, etc., that accommodate all learners' learning needs."*

The observation information supported John's explanation of his teaching methodologies during practical work. During the lesson, John grouped learners based on their academic performance and provided them with worksheets containing the investigative question, methodology, and formative questions ranging from simple to more challenging. The worksheet provided to learners included questions across a range of cognitive levels, from basic recall to higher-order thinking. John used the worksheet to guide learners through the lesson, requiring them to follow instructions, analyse results, evaluate mistakes, and apply theoretical concepts. Figure 4.6 below shows the worksheet with the investigative question, method, and questions that John provided to the learners during the lesson.

ACTIVITY

Titration of acetic acid against sodium hydroxide to determine the concentration of the sodium hydroxide.

INVESTIGATIVE QUESTION

What is the concentration of a sodium hydroxide solution using a titration with a standard solution of acetic acid?

In this investigation, you will prepare an acidic solution accurately, and thus you will know its exact concentration. You will then react this acid with a base of an unknown concentration to determine the concentration of the base.

What to do:

1. Prepare a standard solution of acetic acid which has a concentration of approximately 1mol.dm^{-3}.
2. Now prepare a sodium hydroxide solution by dissolving approximately 2g of dry sodium hydroxide in 500ml of water.
3. Add two drops of the indicator solution.
4. Place the burette in the clamp.
5. Using the funnel, fill the burette to the

use it to calculate the concentration of the NaOH.

14. Now, calculate the concentration of the sodium hydroxide solution.
15. Now write a report using the format learnt in class.

Questions

1. What is the appropriate concentration of NAOH (2g in 500ml of water)?
2. Calculate the theoretical concentration of NaOH from the actual mass of NaOH you measured.
3. How does your theoretical value for NaOH concentration (from the actual mass you measured) differ from the actual concentration you calculated (from the titration procedure)? Can you think of some reasons why your values may differ?
4. The average of the results obtained: ______________ ml of NaOH solution
5. What is your observation/colour change at the endpoint?
6. Write the balanced equation for the reaction
7. Calculate the concentration of the unknown solution using the equation nbCaVa = naCbVb

Figure 4.6: Practical worksheet used during John's lesson

Within the groups, John included a blend of high achievers, moderate performers, and those requiring additional support. John balanced the groups, ensuring that no single learner dominated the activities. Hence, he provided groups with varying levels of support and used different teaching strategies. He offered some groups structured guidance by including results for them to interpret, and other groups worked independently, designing and completing their tasks without additional prompts. This was evident when he provided solutions to groups with struggling learners and left the performing learners to find their own solutions.

Case 3: Willy

In the interview, Willy explained how he uses inquiry-based learning strategies for practical work. Willy explained that when he conducts practical work, he applies different teaching strategies. Willy said that he prepared a practical lesson using collaborative teaching, hypothesis generation, and testing as the main inquiry-based instructional approaches. For instance, in the practical work he planned to conduct on titration, he said he would perform it with the learners, having taught them the topic beforehand. He further explained that during the practical, he would arrange the learners into groups to collaborate and learn from one another. Furthermore, Willy mentioned that he would assign roles and responsibilities to each learner in each group to contribute to the practical. The excerpt below shows this:

> *"I taught the topic and completed acids and bases. I taught them some things, but then I wanted them to have a practical feel of what titration is, rather than just a theoretical, fictional example. So, I sat down one evening, planned, and designed the practical, taking note of the teaching methods I would implement during the practical. I thought that if they are sitting in a group, there is no way they can conduct, for instance, a titration in a group of three without collaborating. Roles and duties will be assigned so that each learner can contribute. Learner collaboration is important. I arrange groups carefully to allow them to learn from each other. For the practical, I will provide the learners with the worksheets, and they must be able to get the endpoint and the equivalence point. Initially, on the first run, some might fail to get it. But for the fact that they saw themselves as other learners getting it right, they would get inspired and get so challenged in such a way that they say ''We don't want you to assist us, don't assist us, don't tell us anything, let us re-do it ourselves."*

The observational data mainly supported Willy's explanation of his teaching approach during practical work. In the observed lesson, Willy bridged theory and practice before learners engaged in hands-on titration activities by first teaching acids and bases. When he taught, he encouraged learners to experience chemical changes by connecting theoretical knowledge to practice, using traditional teaching methodologies. Thereafter, he arranged the learners into groups and mixed high-flyers, average learners, and below-average learners together. Willy then assigned roles to each member of the group. Each group member had specific roles, including preparing the standard solution, reading the burette, recording results, serving as a group leader, and serving as a data capturer.

Additionally, he provided the learners with a practical worksheet containing questions that required them to accurately measure, observe the endpoint, and draw conclusions from experimental data. The worksheet included the aim, procedural steps, and lesson scaffolding questions ranging from simple to complex. Figure 4.7 below shows a part of the worksheet that Willy provided to the learners during the practical work.

1. **AIM**

To determine the unknown concentration of sodium hydroxide solution by titrating against a standard solution of oxalic acid.

METHOD OR PROCEDURE:

6.1 Rinse one burette before using it.

Must the burette be rinsed with distilled water or sodium hydroxide? Explain your answer (2)

6.2 Fill the burette with sodium hydroxide solution, exactly to the zero mark.

6.2.1Why should learners be cautious when using concentrated NaOH? (2)

6.3 Using the pipette, transfer 25mℓ of oxalic acid solution into the conical flask.

6.4 Add 3-5 drops of phenolphthalein indicator into the conical flask.

6.4.1 Record your observation (Any colour change) (1)

6.4.2 Explain why phenolphthalein is a suitable indicator for this experiment. (2)

6.5 Add sodium hydroxide solution from the burette to the conical flask until you observe a colour change.

6.5.1 Write down one word/term of the underlined phrase. (1)

6.5.2 Describe the word/term mentioned above. (3)

Figure 4.7: *Practical worksheet used during Willy's lesson*

From the worksheet, Willy used simple, direct questions at the start of the lesson and moderate questions to scaffold the practical work. He stimulated learning by asking higher-order theoretical questions, such as why phenolphthalein was chosen and requesting that learners predict the outcomes of the practical, while encouraging learners to practice hands-on.

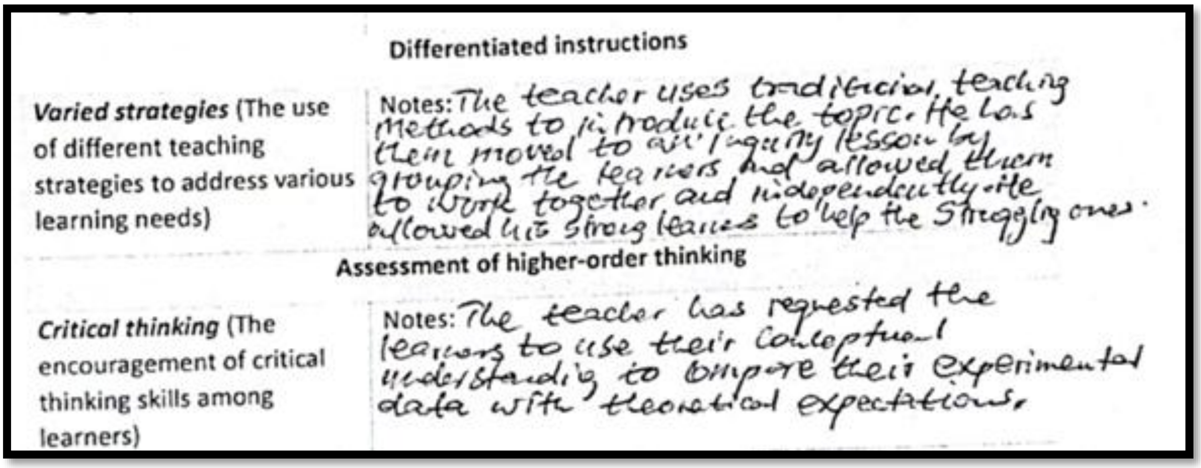
Although the methodology was given to the learners, Willy allowed the groups to work independently, encouraging peer teaching and learning by asking stronger learners to support the weaker ones. Similar to John, Willy facilitated the lesson by moving between groups, encouraging collaboration, and offering support through guiding questions and clarifications rather than direct teaching. He allowed learners to take charge of their learning and maintained a balance between structured oversight and opportunities. Willy constantly questioned learners' understanding of the use of standard laboratory equipment such as burettes and conical flasks. These perceived practices supported his earlier statements, particularly his efforts to foster learner participation in the scientific process, promote critical reflection, and support understanding through ongoing open collaboration.

Case 4: Mpho

Mpho explained during the interview how he uses inquiry-based learning strategies during practical work. He stated that one of the inquiry-based learning strategies he employs is learner collaboration. Mpho believed that during practical work, learners need to work together. When justifying learner collaboration, he explained that in the practical activity he planned for the titration experiment, he would group the learners, provide them with worksheets, and then encourage them to work together to obtain the results. Additionally, he said that he assigns learners to groups with different roles, guided by their academic performance. Furthermore, he noted that learners in groups must collaboratively discuss the practical process, arrive at their results, and reflect on their conclusions before they are engaged in assessment for learning through post-experiment calculations. This is what Mpho said during the interview:

> *''…I will prepare my learners in terms of grouping them over the worksheets, doing the worksheet, and preparing it for them with some questions and some roles. Once learners arrive, I just give them worksheets and then go through the worksheets with them, and from there, once they understand what needs to be done and then that's where we will start the experiment. Group work is one of my strategies in terms of presentation and facilitation. I will mix the learners in groups to allow the gifted to assist the struggling ones. In terms of checking their understanding, I normally give them some tests after writing to compare the results, and the write-up, and then from there I will be able to see if they met the requirements that I wanted. Merging the practical part with the theory part to compare the theory with the practical. Because I will be having the results by the way, and if they do come with the results, it means now exactly I will be saying that they do understand."*

The observational and document analysis data mainly supported Mpho's explanation of using collaboration as one of the inquiry-based strategies. In his lesson, he was observed organising learners into groups and providing them with worksheets before the experiment, demonstrating a collaborative strategy. The worksheet he provided also directed learners to work in groups. However, the observation data also revealed a contradiction to what Mpho stated during the interviews. While he claimed to implement inquiry-based strategies, in the observed lesson, he mainly used a traditional approach. Mpho mostly directed the lesson himself, with learners simply following his instructions. Figure 4.8 below shows the data recorded during Mpho's practical work lesson.



	Differentiated instructions
Varied strategies (The use of different teaching strategies to address various learning needs)	Notes: The teacher uses traditional teaching methods to introduce the topic. He has then moved to an inquiry lesson by grouping the learners and allowed them to work together and independently. He allowed his strong learners to help the struggling ones.
	Assessment of higher-order thinking
Critical thinking (The encouragement of critical thinking skills among learners)	Notes: The teacher has requested the learners to use their conceptual understanding to compare their experimental data with theoretical expectations.

Figure 4.8: *Observation data obtained from Mpho's practical work lesson.*

It was only towards the end of the session that he allowed learners to work in groups, providing a limited opportunity for learner-led inquiry and collaboration. Most importantly, Mpho carried out the practical work while the learners watched him. Afterwards, he assigned tasks to different learners in various groups and instructed the groups to work independently to record and analyse the results. During the practical, Mpho moved between the groups, supporting them by asking guiding questions, checking their progress, answering questions, and offering guidance on how to read the burette, thereby promoting learner engagement and collaboration. Mpho further encouraged collaborative learning among learners by posing questions. The observed practices aligned with his earlier statements about promoting learner collaboration and participation during practical work.

Case 5: Lebo

Lebo explained during the interview how he uses inquiry-based learning strategies during practical work. Lebo stated that some of the inquiry-based learning strategies he employed are learner collaboration and guided inquiry. Lebo believed that during practical work, learners need to work together. When defending his teaching strategies, Lebo explained that, through guided inquiry, he would provide learners with the investigative question and procedure and allow them to explore and draw conclusions. He would then group the learners, provide them with the worksheets containing a set of questions, and encourage them to engage and find the results collaboratively. Further, he noted that learners in groups would be assigned different roles guided by their skills. Furthermore, Lebo said that learners in groups must collaboratively discuss the practical process and arrive at their results before engaging with the questions on their worksheets. This is what Lebo said during the interview:

> *"So, we did preparations beforehand, providing them with worksheets, looking at the list of the apparatus we needed, and making sure that all the apparatus was available for them. I will design an investigative question for the topic first, then come up with a set of questions. It will be a safe way for the learners to be engaged in the topic. So in our planning, we will come up with resources that we are going to use and the materials that we are going to use. I will do holistic teaching. I will group the learners and try to assign roles based on their skills, based on what they can put on the table. So, like I indicated before, with us assigning different responsibilities, we then obviously, based on their skills, we say okay, we are going to assign you this role, we take a learner and say okay, we are going to put you this role, some opening the tap, some shaking, some checking the endpoint..."*

The observation and document analysis data supported Lebo's explanation of inquiry-based learning strategies in relation to both collaborative learning and guided inquiry. During his lesson, he was observed organising learners into groups. He provided them with a worksheet that contained an investigative question before starting the experiment, demonstrating both guided and collaborative strategies. His worksheet instructed learners to work in groups as one of his lesson strategies.

However, the observational data also revealed a contradiction to what Lebo stated during the interviews. Although he claimed to have fully implemented inquiry-based learning strategies, in the observed lesson, he mainly used a traditional approach. Lebo, similar to Mpho, directed the lesson himself, with the learners simply following his instructions. It was only towards the end of the session that he allowed learners to work in groups.

4.4 THEME 2: How Teachers Design Their Practical Work

4.4.1 Alignment of practical work with inquiry-based learning objectives

Table 4.4 summarises the teachers' approaches to aligning practical work with inquiry-based learning objectives, highlighting similarities and differences in the sequencing and integration of traditional instruction and inquiry in practical lessons.

Table 4.4: *Summary Table of Teachers' Alignment Approaches*

Teacher	Approach to Alignment	Role of Traditional Teaching	Inquiry Emphasis in Practical Work	Key Features
Tshepo	Sequential (theory → inquiry)	Used first to build concepts	Exploration, questioning, conclusions	Critical thinking through guided exploration
John	Structured progression (theory → application)	Foundational teaching before inquiry	Application of concepts in practical tasks	Strong focus on understanding before inquiry
Willy	Curriculum-driven with inquiry opportunities	Dominant but complemented by inquiry	Observation, questioning, reflection	Uses resources to support discovery learning
Mpho	Integrated inquiry planning	Supports conceptual grounding	Investigation, collaboration, guided discovery	Emphasis on non-routine experiments
Lebo	Reinforcement model	Traditional teaching first	Application, questioning, real-life links	Focus on applying knowledge and reflection

4.4.1.1. Cross-case findings

Across all five cases, a dominant pattern emerged. Teachers (Tshepo, John, Willy, Mpho, Lebo) generally viewed traditional teaching as a prerequisite for effective inquiry-based practical work. This indicates a shared belief that learners require foundational conceptual knowledge before engaging meaningfully in inquiry activities. However, the teachers differed in how they positioned inquiry within the learning sequence. Tshepo and John adopt a clearly sequential model, where traditional instruction is prioritised before learners engage in hands-on inquiry. For these teachers, inquiry served primarily as a means of applying and reinforcing previously taught concepts, ensuring conceptual understanding before exploration.

Similarly, Lebo also emphasised foundational teaching, but placed stronger emphasis on application and real-life relevance, suggesting a slightly more applied orientation to inquiry outcomes. In contrast, Willy and Mpho demonstrated a more integrated approach, where inquiry is embedded within planning from the outset. Willy emphasised transforming available resources into opportunities for discovery, while Mpho highlighted learner-led investigation, observation, and collaborative problem-solving as central to practical work design. Despite these differences, all five teachers converged on a key idea that practical work should not be purely procedural, but should instead support critical thinking, investigation, and learner reflection. This suggests that while inquiry-based learning is valued, it is often implemented within a structured or curriculum-constrained framework rather than as fully open inquiry.

Case 1: Tshepo

Tshepo explained during the interview how he aligns the practical work with inquiry-based learning objectives. Tshepo believed that before learners can engage in practical work, they need to be taught using traditional approaches first, so that they can master certain concepts to fit into the practical activity. He further believed that he would align the practical work with the inquiry-based learning objectives by allowing learners to master the fundamental concept he taught, guiding them to explore and investigate through hands-on practical work. Additionally, he said that by encouraging learners to ask questions, evaluate their thoughts, and draw conclusions, the practical work should improve their critical thinking. This is what Tshepo said during the interview:

> *"The traditional way is where we mostly start the practical work because we need to explain certain things that require us to explain them traditionally, so that it will fit into the practical work that we are supposed to do. Once the foundational concepts are clear, we then guide learners to explore and investigate through practical activities that encourage them to ask questions, test ideas, and draw conclusions. Therefore, aligning the hands-on tasks with the objectives of inquiry-based learning."*

The lesson observation and document analysis data mainly supported Tshepo's explanation of how he aligns practical work with inquiry-based learning objectives. Tshepo used a lesson plan to facilitate the practical work. In his lesson, he explained the fundamental concepts by providing learners with reasons for titrations, definitions of endpoint and equivalence point, how to conduct measurements, and how indicators work, demonstrating a traditional teaching approach. Tshepo taught using a traditional approach, establishing a conceptual foundation before allowing learners to engage in the practical work. He then encouraged the whole class to discuss these concepts before transitioning into the hands-on activity. This was observed when he integrated practical work with the prior conceptual foundation he established at the beginning of the lesson. Tshepo used little time to clarify the variables and outline learning objectives that aligned with the lesson plan. Figure 4.10 below shows the objectives extracted and reflected in the lesson plan used by Tshepo.

:

LESSON PLAN

TOPIC: Acid-base titration

DURATION: 4 Hours

Learning objectives

- At the end of the lesson, learners must be able to:

  - Apply your knowledge of mole calculations to practical experimental data.
  - Write balanced equations for practical experiments.
  - Review practical techniques.

Figure 4.9: *Lesson objectives reflected on Tshepo's lesson plan*

The observation data further revealed that Tshepo used a questioning technique to scaffold the lesson. This was noted when he asked learners to predict outcomes in response to a question he posed, and when he asked them to define titration and provide reasons why they should titrate. Additionally, Tshepo used a worksheet that posed an investigative question to learners.

Case 2: John

John explained during the interview how he aligns practical work with inquiry-based learning objectives. He stated that he would prefer to teach using traditional methodologies and introduce inquiry strategies later. Just as Tshepo did, John believed in foundational teaching before he introduced open inquiry. When justifying his strategy, he said he would align practical work with the inquiry-based learning objectives by teaching and checking whether learners understood the material through hands-on activities. He believed that these activities would ensure that learners can apply concepts, investigate problems, and reflect on their understanding. In addition, he mentioned that he would align the practical work with the learners' critical thinking, investigation, and independence, to make it meaningful. This is what John said during the interview:

> *"One thing that would be balanced is that you, as a teacher, would have done your traditional teaching and inquiry-based learning, or that type of practical work would be you trying to check if what you have taught in class, your learners understood you or not. So, inquiry-based learning can be used to validate whether they understood you or not. In this way, practical work is not just for demonstration, but becomes a tool through which learners apply concepts, investigate problems, and reflect on their understanding. By so doing, I will be ensuring that inquiry-based learning objectives such as critical thinking, exploration, and learner autonomy are met in a meaningful context."*

Data drawn from observations and document analysis mainly supported John's explanation of how he would align the practical work with inquiry-based learning objectives. During the lesson, he was observed discussing the practical activity with the whole class. He led the learning process. John explained the activity; thereafter, he guided learners in planning their investigation. After that, he transitioned into a hands-on investigation, as articulated in the interview. John engaged his learners by aligning expectations with the previous explanation he had provided. He, therefore, allowed learners to generate the hypotheses before they commenced the practical work. John permitted learners to demonstrate what they had been taught by conducting the practical work independently. Learners had procedural control and followed the investigative question. John controlled the practical inquiry through balancing autonomy with clarity, encouraging learners to analyse the results and compare them with what they had learned.

Case 3: Willy

Willy explained during the interview how he would align practical work with inquiry-based learning objectives. He said that during practical work, he spends more time using traditional methodologies as required by the curriculum. However, he further stated that he plans practical work objectives that promote inquiry by encouraging learners to observe, ask questions, and reflect on their learning process. Willy further mentioned that he would turn available resources into opportunities for learners to discover and construct their understanding through hands-on activities. This is what Willy said during the interview:

> *According to our curriculum requirements, you will spend more time using traditional teaching methods unless the topic involves practical activities that are feasible. However, I make every effort to include some practical elements in every topic, resources permitting. Despite these limitations, I strive to incorporate practical work that encourages inquiry, prompting learners to observe, ask questions, and draw connections. In doing so, I align the practical activities with inquiry-based learning goals by transforming available opportunities into moments where learners can discover and build understanding, even with limited resources."*

Data from observations and document analysis largely supported Willy's explanation of how he intended to align practical activities with inquiry-based learning objectives. In his lesson, he was observed starting with direct teaching and learner discussions, then transitioning into the practical activity. Just like Tshepo, His practical work lesson had objectives as reflected in his lesson plan document. The lesson observational data further showed that Willy guided the lesson, in which learners formulated their hypotheses at the beginning, asked clarity-seeking questions, and analysed the results independently. Willy managed the investigation and enabled learners to reflect on and redesign their tasks for accuracy.

Case 4: Mpho

Mpho explained during the interview that when he plans a practical work lesson, he considers different teaching strategies that also allow learner inquiry. He said he allows learners to explore through investigations and hands-on learning. He further mentioned that learners would be allowed to observe, ask questions, and collaboratively solve problems. Furthermore, he pointed out that in his planning, he ensured that the practical work goes beyond repetitive experiments and actively supports the goals of inquiry-based learning, where learners construct knowledge through guided discovery. He stated the following:

> *"In terms of designing, it's like, first thing that I will do is to look at the lesson, and after looking at the lesson, what is it that I want learners to do? If I want them to investigate, they will be in a group. The traditional method is still applicable, but not too much. I can say that, not too much. When I see that a topic offers space for exploration, I design the practical component in a way that learners can take ownership of the learning process through observation, questioning, and collaborative problem-solving. This helps ensure that the practical work goes beyond routine experiments and actively supports the goals of inquiry-based learning, where learners construct knowledge through guided discovery."*

From the observation and document data, he was observed starting with direct teaching and transitioning into a guided practical task, which supported what he said in the interview. Mpho taught the practical work using traditional teaching methodologies before the hands-on phase. He combined explanations with a practical task when his learners were observing him. Further, Mpho used a lesson plan that contained the lesson strategies to align the practical work with the inquiry objectives. Figure 4.11 below shows the strategies that Mpho employed during the practical work lesson, linking with what he said.

Lesson Strategies	Lesson steps and activities that will take place during the lesson:
	✓ Content covered as in the ATP ✓ Examinable content from the Examination Guidelines 2021 ✓ Definitions of terms ✓ Implementing IBL strategies to scaffold the content ✓ Strategies for the steps involved in solving problems ✓ Outline of possible misconceptions about the topic **Group activities on:** ✓ Setting up the required apparatus and chemicals for the acid-base reaction ✓ Preparing the standard solution ✓ Conducting a titration experiment ✓ Calculations of the unknown concentrations ✓ Problem-solving for calculations on PH and titration ✓ Interpretation of results and report writing

Figure 4.10: *Strategies Mpho used to align practical work with inquiry-based*

Case 5: Lebo

Lebo stated that he teaches the content using traditional methods to primarily build the conceptual foundations, similar to what other teachers said. He believed that the purpose of practical work is to reinforce the content and enable learners to engage in inquiry. He further noted that he would align the practical work with inquiry-based learning objectives by allowing learners to ask questions during the learning process, test their ideas, and encourage them to apply their knowledge in real-life situations, thereby promoting their understanding and critical thinking. During the interview, Lebo said:

> *"The primary thing that we follow is to teach first. So yes, teaching is the one thing that we are trying to balance in our planning. After laying the conceptual foundation through traditional teaching, I use practical work not just to reinforce content, but to allow learners to engage in inquiry by posing questions and testing their ideas. This way, the practical activities become a bridge between curriculum coverage and inquiry-based learning objectives, promoting both understanding and critical thinking."*

Observation and document analysis data maintained Lebo's description of using questioning, knowledge testing, and prior-knowledge application to align practical work with inquiry-based learning strategies. In his lesson, he was observed leading the practical lesson and then changing it into a learner-centred investigation. The observation reveals that Lebo spent some time teaching the content using traditional methodologies. He then guided learners into setting up their practicals and allowed them to work independently.

Lebo provided learners with worksheets that contained the investigative question and the lesson objective. He required learners to answer the question using a prescribed methodology, as reflected in the worksheet. Lebo further expected learners to record observations, analyse the results, and relate them to what was taught at the beginning of the lesson.

4.4.2 Structure and sequencing of practical activities

Table 4.5 below presents a summary of how Tshepo, John, Willy, Mpho and Lebo structure and sequence practical activities in their classrooms, emphasising the different approaches they use to organise lesson flow, the starting points of practical work, and the balance between teacher guidance and learner independence.

Table 4. 5: *Summary Table of Sequencing Approaches*

Teacher	Sequencing Approach	Starting Point of Lesson	Role of the Teacher	Learner Role	Key Emphasis
Tshepo	Gradual progression (guided → independent)	Explanation of purpose	Facilitator	Move from guided to independent work	Confidence-building and gradual autonomy
John	Teacher-led sequential model	Theory first; teacher demonstration	Instructor/ demonstrator	Apply pre-taught knowledge	Conceptual understanding before practice
Willy	Learner-first exploratory model	Hands-on exploration first	Facilitator after exploration	Discover before formal teaching	Experience-driven learning
Mpho	Problem-based sequence	Problem statement	Organiser of groups	Independent investigation	Inquiry through structured problem-solving

Lebo	Guided inquiry sequence	Investigative question	Scaffolded guidance	Respond to guiding questions	Directed inquiry and thinking stimulation

4.4.2.1. Cross-case findings

Across the five cases, there was a variation in how teachers (Tshepo, John, Willy, Mpho, and Lebo) structure and sequence practical activities, ranging from teacher-directed sequencing to learner-driven inquiry sequences. Despite these differences, all teachers aim to create lessons that support meaningful engagement with scientific concepts. A dominant pattern is the use of structured sequencing to support learner understanding before or during practical engagement. For example, John follows a traditional-to-practical sequence, where theoretical instruction precedes hands-on work. Similarly, Tshepo begins by explaining the practical purpose and gradually moves learners from guided participation to independent application. These approaches reflect a linear, structured sequencing model in which teacher input is central at the beginning of the lesson.

In contrast, Willy adopts a more inquiry-first sequence, allowing learners to engage with the practical activity before formal theoretical input. This approach prioritises experiential learning and positions the teacher as a facilitator who consolidates understanding after exploration. Mpho and Lebo both demonstrate guided inquiry sequencing models, although with different starting points. Mpho begins with a problem statement and encourages learners to investigate collaboratively, while Lebo initiates learning through investigative questions and scaffolding. These approaches reflect a problem-based and questioning-driven structure, which supports learner thinking while still providing direction.

Case 1: Tshepo

During the interview, Tshepo explained how he typically structures and sequences practical activities for his learners. He stated that he typically starts by explaining the purpose of the practical lesson. He said this first step builds learners' confidence and understanding of the practical lesson to be conducted. Tshepo believed that a practical lesson should allow learners to move from familiarisation to a guided process and then to independent application. Therefore, he believed that a practical lesson should not just be a task to complete, but a task that supports both skills and conceptual development. This is what he stated:

> *"…In terms of balancing, we have to start first by explaining the rules of the lab and how the practical will be done, and the reasons and objectives why the practical should be done, and what we are expecting at the end. That gave them a sense of what to expect. We moved from familiarisation to guided practice and then to independent application. This way, the practical was not just a task to complete but a learning process that supported both skills and conceptual development."*

In his lesson, he was observed introducing the practical activities, their objectives, and procedures. He explained the practical by stating its aim and learning outcomes. Further, Tshepo asked the learners to define the concepts he had initially taught at the beginning of the lesson. He managed the transition between activities by providing clarity in the questions he posed and by allowing learners to ask each other questions.

Case 2: John

In the interview, John explained how he usually structures and sequences the practical activities for his learners. John believed in conducting practical work after teaching using traditional methods. He thought that before learners begin with the practical work, he would first perform it. John further thought that practical work should be sequenced primarily to build learners' conceptual understanding before they actively engage in hands-on activities. Therefore, he would ensure each step in his lesson prepared learners for the next by creating a logical flow that reduced confusion and maximised learning outcomes. This is what John said during the interview:

> *"When planning practical work, the theory must be taught first so learners understand the content. Learners need to be taught lab safety beforehand. I always experiment on myself first to ensure the results will be as expected. Key considerations include chemical risks, learner discipline, group sizes, and safety measures such as lab coats. I will begin with the theoretical foundation, followed by safety instructions, and then proceed to the preparation of materials. Sequencing is crucial because learners first build conceptual understanding, then gain awareness of safety procedures, and only then engage in the hands-on practical work. Each stage prepares learners for the next, creating a logical flow that reduces confusion and maximises learning outcomes."*

In the lesson, John was observed briefing learners about laboratory safety, then using traditional methods to teach the practical work. He, therefore, conducted a trial run of the experiment before the learners could engage. John planned a learner-centred practical work, but he was observed directing the lesson himself. He guided the learners through the tasks and gave them little autonomy. During the lesson, he provided learners with a worksheet containing practical tasks that were clear and logical, with questions ranging from simple to complex. However, his transition between activities was unclear because he was the one leading the practical lesson.

Case 3: Willy

During the interview, Willy explained how he would organise and sequence practical activities for the learners. He mentioned that he would allow learners to explore the concept being studied independently through hands-on activities. He also said he would teach the theoretical parts of the topic once the learners have gained experience. Willy believed that by sequencing and structuring each lesson stage, he could create a clear and meaningful learning experience that enhances both scientific understanding and collaborative skills. Therefore, he believed that a practical task should begin with introducing the concept, preparing, planning resources, and then implementing. This is what Willy said during the interview:

> *"When designing practical work, I base it on a concept, such as discovering the equivalence point before explaining it theoretically, using traditional teaching methods. The design includes inquiry questions of varying levels for learners to answer. For example, learners begin by engaging with the concept through practical investigation, which initiates interest and stimulates critical thinking before moving into formal theory. This sequencing of activities must be done before explaining. Overall, the sequencing and structuring of each stage, from concept introduction, preparation, and resource planning, to implementation, will create a clear and meaningful learning experience that supports both scientific understanding and collaborative skill-development."*

In the observed lesson, Willy organised learners into groups and provided them with worksheets. He, therefore, instructed them to start the practical work independently. Thereafter, he provided learners with the purpose of the practical, the procedure, and the expected results. Willy explained each step of the practical and demonstrated a logical progression from theory to practice. Then, he transitioned from explanation to exploration by allowing his learners to reflect on the practical work they had performed.

Case 4: Mpho

During the interview, Mpho explained how he usually structures and sequences practical activities for his learners. He mentioned that he typically begins by presenting the problem first, then asks the learners to find the solution independently. Additionally, he stated that he would group the learners based on available resources, class size, and competence levels. He believed that the sequence should start with the problem statement, followed by active investigation. Most importantly, Mpho believed that his teaching strategies create a learning environment that is purposeful, inclusive, and meaningful for practical learning. This is what Mpho said:

> *"I would prefer teaching the theory using traditional methods first. Then, I will structure my lessons by presenting a problem first, and then learners will find solutions independently. I consider resources, group size, and learner ability in planning. Sequencing is intentional. There should be a problem followed by an investigation to encourage logical scientific thinking. I adapt activities to learners' skills and resources, sequencing tasks to support those needing help while allowing advanced learners to explore more. This balance of structure and flexibility creates an environment for purposeful, inclusive, and meaningful practical learning."*

In the observed lesson, Mpho organised learners into groups and provided them with the investigative question, which reflected on the worksheet. Mpho explained the purpose of the practical, the scientific concepts involved, and how it relates to the curriculum. Therefore, he allowed learners to perform the practical in groups, guiding them to collect and record their data systematically. Mpho offered support to the learners who needed help and left others to continue with the practical independently.

Case 5: Lebo

In the interview, Lebo described how he would organise and sequence practical activities for his learners. He mentioned that he would start the practical work by providing learners with an investigative question to establish a clear direction for the lesson and stimulate their thinking. Additionally, Lebo stated that when scaffolding the lesson, he would pose guiding questions to engage learners. Furthermore, he said that he would consider different teaching methods when preparing for an inquiry-based practical work lesson. Finally, Lebo believed that the sequencing of practical work should be from question posing to hands-on experimentation, to ensure a logical flow that supports inquiry. This is what he said:

> *"...I begin with an investigative question for the topic, followed by questions designed to engage learners. I consider different learning styles and plan experiments based on available resources and chemicals. Starting with an investigative question helps establish a clear focus for the lesson and encourages learners' thinking. The subsequent questions act as scaffolds, gradually guiding learners from simple engagement to more in-depth investigation. The sequence moves from posing questions to selecting resources and then to hands-on experimentation, creating a logical flow that supports inquiry, safety, and clarity."*

During the lesson, Lebo provided learners with the goal and an investigative question at the start. He then shared background information on the practical work and clarified scientific concepts. Lebo allowed learners to participate in hands-on practical activities. During his presentation, he asked guiding questions to support learning. He encouraged learners to explain each step as it was performed, helping them follow a logical flow from theory to practice while also providing process instructions.

4.5. THEME 3: Challenges When Implementing Inquiry-based Learning Strategies for Practical Work

4.5.1. Constraints in designing inquiry-based learning practical work

Table 4.6: *Constraints Affecting the Design of Inquiry-Based Practical Work*

Teacher	Resource Constraints	Time Constraints	Other Challenges
Tshepo	Expired chemicals; delays in procurement	Postponements due to a lack of materials	None
John	Limited equipment (shared use)	Extended time due to group rotations	Classroom management issues
Willy	Limited resources for enrichment practicals	School day too short; after-hours not feasible	Limited support for non-formal practicals
Mpho	Lack of laboratory facilities and chemicals	Timetabling and scheduling difficulties	Requires after-hours preparation

Lebo	Limited materials despite support	Insufficient classroom time	High preparation demands

4.5.1.1. Cross-case findings

Resource Constraints

All five teachers (Tshepo John, Willy, Mpho, and Lebo) highlighted resource limitations as a major barrier. For example, Tshepo and Mpho specifically referred to shortages of chemicals and laboratory facilities, while John emphasised limited equipment requiring learners to share. Similarly, Willy and Lebo noted that although some institutional support exists, resources remain insufficient for meaningful inquiry-based activities. This suggests that resource scarcity is a systemic issue affecting implementation.

Time Constraints

Time emerged as another dominant constraint across all cases. John explained that rotating groups due to limited equipment significantly extends the duration of practical work. Willy and Lebo pointed to restricted classroom time, while Mpho highlighted timetabling challenges. Tshepo also linked time delays to procurement issues. These findings indicate that inquiry-based learning is perceived as time-intensive within existing school structures.

Operational and Contextual Challenges

Beyond resources and time, additional constraints were identified. John reported classroom management difficulties, which can disrupt inquiry-based activities that require active learner participation. Mpho and Willy mentioned the impracticality of after-hours sessions, despite the need for extended time. Lebo emphasised the heavy planning and preparation demands associated with inquiry-based approaches.

4.5.1.2. Synthesis

Overall, the findings reveal that resource limitations, time constraints, and contextual challenges are interrelated barriers that hinder the effective design of inquiry-based practical work. While some schools provide partial support, the constraints collectively limit teachers' ability to fully implement inquiry-based approaches.

Case 1: Tshepo

In the interview, Tshepo mentioned the difficulties encountered in designing inquiry-based practical activities. He said they sometimes lack resources because some of the chemicals they need have expired. Tshepo also mentioned that procurement delays in replacing chemicals often caused postponements. This is what he said:

> *"…Sometimes it is a lack of resources, sometimes I will need a certain chemical, but when I get to the Lab, I see that it has already expired, and to procure it might take two or three weeks, and that would maybe delay the lesson. So, those are the challenges, but I have since learned to plan three or four weeks to check if the chemicals that I would need in four weeks are there, so that if they have to be bought, they can be bought before my experiment."*

In the observed lesson, Tshepo verified that all the chemicals they were about to use were in order. He aligned the experiment with the available chemicals and equipment and asked learners to use the chemicals sparingly during hands-on work.

Case 2: John

In the interview, John described the limitations he faced while developing inquiry-based practical work. He mentioned that they lack the resources to fully conduct inquiry-based practical work. As a result, time became a significant constraint, as groups take turns using a single set of equipment, extending the time required to complete the practical. He further explained that he experienced classroom management challenges due to poor discipline among the learners. This is what John said:

> *"Sometimes you find that we are under-resourced, we don't have enough equipment to accommodate different groups at the same time, which means that we have to do by, we have to, we have the same equipment, one set of equipment, which means the groups must come do go back, and another one must come and do, so if we are under-resourced it becomes very tedious and time consuming. That's most of the challenges, and some learners get overexcited, those who are ill-disciplined, which means that you always have to be there to monitor."*

In the observed lesson, John had only two stations with apparatus and chemicals for five groups of learners. John allowed two groups to conduct the practical, with three trials each. He explained the timing and sequencing process to the learners and allocated 30 minutes for each group to complete their turn. While one group worked, the other groups watched. John managed misbehaviour and used verbal reminders for the groups to complete their activity.

Case 3: Willy

During the interview, Willy discussed the challenges they faced when designing inquiry-based practical work. He said that the school has limited resources for enriching practical activities but offers support for formal practicals, and that these limitations affected his ability to prepare for hands-on practicals. Additionally, Willy mentioned that time constraints during the school day limit the length of longer experiments, and after-hours' sessions were not always practicable. He also pointed out that noise levels from learners' interactions complicated the learning process. Willy said the following:

> *"The main challenges are the availability of resources and time. The school provides enough for formal practicals, but it isn't easy to request expensive equipment for informal or enriching activities, even if they're syllabus-related. Long experiments that require approximately three hours to conduct are challenging during the school day due to time constraints and the noise level from learner interaction. I often have to do them in the afternoon, but that's not always practical. While I have good support from management and access to lab facilities, limited resources and time remain the biggest constraints."*

The observational data upheld Willy's explanation of the limitations they experienced when designing an inquiry-based practical work. In the observed lesson, Willy had fewer chemicals, and he used the available resources to conduct the practical. He facilitated the practical work, encouraging his learners to manage time effectively and to use resources sparingly. Willy controlled the noise level by ensuring that every learner remained engaged in their assigned role.

Case 4: Mpho

During the interview, Mpho emphasised that his school lacks resources, which creates difficulties in developing inquiry-based learning activities. He said they specifically lack proper laboratory facilities and materials, including chemicals. Mpho also mentioned that he faces timetabling and scheduling issues because he must always check the availability of time slots to conduct the practicals. He, therefore, explained that he planned for after-hours work since preparations often required more time. Mpho said the following:

> *"…Constraints we usually face include a lack of resources, particularly chemicals. The lab exists, but it's not up to standard; it's more like a classroom and a hall, which we also use as a lab. I'll need to check the timetable, look for free time, and prepare in advance. Maybe call them after school…"*

Mpho conducted the practical work with his learners after school hours. In the observed lesson, he arranged the equipment and materials in the storeroom and created a makeshift laboratory. Mpho used minimal quantities of chemicals when demonstrating the experiment to the learners.

Case 5: Lebo

During the interview, Lebo said that the limitations they encountered when designing an inquiry-based practical work are the demands it places on time, preparation, and resource planning. He also said that despite support from school management and efforts to provide materials and training, limited resources and classroom time constraints remain significant barriers. Lebo said the following:

> *"One of the major challenges is the lack of resources and the amount of time it takes to prepare for a full inquiry-based learning practical. It requires a lot of preparation and classroom time, which can be difficult to manage. Although the school and departmental heads are supportive and try to provide the necessary materials and encourage teacher development through workshops, resource limitations and time constraints still pose significant challenges."*

The observational data supported Lebo's description of the constraints they encountered when designing an inquiry-based practical work. He conducted the practical work with the learners after regular school hours. In the observed lesson, he provided the necessary materials for the practical, made them available for learners to use, and allowed learners to share across groups. He managed time by shortening activities to fit within the available time.

4.5.2 Issues When Implementing Inquiry-based Learning Strategies

The issues reported by the five teachers (Tshepo, John, Willy, Mpho, and Lebo) reveal both shared and context-specific barriers to implementing inquiry-based learning during practical work. These are summarised in Table 4.7 below.

Table 4. 7: *Cross-Case Summary of Issues in Implementing Inquiry-Based Learning*

Teacher	Key Issues Experienced	Underlying Factors	Impact on Inquiry-Based Learning
Tshepo	Unexpected titration results due to a strong acid	Limited practical skills; poor control of variables	Disrupts the inquiry process; requires adjustment of experimental procedures
John	Incorrect dilution of acids; repeated experiments	Weak theoretical understanding; procedural errors	Inaccurate results; delays in completing inquiry activities
Willy	Difficulty using laboratory instruments (e.g., burette reading)	Lack of instrument literacy and practical skills	Prolonged experiments; recurring errors
Mpho	Shortage of chemicals and apparatus	Resource constraints at the school level	Limits hands-on inquiry; shifts teaching to demonstrations
Lebo	Time constraints, large groups, and difficulty interpreting results	Classroom management challenges: mixed learner abilities	Reduced learner autonomy; reliance on peer support

4.5.2.1. Thematic Analysis of Challenges

Limited Practical and Instrumentation Skills

A common issue across the cases of Tshepo, John, and Willy is learners' insufficient practical skills. Learners struggled to control experimental variables, prepare accurate dilutions, and read laboratory instruments such as burettes correctly. These gaps often resulted in unreliable or inconsistent results, which disrupted the inquiry process and required increased teacher intervention.

Inadequate Theoretical Understanding

John specifically highlighted that learners' weak conceptual understanding contributed to procedural errors during experiments. Without a solid grasp of underlying scientific principles, learners found it difficult to engage meaningfully in inquiry-based activities, leading to inaccurate outcomes and repeated trials.

Resource Constraints

Mpho's case points to structural challenges, particularly the lack of essential chemicals and apparatus. These limitations restricted learners' ability to fully participate in hands-on inquiry activities and often forced the teacher to adopt demonstration methods instead. This shift reduces the effectiveness of inquiry-based learning, which relies on active learner engagement.

Time and Classroom Management Challenges

Time constraints and large class sizes, as noted by Lebo, further complicated the implementation of inquiry-based learning. Additionally, the need to repeat experiments due to errors, as mentioned by John, extended the lesson durations. These factors created difficulties in balancing curriculum coverage with meaningful inquiry experiences.

Balancing Learner Autonomy and Scientific Accuracy

Across several cases, particularly John and Lebo, there is a noticeable tension between promoting learner independence and ensuring accurate scientific outcomes. Teachers often had to intervene, regroup learners, or provide additional scaffolding, which limited the level of autonomy typically associated with inquiry-based learning.

Case 1: Tshepo

In the interview, Tshepo explained that incorporating inquiry-based learning strategies during practical work presents several difficulties. He said, for instance, that during a titration experiment, learners experienced problems when the acid used was too strong, leading to unexpected results. According to Tshepo, the challenge could result from a lack of practical laboratory skills in handling variables and applying the correct experimental procedure. Therefore, Tshepo reflected on the experimental plan, chemical concentration control, and the need for flexibility when implementing inquiry-based learning strategies. This is what Tshepo said:

> *"…The acid that we will be using is too strong; we must stop for a few minutes to dilute it because it is going to give, after only three drops, the endpoint. It will be reached after three drops of the acid to the base, so we needed to dilute the acid so that it takes a bit longer to titrate, to neutralise the base. The main challenge we experienced is the lack of skills when learners are following the experimental method…"*

Observation data supported Tshepo's explanation of the challenges faced in implementing inquiry-based learning strategies for practical work. In the observed lesson, Tshepo explained safety procedures and demonstrated to his learners how they should dilute acids. He, therefore, discussed the importance of diluting acids with the learners. Tshepo guided learners to secure expected experimental results and allowed them to observe and engage.

Case 2: John

In the interview, John mentioned that some learners often fail to dilute the acid correctly, leading to inaccurate results during practical work. He further said that learners lacked a theoretical understanding of the concepts, resulting in uncontrolled experimental results. John also said that repeating the practical due to errors extends the time to obtain the results. According to John, such incidents delayed the scaffolding of inquiry-based learning activities and created an imbalance between learner autonomy, scientific accuracy, and meaningful engagement. John said the following:

> *"Since it's a titration, one thing that I can tell you is, when the learners are working on things on their own, some, for example, didn't dilute the acetic acid, and they used it as it is. So, which means that they immediately start titrating the colour change was just instantly there, so for example, I had to take them back so that they can be able to dilute it and re-perform the experiment…"*

Observation data supported John's explanation about the challenges they encountered during practical work lessons. In the observed lesson, John demonstrated titration techniques to the learners before they could engage in a hands-on practical activity. He allowed learners to conduct three trials before they could analyse their results.

Case 3: Willy

Willy mentioned in the interview that they experience numerous issues when implementing inquiry-based learning strategies for practical work. He said that the major problem is that some learners struggle to interpret how to use laboratory instruments. For example, he mentioned that learners cannot read the burette correctly. According to Willy, this resulted in prolonged practical lessons and recurring experimental errors. He, therefore, stated that there were gaps in learners' practical skills and instrument literacy, which made it difficult for him to scaffold teaching within an inquiry-based learning approach. Willy said the following:

> ''*I don't normally face major challenges myself; it is only when some of the learners struggle to interpret the instrumentation, particularly understanding that the burette scale starts from zero and counts downward. This leads to some overshooting of the endpoint during titration. I had to clarify these issues for a few groups by explaining how to properly use the burette, pipette, and syringe. Once the measurement techniques were understood, the learners followed the instructions well; there should be no further issues that occur..."*

In the observed lesson, Willy engaged the learners through practical skills and instrument literacy lessons at the beginning of the practical. He assisted learners with reading the burette correctly and with related titration techniques, such as avoiding overshooting the endpoint to achieve accurate results.

Case 4: Mpho

During the interview, Mpho mentioned that the issues he faces when implementing inquiry-based learning strategies are limited supplies of important chemicals and insufficient apparatus. He pointed out that, since his school has insufficient apparatus, adaptations such as borrowing equipment from other schools were made, often without success. He said he had to use the materials sparingly, limit learners to a full hands-on practical activity, and force them to shift from inquiry-based learning to teacher demonstration. This is what Mpho said:

> *''As with most experiments, things didn't go exactly as planned. One major challenge was the limited supply of phenolphthalein indicator, which meant I had to use it sparingly while still ensuring learners could identify the endpoint accurately. We also*

had minimal apparatus, so I borrowed some from another school. When the resources ran out, I had to demonstrate the process myself to help learners verify their results…"

The observational data supported Mpho's explanation of issues they encounter when implementing inquiry-based learning strategies for practical work. In the observed lesson, they had few resources and equipment. His ability to engage the learners was seen as lacking because he used the borrowed apparatus and displayed little knowledge of it. Mpho switched from a hands-on approach to teacher-directed practical work to complete the entire lesson.

Case 5: Lebo

During the interview, Lebo highlighted several challenges he encounters when implementing inquiry-based learning strategies, including time management and working with large groups. Lebo further said that equipment handling proved difficult for learners. Additionally, he noted that interpreting experimental results was a struggle for some, prompting him to group learners with peers who had obtained clearer outcomes. Lebo said the following:

> *"We encountered several challenges that affected the flow of the practical work. Some learners took a long time to prepare the standard solution, partly due to the large group size and time constraints. To support accurate measurements, we provided digital scales. Additionally, some learners mishandled the burette by opening the tap too much, so we had to demonstrate the correct technique. Another challenge was that some learners struggled to interpret their results. To address this, we paired them with groups that had completed the experiment, allowing them to observe and understand the expected outcomes. Despite these obstacles, we managed to navigate the challenges and support learners throughout the process."*

Observation data confirmed Lebo's explanation of the challenges faced when implementing inquiry-based learning strategies for practical work. His lesson was delayed due to large group sizes and resource sharing. Challenges further continued during the lesson when Lebo noticed a gap in the learners' familiarity with using digital measurement scales, and he had to assist them. Several groups were unable to correctly determine the outcomes of their practical due to a lack of experimental design skills, as noticed by Lebo. He then paired them with successful groups to share their findings.

4.6. Discussion of Findings

This section discusses the research findings based on participants' responses. The themes and subthemes from the collected data were used to discuss the findings. The findings reveal a notable gap between teachers' expressed beliefs about inquiry-based learning and their actual classroom practices, particularly in the cases of John and Mpho. While both teachers acknowledged the value of inquiry-based approaches in promoting learner engagement and understanding, their implementation was often limited or inconsistent. This gap appears to be influenced by several interrelated factors.

Firstly, pressure to cover the prescribed curriculum within limited time frames may discourage teachers from fully engaging in inquiry-based activities, which are often time-consuming. Secondly, a lack of confidence in managing open-ended inquiry lessons, especially when learners demonstrate limited practical and conceptual skills, may lead teachers to adopt more controlled, teacher-centred approaches. Thirdly, concerns about laboratory safety and the potential for errors during experiments may further restrict the extent to which teachers allow learner autonomy.

These factors are closely linked to the broader challenges identified in this study, including time constraints, resource limitations, and gaps in learners' skills and knowledge. Therefore, the disconnect between teachers' beliefs and practices can be understood as a consequence of these contextual and pedagogical challenges, rather than a lack of commitment to inquiry-based teaching.

4.6.1 Theme 1: Teachers' Knowledge of Implementing Inquiry-based Learning Strategies

This theme explores teachers' knowledge of implementing IBL strategies, focusing on their understanding of IBL, how they apply IBL strategies, and facilitation in their lessons.

Teachers' Understanding of Inquiry-based Learning in Practical Work

The teachers (Tshepo, John, Willy, Mpho, and Lebo) all agreed that inquiry-based learning is a learner-centred approach in which learners investigate, explore, and solve problems. The teachers said that their role during inquiry-based practical work shifts from being a source of information to a facilitator who helps learners learn by asking questions, providing resources, and creating environments where they can study independently. This viewpoint corresponds with the definitions of inquiry-based learning for practical work presented by academics such as Shah-Ph and Kumar (2020) and Akuma and Callaghan (2019a). Shah-Ph and Kumar (2020) note that inquiry-based learning is an approach centred on learners that promotes active participation, critical thinking, and problem-solving. The teachers' decision to group learners and allow them to work together on the practical task independently aligned with Akuma and Callaghan's (2019a) view of inquiry-based learning for practical work. They defined practical work as an experience in which learners work together to use equipment and materials to learn about the natural world while engaging in scientific practices through structured, directed, or open inquiry. Their understanding was consistently evident in their definitions of inquiry-based learning and in their teaching practices.

While teachers collectively supported the learner-centred nature of inquiry-based learning during interviews, their approaches to implementing it differed in extent and prominence. Teachers such as Tshepo, Willy, and Lebo demonstrated practices that promoted autonomy, grouping learners, and encouraging them to experiment, explore, and reach conclusions with minimal direct teaching.

For example, classroom observations showed that Tshepo moved between groups during practical activities, monitoring progress and offering guidance through questioning rather than direct instruction. Similarly, Willy frequently posed probing questions to learners, prompting them to reflect on their observations, justify their results, and reconsider their procedures when errors occurred. In these instances, facilitation involved asking open-ended questions such as “What do you notice?” or “Why do you think this result occurred?”, rather than providing immediate answers. Lebo also encouraged learners to work collaboratively in groups, allowing them to discuss findings and draw conclusions collectively, while he intervened only when necessary. In this way, these teachers let go of control by minimising direct instruction, allowing learners to take responsibility for their investigations, and stepping in primarily to scaffold thinking rather than dictate procedures.

These teachers reduced teacher dominance and emphasised hands-on engagement and critical thinking. Their practices aligned with researchers such as Soysal (2021) and Archer-Kuhn and MacKinnon (2020). Soysal (2021) emphasises that inquiry-based learning strategies are teaching techniques that are more learner-centred and less step-by-step, teacher-directed learning. According to Soysal (2021), the central strategy of inquiry-based learning is an inquiry into authentic questions generated from learners' experiences. The classroom practice was also supported by Archer-Kuhn and MacKinnon (2020), who note that during an inquiry-based lesson, teachers serve as facilitators, helping learners process information, communicate in groups, coach their actions, facilitate their thinking, and model learning.

In contrast, teachers such as Mpho and John tended to combine traditional teacher-led methodologies with inquiry-based strategies. For example, Mpho began his lesson with a theoretical explanation before allowing learners to conduct practical work, and John demonstrated and introduced concepts before providing learners with results to consolidate understanding. In these cases, facilitation was more structured, involving step-by-step guidance and closer teacher control rather than open-ended learner exploration. Their practices supported active engagement, but they focused more on structured guidance than full autonomy. Their classroom practices are supported by researchers such as Machado and Nahar (2023) and Camci and Buyuksahin (2023). Camci and Buyuksahin (2023) note that many teachers are unfamiliar with the constructivist concept and, therefore, lack an understanding of inquiry-based learning strategies. On the one hand, Machado and Nahar (2023) argue that there is inadequate preparation in inquiry methodology, and teachers view inquiry-based strategies as challenging to implement.

Teachers' Applications of Inquiry Strategies in Practical Work

Participants (Tshepo, John, Willy, Mpho, and Lebo) recognised the value of using inquiry strategies in practical work, but the manner in which they did so differed significantly. The most commonly mentioned and used inquiry strategies across them were guided inquiry, collaborative learning, hypothesis generation, and scaffolding techniques. Their perspectives aligned with those of researchers such as Gholam (2019) and Strat et al. (2023). Gholam (2019) emphasises that as teachers guide learners through the stages of inquiry, they should follow these key principles: ensure science is accessible, make thinking transparent, facilitate peer learning, and encourage the development of independent learning skills. The perspective is also supported by researchers such as Photo (2025), who found that novice teachers mainly apply confirmatory and structured inquiry strategies.

In contrast, experienced teachers adopt direct, open inquiry when conducting practical work. On the one hand, Strat et al. (2023) argue that important pedagogical strategies to be considered in inquiry-based lessons include the teacher's organisation of the classroom, crafting and asking of questions, recognition of the learners' prior knowledge, arrangement and facilitation of group discussions, and guiding learners to develop their problem-solving skills. Therefore, their teaching methodologies demonstrated a collective belief that learners engage in practical activities that involve critical thinking, group problem-solving, and reflective discussions.

Despite this shared belief, the actual use of these strategies during lesson observations did not always align with what teachers said they intended during interviews. Teachers such as Tshepo, John, and Willy balanced between teacher guidance and learner independence. Their teaching strategies were supported by Meulenbroeks et al. (2023), who note that scaffolding in inquiry-based lessons involves providing more external support at the beginning of the lesson. Meulenbroeks et al. (2023) further stipulate that support for learners must be gradually removed as the lesson proceeds, until they can work and learn independently. As a result, when their support gradually decreases, the learners' responsibility and autonomy increase. These teachers' lessons included structured worksheets with investigative questions, procedural steps, and scaffolded guidance (Tshepo, John, and Willy).

The teachers (Tshepo, John, and Willy) gave learners chances to collaborate, explore, and make their own decisions. Their practices further aligned with those of researchers such as Bui et al. (2020) and Peel (2020). Bui et al. (2020) argue that in a guided inquiry, learners investigate the teacher-presented question, but they design and select procedures, and the results are not known to them. For this reason, these teachers (Tshepo, John, and Willy) focused on group work and used guiding questions to support reflection, analysis, and evaluation of results, rather than relying on direct instruction. In support of their teaching strategies, Peel (2020) argues that a teacher chooses the question to be investigated during practical work, and the learners, with the help of a teacher, design the procedure to be followed in conducting the investigation. Peel (2020) further argues that such practices demonstrate the effective use of inquiry-based strategies, in which learners are encouraged to engage in scientific reasoning and take responsibility for their own learning.

On the contrary, teachers such as Mpho and Lebo preferred traditional teaching methods, even though they had indicated an interest in inquiry strategies during interviews. Their practices aligned with researchers such as Damoah et al. (2024), Ngobeni et al. (2023), and Naidoo (2022). According to Damoah et al. (2024) and Ngobeni et al. (2023), teachers mainly operated at the mechanical and routine levels because the CAPS curriculum is perceived as not adequately supporting their proper implementation, resulting in a teacher-centred approach during practical work and limited learner engagement. Therefore, with little advocacy for the CAPS curriculum, learners may only watch what the teachers do, and no active participation can be observed (Ngobeni et al., 2023). In their observed lessons, teacher-centred approaches predominated, with learners mostly following their teachers' instructions rather than engaging in open-ended exploration. Such practices were also observed by researchers such as Lesetja (2025), who notes that in a resource-limited setting, teachers employed a demonstration approach: they initially performed the practical activity while learners observed, then asked learners to replicate it. Inquiry strategies, including collaboration and guided questioning, were introduced only towards the conclusion of the lessons, thereby restricting opportunities for learner autonomy. This highlighted a gap between teachers' theoretical knowledge of inquiry strategies and their actual implementation. According to Naidoo (2022), teachers may rely on traditional teaching strategies during practical work due to limited content and pedagogical content knowledge for conducting practical activities.

4.6.2 THEME 2: How Teachers Design Their Practical Work

The theme examines how teachers design their practical work, with particular attention to how teachers align practical work with IBL objectives and how they structure and sequence practical activities to align with IBL principles.

Alignment of Practical Work with Inquiry-based Learning Objectives

Teachers (Tshepo, John, Willy, Mpho, and Lebo) shared a standard view that effective practical work must align with inquiry-based learning objectives. However, they also emphasised the importance of establishing a strong conceptual foundation through traditional teaching before transitioning to inquiry. Collectively, the teachers believed that providing learners with a theoretical foundation would enable them to meaningfully engage in hands-on activities, formulate hypotheses, and critically reflect on their findings. Their perspective is supported by Al-Mamun et al. (2020), who state that the teacher's role in inquiry-based learning involves scaffolding learners by offering theoretical foundations and external support to facilitate effective learning. Jazby (2023) further emphasises that when teachers align practical activities with inquiry-based strategies, they should refrain from overwhelming learners with excessive information; instead, they should facilitate and support learners in independently seeking out information and constructing an understanding of natural phenomena. Therefore, their approach illustrated an effort to balance curriculum demands with the objectives of inquiry-based learning.

During their lesson presentations, teachers used structured lesson plans, investigative worksheets, and guiding questions. Teachers such as Tshepo, John, and Willy scaffolded their lessons by first explaining fundamental concepts, followed by opportunities for learners to generate hypotheses, explore through experiments, and analyse results independently. The teachers integrated teacher-led methodologies with inquiry, ensuring that learners were not only performing experiments involuntarily but were also engaged with the fundamental scientific thinking. As illustrated in Tshepo's lesson plan (Figure 4.9), the objectives clearly aimed to bridge theory and practice by enabling learners to apply conceptual knowledge in a practical context through active experimentation and inquiry-based activities. Their teaching approach has been confirmed by researchers such as Ramnarain (2020) and Thomas (2021), who highlight that inquiry-based learning can significantly empower learners with the knowledge, skills, and dispositions necessary for independent thinking and lifelong learning. Additionally, the researchers highlighted that learners are prompted to articulate their experiences of a natural phenomenon. This process facilitates a comparison of their individual experiences with those of their peers in the group and with established scientific perspectives.

On that note, Mpho and Lebo highlighted the importance of moving beyond repetitive practical tasks and focusing on promoting observation, questioning, problem-solving, and the application of prior knowledge to encourage critical thinking. Their views are supported by Akuma and Callaghan (2019a), who mentioned that Inquiry-based learning is an experience in which learners collaboratively manipulate equipment and materials to gain an understanding of the natural world as they engage in scientific practices through structured, directed, or open inquiry.

Although traditional methodologies dominated the initial stages of the teachers' lessons, they eventually transitioned to practical activities that reflected inquiry-based objectives. Learners were given investigative questions, guided in setting up experiments, and encouraged to record, analyse, and reflect on their observations. The use of questioning and group discussions was consistent across teachers, aligning practical work with inquiry-based learning goals such as hypothesis generation, problem-solving, and reflective thinking. However, the extent of learner autonomy varied. Teachers (Tshepo, John, and Willy) facilitated practical work with independence and allowed their learners to draw conclusions on the practicals. In contrast, Mpho and Lebo maintained stronger oversight, ensuring that learners followed prescribed methodologies.

Structure and Sequencing of Practical Activities

Teachers perceived the structuring and sequencing of practical activities as critical for meaningful learning. Collectively, Tshepo, John, Willy, Mpho, and Lebo believed that practical work should not be treated as isolated tasks but rather as purposeful, step-by-step processes that link theory to practice, build confidence, and promote both conceptual and skills development. Their views are supported by researchers such as Sutiani (2021), who notes that practical work activities are a vital component of the learning process because they help learners develop critical thinking, problem-solving, and inquiry skills. Additionally, Sutiani (2021) notes that the tasks allow learners to gain a better understanding of the concepts they are learning and to improve scientific skills, including measurement, experimentation, data analysis, and observation. Across the teachers, there was a shared emphasis on starting by explaining objectives, stating investigative questions, or introducing theoretical concepts, before moving on to hands-on investigation. This view is supported by Lesetja (2025), who notes that practical skills apply theoretical knowledge in practical situations, and the bridge between theory and application is crucial for understanding and mastering Physical Sciences concepts.

Teachers (Tshepo, John, and Willy) emphasised the importance of primarily establishing conceptual clarity in their lessons. From their arguments, the teachers sequenced their lessons by explaining the aim, background concepts, and expected outcomes before learners actively engaged in experimentation. Meulenbroeks et al. (2023) support their view by noting that scaffolding in inquiry-based lessons involves providing more external support at the beginning of the lesson. Therefore, teachers (Tshepo, John, and Willy) transitioned to practical work by using worksheets that provided procedural steps and scaffolding questions, along with their explanations. This structure provided changing levels of learner autonomy. For instance, Tshepo and Willy allowed learners to take more initiative after the lesson's introductory phase. In support of John and Willy, Meulenbroeks et al. (2023) note that support for learners during practical work must be gradually removed as the lesson progresses, until they can work and learn independently.

On the one hand, John retained firmer control of the lesson, directed tasks, and limited independent investigation despite having designed a learner-centred lesson plan. John’s practices are argued by Machado and Nahar (2023), when they point out that without knowledge and understanding of the implementation of inquiry-based strategies, teachers will never be able to see the benefits and opportunities that come with the strategies, as a result, they will continue to teach learners in the same way they were taught, the traditional way of teaching.

Other teachers (Mpho and Lebo) structured their lesson activities around problem-solving and investigative questions. They revealed that they began their practical work lessons by presenting learners with inquiry activities that promoted investigation and hands-on engagement early in the lesson. This is supported by Shana and Abulibdeh (2020), who emphasised that during practical work, knowledge is actively constructed by a learner rather than being transmitted directly from the teacher to the learner. Therefore, their sequencing of practical activities followed a logical flow from asking questions to hands-on practical work and reflection, supporting learner inquiry. While Mpho scaffolded activities by grouping learners and offering targeted support, Lebo encouraged learners to explain each step, promoting a more engaging and reflective lesson.

4.6.3 THEME 3: Challenges When Implementing Inquiry-based Learning Strategies for Practical Work

The third theme explores the challenges teachers encounter when implementing inquiry-based learning strategies for practical work, highlighting the constraints and difficulties that influence effective classroom application.

Constraints in Designing Inquiry-based Learning Practical Work

Teachers (Tshepo, John, Willy, Mpho, and Lebo) mentioned the constraints they encountered that obstruct the success in designing and implementing inquiry-based practical work. Collectively, their most serious challenges include resource shortages, time constraints, and classroom management difficulties. In this regard, teachers such as Mpho expressed that the allocated school periods were too short for meaningful inquiry, especially since inquiry-based strategies typically require more time for investigation, collaboration, and reflection. Therefore, Mpho and Lebo planned to conduct the practical lessons after school, whereas teachers such as John and Willy shortened activities to fit within the limited time available. These constraints are mentioned by researchers such as Effendi-Hasibuan and Mukminin (2019) and Shohel et al. (2022). According to Effendi-Hasibuan and Mukminin (2019), time constraints and curriculum demand often limit the scope for open-ended inquiry, requiring careful planning and integration of inquiry-based strategies within existing lesson structures. Alternatively, Shohel et al. (2022) pointed out that the lack of resources, especially in resource-constrained schools, is another challenge that delays the implementation of hands-on activities. Collectively, these factors constrain teachers’ ability to design and effectively implement learner-centred inquiry-based practical activities.

Classroom management also posed difficulties during inquiry-based lessons. Teachers (John and Willy) reported challenges, including noise levels, discipline issues, and off-task behaviour when learners were not actively engaged. According to Nzomo et al. (2023), managing a classroom where learners are actively engaged in inquiry-based learning can be challenging for most teachers. Therefore, to mitigate these, teachers assigned roles within groups, provided close supervision, and used verbal reminders to maintain order. While such strategies helped, they also required constant teacher intervention, limiting the freedom necessary for authentic inquiry.

Issues When Implementing Inquiry-based Learning Strategies

Teachers (Tshepo, John, Willy, Mpho, and Lebo) explained that they encountered a series of issues when implementing inquiry-based learning strategies in practical work, many of which originate from learners' limited skills and the challenges of balancing autonomy with accuracy. Teachers highlighted that learners lacked laboratory practical skills, such as handling of apparatus and applying the correct experimental procedures, which influenced the time allocated for lessons.

According to Shohel et al. (2022), teachers face challenges in effectively scaffolding lessons to strike a balance between supervision and learner self-sufficiency. Therefore, a lack of balance between learner autonomy and accuracy poses a challenge. Van-Graan (2020) further notes that teachers' expertise and pedagogical knowledge in conducting practical work remain a challenge, and their content knowledge, together with pedagogical skills, affect the implementation of inquiry-based learning strategies, thereby diminishing the value of teaching and learning in Physical Sciences. Therefore, teachers' skills in implementing practical inquiry-based learning remain a challenge. Collectively, the issues reflect both methodological problems in conducting experiments and pedagogical clashes in scaffolding inquiry while ensuring secure and effective learning outcomes.

4.7. Chapter Summary

This chapter described and discussed how Physical Sciences teachers employ inquiry-based learning techniques during hands-on instruction. The findings were derived from semi-structured interviews, observations, and document analysis (lesson plans and worksheets). The chapter went on to analyse the conclusions drawn from these observations. The following chapter will present a summary, findings, and recommendations for future research.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1. Introduction

This chapter presents a summary of the study's findings, articulates conclusions, and provides recommendations. The study addresses its limitations and offers recommendations for future research.

5.2. Methodological Reflections on the Study

This study adopted a qualitative methodology to explore how Physical Science teachers execute inquiry-based learning strategies during practical activities. The qualitative method was selected because it enabled an in-depth investigation of participants' experiences through comprehensive research techniques. Qualitative research is particularly suited to exploring complex human experiences, perceptions, and social phenomena within their natural contexts (Langley and Meziani, 2020). The qualitative method also allowed an in-depth understanding of teachers' perspectives on implementing inquiry-based strategies in practical work within a specific societal background. This aligns with the interpretivist paradigm, which emphasises understanding participants' subjective meanings and experiences (Pervin and Mokhtar, 2022). While participants' perceptions differed, each view was considered trustworthy and valid.

Data collection involved semi-structured interviews, classroom observations, and document analysis. These methods are commonly used in qualitative research to gather rich, descriptive data from multiple sources (Ayala and Koch, 2019). The researcher observed teachers' practical lessons and analysed their lesson plans and worksheets. The semi-structured interviews provided insights into teachers' opinions, experiences, and approaches to inquiry-based learning strategies during practical work. Semi-structured interviews allow flexibility and enable participants to express their views freely while allowing the researcher to probe for understanding (Conrad and Tucker, 2019). These interviews fostered open conversations, encouraging participants to share detailed, honest responses.

Classroom observations were critical for understanding how teachers engage inquiry-based methodologies in practice. Observations enable researchers to systematically examine behaviours and interactions within natural settings (Mezmir, 2020). They helped identify the teachers' knowledge, strategies, and challenges faced during implementation. The document analysis revealed the necessary resources and objectives for the practical activities, with documents serving as valuable sources of contextual and historical information (Natow, 2020). The use of multiple data collection methods ensured a more comprehensive understanding of the phenomenon and strengthened the study through triangulation (Aguilar-Solano, 2020). These procedures assured fair data collection and helped the researcher gain a better understanding of the topic. The obtained data allowed for the identification of themes that addressed the research questions.

5.3. Summary of Findings

This section summarises the findings that were derived from the study's research questions. The subsequent findings were derived from semi-structured interviews, observations, and document analysis.

5.3.1. Teachers' Understanding of Inquiry-based Learning Strategies in Physical Sciences Practical Activities

The results indicate that teachers held similar perspectives on the definitions of inquiry-based learning methodologies and their application in practical activities. All teachers emphasised that during inquiry-based practical work, learners participate in hands-on activities that promote active learning, improving skills and problem-solving abilities. The primary theme derived from the results indicates that inquiry-based practical activity is seen as a hands-on method of learning. This perspective is consistent with the findings of researchers such as Tsakeni (2021) and Cossa and Uamusse (2015).

Tsakeni et al. (2019) highlight that practical work is an essential component of Physical Sciences teaching, offering learners experiential opportunities to investigate scientific phenomena. Additionally, Cossa and Uamusse (2015) note that practical work encompasses all activities in which learners witness and manipulate objects. While teachers perceived practical work as experiential, the implementation of inquiry-based learning methodologies varied among teachers.

The findings show that teachers collectively understood inquiry-based learning as a learner-centred approach where learners actively participate in investigations, problem-solving, and critical thinking. They recognised their role as facilitators rather than primary sources of knowledge, often guiding learners with questions, scaffolding activities, and encouraging collaboration. However, while all participants valued learner autonomy, their practices varied along a continuum: some relied on traditional teaching methods before transitioning to inquiry, while others allowed learners greater independence to explore and draw conclusions. This is consistent with Machado and Nahar's (2023) observation that many teachers remain uncertain about how to implement inquiry-based learning in practice and often revert to traditional methods when faced with challenges. Similarly, Baroudi and Rodjan-Helder (2021) alert that without adequate understanding of inquiry-based learning, teachers struggle to consistently realise its benefits, which explains the continuum of practice identified in the findings. Finally, the recognition of learner autonomy in the findings resonates with Akuma and Callaghan (2019b), who emphasise the importance of teachers' knowledge of inquiry-based learning implementation and their ability to design practical work that supports learner-centred inquiry.

5.3.2. How Teachers Design Their Practical Work

The findings indicated that most teachers designed their practical work activities to closely align with inquiry-based learning goals, while still maintaining the fundamentals of traditional methodologies to support conceptual understanding. All five teachers (Tshepo, John, Willy, Mpho, and Lebo) believed in preparing learners' theoretical knowledge by teaching them first before engaging in inquiry. Their mixed approach ensured that learners could generate hypotheses, perform the experiment independently, and analyse results. Teachers designed practical activities that reflected the balance between teacher-centred, scaffolding, and learner-centred inquiry as noted by Al-Mamun et al. (2020) and Jazby (2023). They mentioned scaffolding as a central design principle, where teachers deliberately plan to support and guide learners in making sense of natural phenomena.

Further, teachers believed they must use structured lesson plans that include investigative questions to scaffold learning. Furthermore, teachers preferred that their learners be given worksheets containing guiding questions to scaffold learning. This was noted when teachers (Tshepo, John, and Willy) began their lessons with conceptual explanations and gradually transitioned into a learner-centred exploration. At the same time, Mpho and Lebo designed their practical work lessons to prioritise questioning, problem-solving, and the application of prior knowledge to stimulate critical thinking. However, the degree of learner autonomy varied across the lessons, indicating differences in how they designed their practical activities. Tshepo, John, and Willy allowed learner independence, while Mpho and Lebo maintained teacher supervision.

In structuring and sequencing practical activities, teachers emphasised the need for consistency and development from theory to practice. They created practical work that was a planned process rather than individual assignments, assisting learners in acquiring scientific thinking and skills such as observation, measurement, and data analysis (Sutiani, 2021). Teachers structured activities to clarify objectives, introduce key concepts, and then engage learners in hands-on inquiry. Teachers such as Tshepo, John, and Willy provided scaffolding through worksheets that contained guided questions to facilitate the practical work. During their lessons, they gradually reduced support as learners gained confidence, reflecting Meulenbroeks et al.'s (2023) view of fading guidance in inquiry-based lessons. Furthermore, Meulenbroeks et al. (2023) note that support for learners during practical work must be gradually removed as the lesson proceeds, until they can work and learn independently.

Equally, Mpho and Lebo, in their structuring and sequencing, adopted a more problem-based approach by introducing the investigative questions at the beginning of their lessons. The teachers designed the activities to encourage active learning and reflection amongst the learners. Their approach was consistent with that of Shana and Abulibdeh (2020), who emphasise that, in practical work, knowledge is actively constructed by the learner rather than being directly transmitted from the teacher to the learner. Generally, the teachers' approaches demonstrated a shared commitment to linking theory and practice, fostering inquiry skills, and gradually developing learner autonomy through structured and flexible practical work design.

5.3.3. Challenges When Implementing Inquiry-based Learning Strategies for Practical Work

This study's findings indicate that teachers identified several issues impacting the implementation of inquiry-based learning strategies in practical work. Teachers identified contextual factors, including resource limitations, time restrictions, inadequate skills, and insufficient professional development, as obstacles to the effective implementation of inquiry-based practical work. Previous research by Effendi-Hasibuan and Mukminin (2019), Shohel et al. (2022), Nzomo et al. (2023), Baroudi and Rodjan-Helder (2021), and Van-Graan (2020) identify these issues. This study extends their findings, demonstrating that these challenges persist in schools and that minimal efforts have been made to address them. The findings indicate a blend of universal and practical challenges faced by teachers.

Teachers said that they performed practical work under unfavourable circumstances. The circumstances include working in packed classrooms with limited resources and teachers having little time to teach, which restricts the use of inquiry methodologies and lowers the quality of practical work. Furthermore, the challenges led to classroom management issues, including noise and discipline problems, further complicating matters. In addition, teachers mentioned learners' lack of laboratory skills, such as handling equipment or interpreting results, often led to inaccurate outcomes and delayed progress, requiring them to intervene through demonstrations or guided support. These challenges frequently resulted in compromises, where practical work shifted towards teacher-led demonstrations rather than learner-driven inquiry.

5.4. Summary of Findings Based on the Theoretical Framework

This study was guided by the 5E's inquiry-based instructional model and the levels of inquiry-based learning, which together provided the framework for analysing how teachers implement inquiry-based learning strategies in Physical Sciences practical work. The 5E model (Engage, Explore, Explain, Elaborate, Evaluate) offered a structure for examining how teachers organise and facilitate practical lessons, while the levels of inquiry, ranging from structured to open inquiry, helped determine the degree of learner autonomy and teacher facilitation. The findings are, therefore, summarised in accordance with these frameworks, highlighting teachers' knowledge of inquiry-based learning strategies, their design of practical work, and the challenges they faced during implementation.

5.4.1 The 5E's Inquiry-based Instructional Model

Table 5.1: *A summary of findings based on the 5E's inquiry-based instructional model*

The 5E's model	The findings
Engage	The engagement phase was visible in this study when teachers attempted to stimulate learners' interest at the beginning of practical lessons. Teachers such as Mpho and John relied on theoretical introductions; in contrast, Tshepo, Willy, and Lebo used questioning and problem-solving to stimulate curiosity. These practices align with Shah-Ph and Kumar's (2020) definition of inquiry-based learning as a learner-centred approach that promotes curiosity and critical thinking. Similarly, Ramnarain (2020) emphasises that inquiry begins with scientifically oriented questions that activate learners' prior knowledge and stimulate exploration. Therefore, while all teachers achieved engagement, those who used questioning (Tshepo, Willy, and Lebo) were more closely aligned with inquiry-driven engagement.
Explore	The exploration phase was observed when learners were provided opportunities to engage with practical activities. In Mpho and John's classrooms, exploration was teacher-directed, with learners imitating demonstrated procedures, thus limiting open-ended discovery. In contrast, Tshepo, Willy, and Lebo encouraged learners to independently investigate and answer questions, which aligns with Aparicio-Ting et al.'s (2019) constructivist view that inquiry-based strategies should provide learners with opportunities to construct knowledge actively. Similarly, Tsakeni et al. (2019) argue that practical work offers hands-on experiences in which learners can openly explore scientific phenomena. This shows that the exploration step was evident but only fully realised where open-ended investigation was encouraged.
Explain	The explanation phase was visible when teachers scaffolded learners' understanding of observations. John and Mpho relied on teacher-led explanations, while Tshepo, Willy, and Lebo encouraged learners to articulate their own reasoning. This aligns with Al-Mamun et al.'s (2020) point that the teacher's role in inquiry-based learning is to scaffold learning rather than dominate it. Moreover, Li et al. (2023) argue that meaning-making in inquiry occurs through interaction

	between teacher and learners, often starting with authentic questions. In this study, learners were given opportunities to share explanations, but the strong teacher direction in some classrooms meant this step was only partially achieved.
Elaborate	Elaboration was observed when teachers extended learners' understanding beyond initial explanations. Tshepo and Willy encouraged greater inquiry through problem-solving, hypothesis testing, and reflection, allowing learners to justify their reasoning. This aligns with Chu et al. (2021), who highlight that inquiry-based learning empowers learners to become independent thinkers through discourse, problem-solving, and reflection. Equally, John, Mpho, and Lebo limited elaboration by adhering to prescribed methods, thereby restricting opportunities for independent inquiry. Thus, while elaboration was visible, it was unequally implemented across classrooms.
Evaluate	The evaluation phase was present when teachers assessed learning through worksheets, reports, and questioning at the end of the lesson. This corresponds with the Department of Basic Education's (2011) CAPS curriculum, which requires formal assessment of practical tasks to evaluate learners' understanding. However, as Effendi-Hasibuan and Mukminin (2019) note, effective inquiry-based learning requires continuous assessment embedded in the process rather than just at the end. While all teachers received evaluations, they were more formal and summative than continuous and formative.

5.4.2 Levels of Inquiry-based Learning

Confirmation Inquiry

Teachers at this level teach what learners already know. Learners are made to follow a prescribed procedure to confirm previously taught concepts. According to Dema and Yuden (2022), the confirmation inquiry approach is predominantly teacher-centred, positioning learners primarily as respondents to teacher-directed activities. The findings revealed that teachers such as Mpho and Lebo, in their observed lessons, often relied on confirmation inquiries due to limited resources; therefore, their practical lessons were centred on them. This approach provided clarity but offered learners little autonomy, as they followed teacher demonstrations and step-by-step worksheet methodologies.

Structured Inquiry

This is the level of inquiry where learners explore the questions posed by their teachers through a defined methodology. However, the outcomes remain unknown to them (Spernes & Afdal, 2023). Most teachers in this study operated primarily at the structured inquiry level. Their practical activities were planned with investigative questions, procedural steps, and scaffolded worksheets. Teachers such as Tshepo and John first introduced theoretical concepts, then guided learners through activities in which the methodology was provided, and learners analysed the results. While this approach ensured curriculum alignment and reduced confusion, it still placed control primarily in the teacher's hands.

Guided Inquiry

In a guided inquiry, learners explore a question posed by the teacher while formulating and choosing their own methodologies, with the outcomes unknown to them (Bui et al., 2020). Some of the teachers attempted guided inquiry, in which learners were given investigative questions, but had to decide on parts of the process, such as generating hypotheses, exploring results, and interpreting results. Teachers such as Willy and Lebo encouraged collaboration, allowed learners to make independent decisions at certain stages of their lessons, and reduced guidance once learners were more engaged. However, challenges such as time constraints and limited laboratory skills restricted the full implementation of guided inquiry.

Open Inquiry

According to Jegstad (2023), open inquiry is the highest level of inquiry and is entirely learner-centred, with learners beginning by formulating questions about a specific topic to be explored and by designing and selecting the process to be used. In this study, the researcher rarely observed instances in which learners designed and carried out investigations independently. Teachers valued learner autonomy in principle, but systemic constraints, such as insufficient resources, limited laboratory skills, and large group sizes, prevented its consistent application. In most cases, teachers expressed willingness to encourage autonomy but reverted to structured or guided inquiry due to practical challenges. Therefore, none of the participants used this level of inquiry during their lessons.

5.5. Recommendations

This study recommends the following:

- The Gauteng Department of Education should provide ongoing teacher professional development workshops focusing on the implementation of inquiry-based learning strategies during practical work, specifically the 5E instructional model, and on scaffolding inquiry at different levels of learner autonomy.
- Furthermore, the Education Department should promote peer mentoring and Professional Learning Communities in which teachers exchange best practices, lesson plans, and classroom management strategies for inquiry-based, practical work. This will enable teachers to conduct practical work while applying inquiry-based learning strategies, thereby enhancing the quality of teaching in Physical Sciences (Shivolo & Mokiwa, 2024).
- The Gauteng Department of Education and the School Management Teams (SMT) should allocate a budget that prioritises adequate resourcing of laboratories, including apparatus, consumables, and safety equipment, to enable meaningful practical investigations. Teachers should also be trained in low-cost or improvised experiments that still allow learners to engage in inquiry processes.
- The Curriculum and Policy Statement (CAPS) for Physical Science should explicitly include inquiry-based strategies and provide adaptable guidelines for practical work, enabling teachers to tailor activities to their backgrounds.
- Curriculum planners should allocate adequate teaching time for practical work lessons to cover the investigation, collaboration, reflection, and evaluation stages.
- Physical Sciences teachers should adopt a gradual release approach to scaffolding: providing structured guidance initially, then gradually reducing support as lessons progress to foster learner independence.

- Physical Sciences teachers should sequence practical work to link theory and application, beginning with engagement and exploration, followed by opportunities for learners to explain, elaborate, and evaluate their learning.
- Physical Sciences teachers should increase the use of open-ended investigative questions, group problem-solving, and learner reflection to raise critical thinking.
- Physical Sciences teachers should train learners in laboratory skills and inquiry traditions. For example, observation, data recording, and hypothesis formulation to strengthen independence and reduce reliance on teacher intervention.

5.6. Limitations of the Study

The results answered the three research questions on which this study was based. Nonetheless, this study had certain shortcomings. The study examined the experiences of five teachers and their methodologies for adopting inquiry-based learning strategies during practical work. Consequently, the study's conclusions cannot be generalised because this is a qualitative study. Pandey and Pandey (2021) argue that qualitative research methodology is crucial for understanding human behaviour, emotions, attitudes, and experiences. This technique focuses on individuals' opinions, experiences, and perspectives, without generalising the findings to a broader community. Therefore, future research is necessary to utilise a quantitative methodology to extract further insights from a wide range of teachers across all provinces.

5.7. Conclusion

This study investigated how teachers apply inquiry-based learning strategies in their Physical Sciences practical lessons. Its goal was to examine how teachers apply these strategies during practical work in Physical Sciences. It also examined how teachers design practical activities, the challenges they face, and their knowledge of using inquiry-based learning strategies during practical work. The research aimed to add to the growing understanding of teachers' practices in resource-limited schools and how this knowledge can help bridge the educational gap between schools.

The findings revealed that teachers view inquiry-based learning as a learner-centred approach that promotes active participation, critical thinking, and collaboration in solving problems. Teachers see their primary role as facilitators, guiding learners through investigative questions and structured activities. However, their actual implementation often combines traditional methods with structured and guided inquiry. Their lesson plans were aligned with inquiry-based learning goals and moved from building conceptual understanding to practical application. Challenges such as limited resources, time management, large class sizes, and gaps in learners' lab skills sometimes lead teachers to blend inquiry strategies with traditional methods. These factors hinder open-ended investigations and learner independence. The study recognises that, although teachers are knowledgeable and committed to inquiry-based learning, external factors significantly influence how effectively they can implement these strategies. It also records notable disparities among schools in laboratory resources, practical skill development, professional support for teachers, and flexibility in curriculum and assessment. If these issues are not addressed, the gap will continue to grow, negatively affecting learner performance in Physical Sciences.

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APPENDICES

APPENDIX A: ETHICS CLEARANCE LETTER

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 12 July 2024

Ref: **2024/07/12/00000056/02/RB**
Name: **Mr. Lesiba Frans Phalane**
Student No.: 41471385

Decision: Ethics Approval form

Dear **Mr. Lesiba Frans Phalane**

Researcher(s): Name: **Mr. Lesiba Frans Phalane**
E-mail address: 41471385@mylife.unisa.ac.za
Telephone: 081 561 8964

Supervisor(s): Name: **Dr. P Photo**
E-mail address: photop@unisa.ac.za
Telephone: 079 181 8165

Title of research: Teachers' implementation of Inquiry-Based learning strategies for practical work in Physical Sciences: A case study in Tshwane South District

Qualification: MEd (Natural Sciences)

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above-mentioned research. Ethics approval is granted for the period **2024/07/12** to **2027/07/12**.

*The **write risk level** application was reviewed by the Ethics Review Committee on **12 July 2024** in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

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

3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2027/07/12.** Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2024/07/12/00000056/02/RB** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof RB Monyai
Acting Head: CEDU Research
monyarb@unisa.ac.za

Prof Mpine Makoe
Executive Dean: CEDU
qakisme@unisa.ac.za

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APPENDIX B: PERMISSION LETTER FROM DBE GAUTENG

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	15 August 2024
Validity of Research Approval:	08 February 2024– 30 September 2024 2024/260
Name of Researcher:	Phalane L F
Address of Researcher:	4950 Grand Place North
	Garden Road/ The Orchards Ext. 31
Telephone Number:	081 561 8964
Email address:	lesibaplane@gmail.com
Research Topic:	Teachers' implementation of Inquiry-Based learning strategies for practical work in Physical Sciences: A case study in Tshwane South District
Name of University:	UNISA
Type of qualification	Masters
Number and type of schools:	5 Secondary schools
District/s/HO	Tshwane South

Re: Approval in Respect of Request to Conduct Research

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

15/08/2024

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

1

Making education a societal priority

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

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

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

Kind regards

....

Dr. Gumani Mukatuni
DCES: Education Research and Knowledge Management

DATE: 15/08/2024

2

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
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APPENDIX C: INTERVIEW TOOL

Topic: Implementation of inquiry-based learning strategies by teachers for practical work in Physical Sciences: A case study in Tshwane South District.

Interview BEFORE a class visit

Section A (Introduction)

1. Please introduce yourself

Section B (Educational background and teaching experience)

This section deals with the educational background of the participant.

- ***Before I begin, do you have any questions?***

1. Please tell me about your background, where you studied, and for how many years.
2. What subject(s) are you teaching?
3. How long have you been teaching the subject (s) you are teaching?
4. What Grade(s) do you teach?

Section C (Teachers' knowledge of inquiry-based learning strategies)

This section deals with the teachers' knowledge of inquiry-based learning

1. How would you define and describe inquiry-based learning in the context of teaching Physical Sciences?
2. Can you describe how you implement inquiry-based learning strategies when guiding learners through practical work in your Physical Sciences lessons?
3. What factors influenced your decision to incorporate inquiry-based learning strategies into your teaching of practical work in Physical Sciences?

Section D (Teachers' preparation)

This section deals with how teachers incorporate inquiry-based learning strategies when preparing for practical work.

1. How do you design and plan for an inquiry-based practical work? What considerations do you take into account?
2. How do you assess learners' understanding and performance during practical work?
3. How do you balance inquiry-based learning with more traditional teaching methods when it comes to practical work in Physical Sciences?

Section E (Teachers' role and experiences)

This section deals with the teachers' perception of their role when implementing inquiry-based learning strategies during practical work.

1. In what ways do you encourage learner collaboration and engagement during inquiry-based learning activities related to practical work in the Physical Sciences?
2. How do you differentiate instruction to meet the diverse needs of learners when implementing inquiry-based learning strategies for practical work?
3. Have you observed any changes in learners' attitudes towards learning Physical Sciences due to incorporating inquiry-based approaches? If so, can you describe these changes?
4. How do you stay updated on new research or best practices related to inquiry-based learning in the Physical Sciences?

Section F (This section is to check good practices from the participant)

1. Can you share a success story or positive outcome from your experience with implementing inquiry-based learning strategies in the Physical Sciences classroom?
2. What challenges have you encountered when designing an inquiry-based lesson, particularly about practical work?

Interview AFTER a class visit

1. How did you plan this lesson? Did you achieve the main objectives you aimed to achieve?
2. What challenges did you encounter during the lesson, and how did you deal with them?

Thank you for participating

APPENDIX D: LESSON OBSERVATION TOOL

UNISA college of education

Observation date and time________________________________

Participants' School_____________________________________

Lesson Design	
Clear objectives (The extent to which the learning objectives are clear and aligned with the lesson)	Notes:
Appropriate assessment (The suitability of assessment methods for evaluating learner understanding)	Notes:
Accuracy (The provision of accurate information during the lesson)	Notes:
Instructional Delivery	
Clarity (How clear and understandable the teacher's instructions and explanations are)	Notes:
Engagement (The level of learner engagement in the lesson)	Notes:
Classroom culture	
Classroom management (The effectiveness of managing learner behaviour)	Notes:
Learner assessment and feedback	
Feedback quality (The specificity, constructiveness, and targeting for improvement in feedback)	Notes:

Learner engagement	
Motivation (The effectiveness of the teacher in motivating learners to be engaged)	Notes:
Differentiated instructions	
Varied strategies (The use of different teaching strategies to address different learning needs)	Notes:
Assessment of higher-order thinking	
Critical thinking (The encouragement of critical thinking skills among learners)	Notes:
Problem-solving (The promotion of problem-solving abilities)	Notes:
Classroom Discourse	
Inquiry-based learning elements	
Learner motivation (How are learners encouraged to ask and pose questions?)	Notes:
Critical thinking (How is critical thinking promoted throughout the lesson?)	Notes:
Preparation and set up	
Teacher facilitation	
Teaching and learning strategies (Strategies the teacher uses to guide and support learner inquiries)	Notes:
Learner engagement	
Questioning (Are the teaching strategies encouraging learners to pose questions and discuss them with their peers?)	Notes:
Differentiation	

Learning approach (Are learners allowed to choose different paths of inquiry?)	Notes:
Assessment and feedback	
Feedback (Is feedback provided to the learners throughout the inquiry process?)	Notes:

APPENDIX E: DOCUMENT ANALYSIS TOOL

UNISA college of education

Type of Document: (e.g. lesson plan, practical worksheet)

Insert the type: ________________________________ Date: ________________________

1. Overview and purpose:

***Brief Overview**: A summary of the document, highlighting its primary purpose and intended use.*

____

____

____

Educational Objectives: Identified educational objectives/learning outcomes stated in the document (if any)

____

____

____

2. Alignment with curriculum:

***Alignment with Curriculum Standards**:* Evaluate how the document aligns with relevant curriculum standards for Physical Sciences.

____

____

____

Integration of inquiry-based learning elements: Identify elements within the document that incorporate or promote inquiry-based learning strategies.

____

____

____

3. Inquiry-based learning components:

Learner engagement strategies: Examine how the document encourages learner engagement in the learning process.

Questioning techniques: Evaluate the types of questions posed to learners to stimulate inquiry.

Hands-on practical work: Identify and describe practical activities or experiments included in the document.

4. Assessment and feedback:

Methods of assessment: Identify the assessment methods or tools suggested or provided in the document.

Feedback mechanisms: Examine how the document incorporates feedback mechanisms to support learners' learning.

5. Practical worksheets:

Format and structure: Evaluate the format and structure of practical worksheets included in the document.

Clarity of instructions: Assess the clarity and comprehensibility of instructions provided in the practical worksheets.

6. Lesson plans:

Structure of lesson plans: Analyse the organisation and structure of the lesson plans presented.

____

____

____

Integration of inquiry-based learning throughout lessons: Examine how inquiry-based learning strategies are integrated into different stages of the lesson plans.

____

____

____

Interactive elements: Identify any interactive elements or activities within learners' workbooks that support inquiry-based learning.

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____

APPENDIX F: INFORMED CONSENT LETTER TO THE CIRCUIT MANAGER

The circuit manager

Tshwane South Education District

Gauteng Department of Education

Request for permission to conduct research at sampled schools in your circuit

Title: Implementation of inquiry-based learning strategies by teachers for practical work in Physical Sciences: A case study in Tshwane South District.

Date: 29 May 2024

ATT: Mr Lucky Rapudi

Cell: 066 487 2645

Email: lucky.rapudi@gauteng.gov.za

Dear Mr. Rapudi

I, Lesiba Frans Phalane, am doing research under the supervision of Dr Photo, a lecturer in the Department of Science and Technology Education, towards a master's degree in Education at the University of South Africa. There is no funding for this study. I am requesting written permission to use the schools that will be interested in participating in the study entitled Teachers' Implementation of inquiry-based learning strategies for Practical Work in Physical Sciences: A Case Study in Tshwane South District, Pretoria, South Africa.

The study aims to gain an understanding of how teachers implement inquiry-based learning strategies for practical work in Physical Sciences. The study will also investigate how teachers design practical work activities to integrate inquiry-based learning strategies in their lessons, their knowledge of implementing inquiry-based learning strategies during practical work, and the challenges they experience when implementing inquiry-based strategies during practical work if any.

Your circuit has been selected because the main objective of the study is to explore teachers' knowledge of implementing inquiry-based learning strategies during practical work in

Physical Sciences, specifically in circuit three (3) and this objective can be realised within your circuit.

The study will request the consent of Physical Sciences teachers from circuit three (3) to participate in this study, before interviews, and observations, participants' permission will be requested, and a recording device will be used. Upon the granted permission from the participants to take part in the study, I will then work with them throughout the research process. In this study, five schools are selected to participate and one teacher in each school will be observed and interviewed.

The benefit of this study is to encourage Physical Sciences teachers in my circuit, district, and in South Africa to plan practical work lessons through inquiry-based learning strategies. The study will also help in identifying challenges that teachers are facing in schools, with teaching strategies that promote inquiry-based learning. Furthermore, the study will help the researcher to understand how teachers understand the implementation of the strategies to alert curriculum developers to review policies relating to the implementation. The study will also alert education officials to consider skills development programmes that will assist in improving teachers' professional development in Physical Sciences, to motivate them to teach effectively.

Potential risks are no known risks associated with the study. 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 purposes.

There will be no reimbursement or any incentives for participation in the research.

Participants will receive a summary of the research findings upon request.

For more information regarding the study, please contact me at 081 561 8964 or email: lesibaplane@gmail.com. My supervisor Dr. P Photo can be reached at 079 539 7066 or by email: photop@unisa.ac.za

Yours sincerely

Lesiba Frans Phalane

M.Ed. student at Unisa & Teacher at Pretoria Secondary School

APPENDIX G: INFORMED CONSENT LETTER TO THE SCHOOL PRINCIPAL

Title: Implementation of inquiry-based learning strategies by teachers for practical work in Physical Sciences: A case study in Tshwane South District.

Date: …../…../ 2024
The principal
Dear Sir/Madam

Dear Principal

I, Lesiba Frans Phalane, am doing research under the supervision of Dr Photo, a Senior Lecturer in the Department of Science and Technology Education towards a master's degree in Education at the University of South Africa. There is no funding for this study. I am requesting written permission to use the schools that will be interested in participating in the study entitled Teachers' Implementation of Inquiry-based Learning Strategies for Practical Work in Physical Sciences: A Case Study in Tshwane South District, Pretoria, South Africa.

The study aims to gain an understanding of how teachers implement inquiry-based learning strategies for practical work in Physical Sciences. The study will also investigate how teachers design practical work activities to integrate inquiry-based learning strategies in their lessons, their knowledge of implementing inquiry-based learning strategies during practical work, and the challenges they experience when implementing inquiry-based strategies during practical work if any.
Your circuit has been selected because the main objective of the study is to explore teachers' knowledge of implementing inquiry-based learning strategies during practical work in Physical Sciences, specifically in circuit three (3) and this objective can be realised within your circuit.

The study will request the consent of Physical Sciences teachers from circuit three (3) to participate in this study, before interviews, and observations, participants' permission will be requested, and a recording device will be used. Upon the granted permission from the participants to take part in the study, I will then work with them throughout the research process. In this study, five schools are selected to participate and one teacher in each school will be observed and interviewed.

The benefit of this study is to encourage Physical Sciences teachers in my circuit, district, and in South Africa to plan practical work lessons through inquiry-based learning strategies. The study will also help in identifying challenges that teachers are facing in schools, with teaching strategies that promote inquiry-based learning. Furthermore, the study will help the researcher to understand how teachers understand the implementation of the strategies to alert curriculum developers to review policies relating to the implementation. The study will also alert education officials to consider skills development programmes that will assist in improving teachers' professional development in Physical Sciences, to motivate them to teach effectively.

Potential risks are no known risks associated with the study. 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 purposes.

There will be no reimbursement or any incentives for participation in the research. Participants will receive a summary of the research findings upon request.

For more information regarding the study, please contact me at 081 561 8964 or email: lesibaplane@gmail.com. My supervisor Dr P Photo can be reached at 079 539 7066 or by email: photop@unisa.ac.za

Yours sincerely

Researcher

APPENDIX H: INFORMED CONSENT LETTER TO THE TEACHER

Date: 29 May 2024

Title: Teachers' implementation of inquiry-based learning strategies for practical work in Physical Sciences: A case study in Tshwane South District.

DEAR PROSPECTIVE PARTICIPANT

My name is Lesiba Frans Phalane and I am doing research under the supervision of Dr. P Photo, a lecturer in the Department of Science and Technology Education towards a Master's degree in Education at the University of South Africa. We are inviting you to participate in a study entitled Teachers' Implementation of inquiry-based learning Strategies for Practical Work in Physical Sciences: A Case Study in Tshwane South District, Pretoria, South Africa.

WHAT IS THE PURPOSE OF THE STUDY?

This study is expected to collect important information that could be beneficial to the school, the district, and South African Physical Sciences teachers at large by enabling them to plan their practical work lessons through inquiry-based learning strategies. The study will also help in identifying challenges relating to teaching strategies that promote inquiry-based learning to develop a greater understanding of the teaching of Physical Sciences. The study should also alert curriculum developers to review policies relating to the implementation of inquiry-based learning strategies. Furthermore, it will alert education officials to consider skills development programmes that will assist in improving teachers' professional development in Physical Sciences, to motivate them to teach effectively.

WHY AM I BEING INVITED TO PARTICIPATE?

You are invited because you have shown a keen interest in teaching Physical Sciences in the district, and your participation in the study will help to improve learner performance.

I obtained your contact details from your school principal when I asked for teachers teaching Physical Sciences in their school. Please note that five participants are selected from different schools for this study.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

Describe the participant's actual role in the study.

The study involves audio recordings, lesson observation, and a semi-structured interview. You will be observed when teaching in the classroom. You will be interviewed on knowledge about the implementation of inquiry-based learning strategies. The first interview will be done before your lesson in the classroom and the second interview will be done after the lesson. Each interview will last for approximately 30 minutes.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent adult form. You are free to withdraw at any time and without giving a reason. All the information given in the study will remain anonymous.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

This study is expected to benefit both the participants and the Physical Sciences teachers in secondary schools around Pretoria in the knowledge of implementing inquiry-based learning strategies during practical work, by reviewing the practices of teachers in the classrooms.

It will also assist the Physical Sciences teachers in Pretoria and the scientific community at large with a better way of designing practical work activities during their lesson planning.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

Since the research involves the familiar task (teaching in their classrooms) of the participants there are no negative consequences for participating in this research project.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research OR Your name will not be recorded anywhere and no one will be able to connect you to the answers you give. Your answers will be given a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you permit other people to see the records.

All the information gathered in this study will remain anonymous and cannot be traced to your name.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for five years in a locked cupboard/filing cabinet at the College of Education, Unisa for future research or academic purposes; electronic information will be stored on a password-protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. Hard copies will be shredded, and electronic copies will be permanently deleted from the hard drive of the computer using a relevant software program.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No payment will be given to any participant.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Research Ethics Review Committee of the Department of Science Education*,* Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Lesiba Frans Phalane on 081 561 8964 or email lesibaplane@gmail.com

Should you have concerns about how the research has been conducted, you may contact Dr. P Photo at photop@unisa.ac.za

Thank you for taking the time to read this information sheet and for participating in this study.

Thank you.

____

Researcher

CONSENT/ASSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, __________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits, and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications, and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the classroom observation and the semi-structured interview.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print) ____________________________________

______________________________ ____________________________________

Participant Signature Date

Researcher's Name & Surname (please print) LESIBA FRANS PHALANE

____________________ 29 May 2024

Researcher's signature Date

APPENDIX I: TSHEPO INTERVIEW TRANSCRIPT

Researcher: Before I begin, do you have any questions?
Tshepo: No questions, I am already briefed.
Researcher: Before we start, please introduce yourself

Tshepo: I am Tshepo, the Physical Sciences teacher at this school.
Researcher: Please tell me about your background, where you studied, and for how many years.
Tshepo: I hold a Master of Science degree (M.Ed.) in Applied Radiation Science from Wits University and a Postgraduate Certificate in Education (PGCE) specialising in Physical Sciences and Natural Sciences from Unisa.
Researcher: What subjects are you teaching?

Tshepo: Currently I am teaching Physical Sciences and Natural Sciences in
Researcher: How long have you been teaching the subjects you are teaching?
Tshepo: I have taught Physical Sciences for 11 years.
Researcher: What Grades do you teach?

Tshepo: Grades 10-12 and Grade 9
Researcher: How would you define and describe inquiry-based learning in the context of teaching Physical Sciences?

Tshepo: I think this is a learner-centred approach to learning where learners have to be the ones doing the work and the educator is just an instructor.
Researcher: Can you describe how you implement inquiry-based learning strategies when guiding learners through practical work in your Physical Sciences lessons?
Tshepo: I will therefore encourage learners to predict what might happen if the concentration is incorrect and ask them questions about why certain steps were necessary. This will help them to think critically about the procedure rather than follow my instructions. In the second half, while conducting the titration, I will encourage learners to record their observations, suggest possible causes of error, if any, and discuss in groups how to improve accuracy so that they can reflect on their conclusions and explain them. This will make the practical more interactive and help learners to understand the fundamental concepts.

Researcher: What factors influenced your decision to incorporate inquiry-based learning strategies to your teaching of practical work in the Physical Sciences?

Tshepo: Well, the topic titration is a very complex topic if you teach it only using the traditional methods the learners tend to not understand it well but if you incorporate practicals for learners to explore on their own, see or touch the apparatus and work with them their skills will be improved.

Researcher: How do you design and plan for an inquiry-based practical work? What considerations do you take into account?

Tshepo: The traditional way is where we mostly start the practical work because we need to explain certain things that require us to explain them traditionally, so that it will fit into the practical work that we are supposed to do. Once the foundational concepts are clear, we then guide learners to explore and investigate through practical activities that encourage them to ask questions, test ideas, and draw conclusions. Therefore, aligning the hands-on tasks with the objectives of inquiry-based learning.

Researcher: How do you assess learners' understanding and performance during practical work?

Tshepo: I let them engage with one another. I also let them do the practical themselves first to try and make mistakes and then I will correct them as they go on and I will also ask them questions as they are busy mixing the chemicals or touching the apparatus to check if they understand what they are doing.

Researcher: How do you balance inquiry-based learning with more traditional teaching methods when it comes to practical work in Physical Sciences?

Tshepo: In terms of balancing, we have to start first by explaining the rules of the lab and how the practical will be done, and the reasons and objectives why the practical should be done, and what we are expecting at the end. That gave them a sense of what to expect. This must be done using traditional teaching methods. Therefore, we move from familiarisation to guided practice and then to independent application. This way, the practical will not just be a task to complete but a learning process that supported both skills and conceptual development.

Researcher: In what ways do you encourage learner collaboration and engagement during inquiry-based learning activities related to practical work in the Physical Sciences?

Tshepo: I group the learners, and after grouping them I let them enjoy the practical and I also try to implement, give them roles within the group to do different roles during the practical.

Researcher: How do you differentiate instruction to meet the diverse needs of learners when implementing inquiry-based learning strategies for practical work?

Tshepo: Remember I said I will group them. It depends on the learners' strengths. The ones who are scared of chemicals, I would not let them mix the chemicals before I explain to them and those who are more confident will be the ones who start the practical and those who are more shy will be the ones that follow next. So, I start by looking at the learners' body language before I give them the roles in the group.

Researcher: Have you observed any changes in learners' attitudes towards learning Physical Sciences due to incorporating inquiry-based approaches? If so, can you describe these changes?

Tshepo: The learners are happier to do practicals and then for them they wish we can do practicals every day and then they enjoy doing practicals. Some of them they said they chose this subject because they wanted to work with apparatus. So, there is a change in attitude when we use the practical assessment to incorporate the learning.

Researcher: How do you stay updated on new research or best practices related to inquiry-based learning in the Physical Sciences?

Tshepo: I read about them, I attend workshops where the department would make those workshops available to us and I also liaise with the neighbouring schools to share the best practice to how we can improve the results.

Researcher: Can you share a success story or positive outcome from your experience with implementing inquiry-based learning strategies in the Physical Sciences classroom?

Tshepo: I had a certain class this year, there was a boy who was struggling with Physical Sciences. But once we did an informal practical task that was not counting for marks just to help with understanding, the boys' understanding changed about the topic and the marks improved. So, that's when I thought that this should be done not only for formal assessments but also for informal.

Researcher: What challenges have you encountered when designing an inquiry-based lesson, particularly about practical work?

Tshepo: Sometimes it is a lack of resources, sometimes I will need a certain chemical, but when I get to the Lab, I see that it has already expired, and to procure it might take two or three weeks, and that would maybe delay the lesson. So, those are the challenges, but I have since learned to plan three or four weeks to check if the chemicals that I would need in four weeks are there, so that if they have to be bought, they can be bought before my experiment.

Researcher: How did you plan this lesson? Did you achieve the main objectives you aimed to achieve?

Tshepo: We started by dividing the practical into two halves just to make sure that we don't waste time, and the first half was when we did the standard solution which we needed to do the titration practical with. As to whether we achieved the objectives, yes, we did, all the learners that participated in the groups managed to reach the endpoint of the titration and they were happy to see the colour changing from what they had before and what they had at the end.

Researcher: What challenges did you encounter during the lesson, and how did you deal with them?

Tshepo: I encountered a number of challenges. If I can name a few, the acid that we will be using is too strong; we must stop for a few minutes to dilute it because it is going to give, after only three drops, the endpoint. It will be reached after three drops of the acid to the base, so we needed to dilute the acid so that it takes a bit longer to titrate, to neutralise the base. The main challenge we experienced is the lack of skills when learners are following the experimental method.

Researcher: Thank you so much for your time. This brings us to the end of our interview.

APPENDIX J: JOHN INTERVIEW TRANSCRIPT

Researcher: Before I begin, do you have any questions?
John: No thanks.
Researcher: Before we start, please introduce yourself

John: My name is John. I am a teacher and a Departmental Head for Sciences in this school. Thank you.
Researcher: Please tell me about your background, where you studied, and for how many years.
John: I hold a Bachelor of Science degree, majoring in Geology and Chemistry from the University of Limpopo, and a Postgraduate Certificate in Education (PGCE) with specialisations in Physical Sciences and Natural Sciences, from Unisa.
Researcher: What subjects are you teaching?

John: I am currently teaching Physical Sciences and Natural Sciences
Researcher: How long have you been teaching the subject (s) you are teaching?

John: I have been teaching the subjects for a period of 8 years.
Researcher: What Grade(s) do you teach?

John: Physical Sciences in Grades 10- 12 and Natural Sciences in Grade 8.
Researcher: How would you define and describe inquiry-based learning in the context of teaching Physical Sciences?

John: Inquiry-based learning in teaching Physical Sciences is the approach that I would take in a class as the teacher. For example, I can go with question, method, and results, whereby it becomes a learner-centred learning in such a way that if I provide them with questions, they can go through the questions and answer, and when they are done, I will be able to give them the results to check if they understood.
Researcher: Can you describe how you implement inquiry-based learning strategies when guiding learners through practical work in your Physical Sciences lessons?
John: I designed a worksheet that covers all the cognitive levels. When putting them in groups, you cannot have all the level seven type of learners in one group. The group must include all cognitive levels so they can learn from each other. During practical

work, it’s all about what they contribute. You provide some learners with results, and others have to generate their own results and conclusions. There are different types of inquiry-based learning strategies, ranging from guided inquiry to confirmation, structured, etc., that accommodate all learners' learning needs.

Researcher: What factors influenced your decision to incorporate inquiry-based learning strategies to your teaching of practical work in Physical Sciences?

John: One thing that I have understood is that it stimulates understanding and interest on learners. If they are doing things on their own you will never have a learner who is sleeping in class, you will never have a learner who is not showing interest who is just doing their own things. But because they are all involved there and they understand that at the end of the day they have to draft their own questions and they have to come up with their own solutions. So, it brings about interest and better understanding.

Researcher: How do you design and plan for an inquiry-based practical work? What considerations do you take into account?

John: One thing that would be balanced is that you, as a teacher, would have done your traditional teaching and inquiry-based learning, or that type of practical work would be you trying to check if what you have taught in class, your learners understood you or not. So, inquiry-based learning can be used to validate whether they understood you or not. In this way, practical work is not just for demonstration, but becomes a tool through which learners apply concepts, investigate problems, and reflect on their understanding. By so doing, I will be ensuring that inquiry-based learning objectives such as critical thinking, exploration, and learner autonomy are met in a meaningful context.

Researcher: How do you assess learners' understanding and performance during practical work?

John: I assess learners’ understanding and performance during practical work by examining their reports and the structure of the questions they formulate to determine whether they truly grasp what they are doing. For example, when learners include clear aims, hypotheses, and conclusions in their reports, it shows that they understand the purpose of the experiment and can anticipate the expected outcomes before conducting it. Their understanding is further reflected in how they analyse results, draw graphs, and interpret data to reach logical conclusions. I also look at how well they construct investigative questions and identify key components such as the aim, variables, and apparatus used, as this demonstrates their comprehension of the experimental process. In activities like titrations, where learners conduct multiple runs, repetition is used to emphasise the concept of validity and help them recognise potential experimental errors. By comparing results across different runs, learners can identify inconsistencies, reflect on possible mistakes, and develop an understanding of accuracy and reliability in practical work.

Researcher: How do you balance inquiry-based learning with more traditional teaching methods when it comes to practical work in Physical Sciences?

John: When planning practical work, the theory must be taught first so learners understand the content. Learners need to be taught lab safety beforehand. I always experiment on myself first to ensure the results will be as expected. Key considerations include chemical risks, learner discipline, group sizes, and safety measures such as lab coats. I will begin with the theoretical foundation, followed by safety instructions, and then proceed to the preparation of materials. Sequencing is crucial because learners first build conceptual understanding, then gain awareness of safety procedures, and only then engage in the hands-on practical work. Each stage prepares learners for the next, creating a logical flow that reduces confusion and maximises learning outcomes.

Researcher: In what ways do you encourage learner collaboration and engagement during inquiry-based learning activities related to practical work in the Physical Sciences?

John: Like I said, they do it in their own groups. And in a group of learners which means that, there must be a contribution from each and every learner. And whenever they contribute and we call that collaboration and it brings about understanding even a learner who is a little bit slower in class, can be able to contribute something because is a practical work. Is something that they can be able to see. Which means that they are there throughout the whole process of understanding. So collaboration is a lot because it takes a group work. They have to assign roles on their own to show understanding because if you keep on, yours is to observe as per group if the safety measures are followed, if they are actually following the protocol, but everything should be entirely on their own.

Researcher: How do you differentiate instruction to meet the diverse needs of learners when implementing inquiry-based learning strategies for practical work?

John: I differentiate instruction during inquiry-based practical work by grouping learners with mixed cognitive levels so they can learn from and support one another.

This approach builds confidence and promotes collaboration. I also differ in the type of inquiry tasks. For example, some learners receive structured guidance or are given results to analyse, when others design their own investigations and draw conclusions, to provide to different abilities. This allows high achievers to engage in critical thinking while supporting slower learners in building understanding and proper practical skills.

Researcher: Have you observed any changes in learners' attitudes towards learning Physical Sciences due to incorporating inquiry-based approaches? If so, can you describe these changes?

John: Yes, I have observed positive changes in learners' attitudes toward Physical Sciences through inquiry-based approaches. Learners become more interested and engaged because of the hands-on nature of practical work compared to traditional teaching. Even those who were previously less motivated show greater curiosity and improved understanding. Their performance improves as they apply concepts through investigation, demonstrating deeper comprehension and enhanced critical thinking skills.

Researcher: How do you stay updated on new research or best practices related to inquiry-based learning in the Physical Sciences?

John: I stay updated on inquiry-based learning through training workshops where teachers share best practices and new strategies. During marking sessions at the end of the year or midyear, I also learn from observing learners' work, which helps me identify effective inquiry-based approaches compared to traditional teaching methods.

Researcher: Can you share a success story or positive outcome from your experience with implementing inquiry-based learning strategies in the Physical Sciences classroom?

John: A good practice I've observed is that incorporating inquiry-based strategies greatly improves learners' performance and interest. For example, a learner who previously achieved level two now attains level five or six after engaging in inquiry-based practical work. This approach, which is also emphasised in the Physical Sciences syllabus through compulsory practicals, stimulates learning and enhances understanding of the content.

Researcher: What challenges have you encountered when designing an inquiry-based lesson, particularly about practical work?

John: Sometimes you find that we are under-resourced, we don't have enough equipment to accommodate different groups at the same time, which means that we have to do by, we have to, we have the same equipment, one set of equipment, which means the groups must come do go back, and another one must come and do, so if we are under-resourced it becomes very tedious and time consuming. That’s most of the challenges, and some learners get overexcited, those who are ill-disciplined, which means that you always have to be there to monitor.

Researcher: How did you plan this lesson? Did you achieve the main objectives you aimed to achieve?

John: In planning the lesson, I considered the availability of accessible chemicals since we are an under-resourced school. I used sodium hydroxide, vinegar (acetic acid), and phenolphthalein as the indicator for the titration. I also designed a worksheet that addressed all cognitive levels to accommodate every learner. Despite some challenges with learners being playful during the experiment, the main objectives of the lesson were ultimately achieved.

Researcher: What challenges did you encounter during the lesson, and how did you deal with them?

John: Since it’s a titration, one thing that I can tell you is, when the learners are working on things on their own, some, for example, didn’t dilute the acetic acid, and they used it as it is. So, which means that they immediately start titrating the colour change was just instantly there, so for example, I had to take them back so that they can be able to dilute it and re-perform the experiment.

Researcher: Thank you so much for your time. This brings us to the end of our interview.

APPENDIX K: WILLY INTERVIEW TRANSCRIPT

Researcher: Before I begin, do you have any questions?
Willy: No questions.
Researcher: Before we start, please introduce yourself

Willy: Okay, my name is Willy I am a teacher in this school.

Researcher: Please tell me about your background, where you studied, and for how many years.
Willy: I hold a three-year Teacher's Diploma specialising in Physical Sciences and Mathematics from Zimbabwe.
Researcher: What subjects are you teaching?

Willy: Physical Sciences and Natural Sciences
Researcher: How long have you been teaching the subject (s) you are teaching?
Willy: Okay, since 2006
Researcher: What Grades do you teach?

Willy: Grades 10-12 and Grade 9
Researcher: How would you define and describe inquiry-based learning in the context of teaching Physical Sciences?

Willy: I think to some extent, it involves the learners investigating some things and coming to conclusions about some concepts without me as the teacher necessarily having to sit them down, bring up a question, and explain everything to them. Without me being the teacher having to bring up a concept, explaining everything to them.
Researcher: Can you describe how you implement inquiry-based learning strategies when guiding learners through practical work in your Physical Sciences lessons?
Willy: I taught the topic and completed acids and bases. I taught them some things, but then I wanted them to have a practical feel of what titration is, rather than just a theoretical, fictional example. So, I sat down one evening, planned, and designed the practical, taking note of the teaching methods I would implement during the practical. I thought that if they are sitting in a group, there is no way they can conduct, for instance, a titration in a group of three without collaborating. Roles and duties will be assigned so that each learner can contribute. Learner collaboration is important. I arrange groups carefully to allow them to learn from each other. For the practical, I will

provide the learners with the worksheets, and they must be able to get the endpoint and the equivalence point. Initially, on the first run, some might fail to get it. But for the fact that they saw themselves as other learners getting it right, they would get inspired and get so challenged in such a way that they say ‘’We don’t want you to assist us, don’t assist us, don’t tell us anything, let us re-do it ourselves.

Researcher: What factors influenced your decision to incorporate inquiry-based learning strategies to your teaching of practical work in Physical Sciences?

Willy: First of all, I noticed that most of the time learning is normally one-dimensional. Learners come to school sit in class they are taught and then they go back home and it’s a repetition. But I then discovered that something which is slightly different from the normal thing that they do in almost every subject those are things that they really forget in most of the cases. So, if learners do a practical, they seldom forget the practical that they have conducted, so to some extent is a different way of teaching learners and it also appeals to the part of their memory that doesn’t forget the things, they barely forget the things they do in practicals more than the things they are taught in class.

Researcher: How do you design and plan for an inquiry-based practical work? What considerations do you take into account?

Willy: According to our curriculum requirements, you will spend more time using traditional teaching methods unless the topic involves practical activities that are feasible. However, I make every effort to include some practical elements in every topic, resources permitting. Despite these limitations, I strive to incorporate practical work that encourages inquiry, prompting learners to observe, ask questions, and draw connections. In doing so, I align the practical activities with inquiry-based learning goals by transforming available opportunities into moments where learners can discover and build understanding, even with limited resources.

Researcher: How do you assess learners' understanding and performance during practical work?

Willy: So, during practical work, so as they go with instructions, in between the instructions there are some mini questions that they will get to answer there, based on what they would have discovered. What can you conclude based on that? What can you conclude based on that? So, during the structure of the question, and also I will just move around, just checking, are they able to follow the very simple instructions.

Researcher: How do you balance inquiry-based learning with more traditional teaching methods when it comes to practical work in Physical Sciences?

Willy: When designing practical work, I base it on a concept, such as discovering the equivalence point before explaining it theoretically, using traditional teaching methods. The design includes inquiry questions of varying levels for learners to answer. For example, learners begin by engaging with the concept through practical investigation, which initiates interest and stimulates critical thinking before moving into formal theory. This sequencing of activities must be done before explaining. Overall, the sequencing and structuring of each stage, from concept introduction, preparation, and resource planning, to implementation, will create a clear and meaningful learning experience that supports both scientific understanding and collaborative skill-development.

Researcher: In what ways do you encourage learner collaboration and engagement during inquiry-based learning activities related to practical work in the Physical Sciences?

Willy: I encourage collaboration by grouping learners during practical work, usually three per workstation, to ensure everyone participates. Each learner is assigned a specific responsibility so that all contribute to the experiment and share ownership of the results. This teamwork not only promotes engagement but also allows every learner to gain hands-on experience and feel part of the learning process.

Researcher: How do you differentiate instruction to meet the diverse needs of learners when implementing inquiry-based learning strategies for practical work?

Willy: I differentiate instruction by designing tasks with different levels of difficulty, from basic questions for below-average learners, moderate ones for all learners, and higher-order questions for advanced learners. This ensures everyone is challenged appropriately and remains engaged. I also group learners strategically, mixing different ability levels so they can learn from one another, collaborate effectively, and each contribute meaningfully during practical work.

Researcher: Have you observed any changes in learners' attitudes towards learning Physical Sciences due to incorporating inquiry-based approaches? If so, can you describe these changes?

Willy: Yes, I believe practical, inquiry-based activities are critical in teaching Physical Sciences. Learners show great interest and are often willing to stay after school to complete experiments. These hands-on experiences leave a lasting impact. Learners still recall practicals they did in earlier grades, showing how engaging and memorable this approach is.

Researcher: How do you stay updated on new research or best practices related to inquiry-based learning in the Physical Sciences?

Willy: To stay updated and apply best practices, I conduct ongoing research, attend content workshops to learn from colleagues, and use online resources and books. This helps me refine my teaching methods and ensure that my lessons and tasks align with current standards and exam requirements.

Researcher: Can you share a success story or positive outcome from your experience with implementing inquiry-based learning strategies in the Physical Sciences classroom?

Willy: In 2023, my class performed a weekend practical on acids and bases, focusing on titrations. Although some learners initially struggled to reach the endpoint, seeing their peers succeed motivated them to try independently. By the end of the experiment, all learners accurately obtained the endpoint, which translated into top performance in the topic during the June examination, as they could visualise and apply the practical experience in their answers.

Researcher: What challenges have you encountered when designing an inquiry-based lesson, particularly about practical work?

Willy: The main challenges are the availability of resources and time. The school provides enough for formal practicals, but it isn't easy to request expensive equipment for informal or enriching activities, even if they're syllabus-related. Long experiments that require approximately three hours to conduct are challenging during the school day due to time constraints and the noise level from learner interaction. I often have to do them in the afternoon, but that's not always practical. While I have good support from management and access to lab facilities, limited resources and time remain the biggest constraints.

Researcher: How did you plan this lesson? Did you achieve the main objectives you aimed to achieve?

Willy: After teaching acids and bases theoretically, I designed a titration practical to give learners hands-on experience. I planned the experiment based on available resources, using sodium hydroxide as the strong base, ethanoic acid as the weak acid, and phenolphthalein as the indicator. Once I confirmed all apparatus were available, I prepared copies of the practical instructions and organised learners into groups to carry out the experiment.

Researcher: What challenges did you encounter during the lesson, and how did you deal with them?

Willy: I don’t normally face major challenges myself; it is only when some of the learners struggle to interpret the instrumentation, particularly understanding that the burette scale starts from zero and counts downward. This leads to some overshooting of the endpoint during titration. I had to clarify these issues for a few groups by explaining how to properly use the burette, pipette, and syringe. Once the measurement techniques were understood, the learners followed the instructions well; there should be no further issues that occur.

Researcher: Thank you so much for your time. This brings us to the end of our interview.

APPENDIX L: MPHO INTERVIEW TRANSCRIPT

Researcher: Before I begin, do you have any questions?
Mpho: No questions; I am already briefed.
Researcher: Please introduce yourself

Mpho: I am Mpho. I am an educator and a Departmental Head at this school
Researcher: Please tell me about your background, where you studied, and for how many years.
Mpho: I studied a four-year Bachelor of Education Degree, majoring in Physical Sciences and Natural Sciences at the University of Limpopo
Researcher: What subjects are you teaching?

Mpho: I am currently teaching Physical Sciences in Grades 10-12 and Natural Sciences in Grades 8 and 9.
Researcher: How long have you been teaching the subject (s) you are teaching?

Mpho: For 14 years
Researcher: What Grade(s) do you teach?

Mpho: Physical Sciences in Grade 10-12 and Natural Sciences in Grade 8 and 9.
Researcher: How would you define and describe inquiry-based learning in the context of teaching Physical Sciences?

Mpho: Well, I think in terms of inquiry-based learning, inquiry to me we unpack this word the inquiry is all about finding out, investigating, that's your inquiry, actually, a learner-centred approach in terms of a lesson. Well, in terms of teaching Physical Sciences, it's like when you give learners a problem and then learners start to find out the solutions, like we are doing in practical investigations and so on, where we have investigative questions.
Researcher: Can you describe how you implement inquiry-based learning strategies when guiding learners through practical work in your Physical Sciences lessons?
Mpho: I will prepare my learners in terms of grouping them over the worksheets, doing the worksheet, and preparing it for them with some questions and some roles. Once learners arrive, I just give them worksheets and then go through the worksheets with them, and from there, once they understand what needs to be done and then that's

where we will start the experiment. Group work is one of my strategies in terms of presentation and facilitation. I will mix the learners in groups to allow the gifted to assist the struggling ones. In terms of checking their understanding, I normally give them some tests after writing to compare the results, and the write-up, and then from there I will be able to see if they met the requirements that I wanted. Merging the practical part with the theory part to compare the theory with the practical. Because I will be having the results by the way, and if they do come with the results, it means now exactly I will be saying that they do understand.

Researcher: What factors influenced your decision to incorporate inquiry-based learning strategies into your teaching of practical work in Physical Sciences?

Mpho: Well, we are living in a modern world so basically nowadays, learners are more exposed to different situations, exposed to different information. So they do have a lot therefore and when you don't engage them they start to do their own things and so on. They need to be exposed to the current situation in terms of more information, exposed to more information."

Researcher: How do you design and plan for an inquiry-based practical work? What considerations do you take into account?

Mpho: In terms of designing, it's like, first thing that I will do is to look at the lesson, and after looking at the lesson, what is it that I want learners to do? If I want them to investigate, they will be in a group. The traditional method is still applicable, but not too much. I can say that, not too much. When I see that a topic offers space for exploration, I design the practical component in a way that learners can take ownership of the learning process through observation, questioning, and collaborative problem-solving. This helps ensure that the practical work goes beyond routine experiments and actively supports the goals of inquiry-based learning, where learners construct knowledge through guided discovery.

Researcher: How do you assess learners' understanding and performance during practical work?

Mpho: In terms of assessment, we, let's say I give them a practical investigation, I will assess different skills so that they able to handle the apparatus. They are able to ask questions and they are able to measure. So, lots of skills that are inquired. During practical work, I will check if they can handle the apparatus, if they can measure, and also determining the endpoint without a lot of issues, yes.

Researcher: How do you balance inquiry-based learning with more traditional teaching methods when it comes to practical work in Physical Sciences?
Mpho: I would prefer teaching the theory using traditional methods first. Then, I will structure my lessons by presenting a problem first, and then learners find solutions independently. I consider resources, group size, and learner ability in planning. Sequencing is intentional. There should be a problem followed by an investigation to encourage logical scientific thinking. I adapt activities to learners' skills and resources, sequencing tasks to support those needing help while allowing advanced learners to explore more. This balance of structure and flexibility creates an environment for purposeful, inclusive, and meaningful practical learning.
Researcher: In what ways do you encourage learner collaboration and engagement during inquiry-based learning activities related to practical work in the Physical Sciences?
Mpho: Collaboration, we encourage them in terms of competitions, and then in terms of grouping prizes awarding those are the things that can encourage them to collaborate. They will work in groups. When you group them, you give them roles you are the scriber, you are speaker you are leader, so you they play different roles. In terms of titrations, as I do group them, some will be actually measuring the standard solution create the standard solution as we are going to use it before and then other will be preparing the apparatus and then from there others will be titrating and then in those groups.
Researcher: How do you differentiate instruction to meet the diverse needs of learners when implementing inquiry-based learning strategies for practical work?
Mpho: I differentiate instruction by using group work during experiments, presentations, and facilitation to engage all learners. To check understanding, I compare their practical write-ups with test results, merging theory and practical outcomes. When learners produce accurate results, it indicates they have grasped the concepts and met the learning objectives.
Researcher: Have you observed any changes in learners' attitudes towards learning Physical Sciences due to incorporating inquiry-based approaches? If so, can you describe these changes?
Mpho: Yes, it sparks the interest in some of the learners because when you do the practicals and when they find the things on their own, that's when they become, starts to be happy and excited, and then the lesson becomes exciting. In terms of

performance, they do perform, after actually this experiment you can see that in terms of their performance is improving.

Researcher: How do you stay updated on new research or best practices related to inquiry-based learning in the Physical Sciences?

Mpho: Well, through workshops, yes, we are informed of the new methods, and then also through seminars, and then on PLC, we are up-to-date with the new methods. Actually, though, teacher development. That's why I am saying PLC. Through Professional Learning Communities.

Researcher: Can you share a success story or positive outcome from your experience with implementing inquiry-based learning strategies in the Physical Sciences classroom?

Mpho: A success story from inquiry-based learning involved linking a class test to a following experiment. Learners first explored concepts theoretically, then conducted the experiment to verify their answers. This process excited them, showing the connection between theory and practice, and highlighting that Science is best learned through hands-on work. Practical inquiry not only engages learners but also develops a wider range of skills beyond traditional written assessments.

Researcher: What challenges have you encountered when designing an inquiry-based lesson, particularly about practical work?

Mpho: Okay, we have a lot of challenges. Constraints we usually face include a lack of resources, particularly chemicals. The lab exists, but it's not up to standard; it's more like a classroom and a hall, which we also use as a lab. I'll need to check the timetable, look for free time, and prepare in advance. Maybe call them after school.

Researcher: How did you plan this lesson? Did you achieve the main objectives you aimed to achieve?

Mpho: I began by reviewing the ATP (Annual Teaching Plan) and checking the availability of accessible resources, using sodium hydroxide, acetic acid, and suitable apparatus. After preparing the lab and ensuring safety, I grouped learners, assigned roles, and provided worksheets with guided questions. Once learners understood the tasks, we conducted the experiment. The main objective was achieved, as learners successfully confirmed the titration endpoint.

Researcher: What challenges did you encounter during the lesson, and how did you deal with them?

Mpho: As with most experiments, things didn't go exactly as planned. One major challenge was the limited supply of phenolphthalein indicator, which meant I had to use it sparingly while still ensuring learners could identify the endpoint accurately. We also had minimal apparatus, so I borrowed some from another school. When the resources ran out, I had to demonstrate the process myself to help learners verify their results.

Researcher: Thank you so much for your time. This brings us to the end of our interview.

APPENDIX M: LEBO INTERVIEW TRANSCRIPT

Researcher: Before I begin, do you have any questions?

Lebo: No questions; let's get straight to the interview.

Researcher: Please introduce yourself

Lebo: My name is Lebo. I am an educator in this school

Researcher: Please tell me about your background, where you studied, and for how many years.

Lebo: I have studied for a four-year Bachelor of Education degree (Senior and FET), with majors in Physical Sciences and Mathematics, along with an honours degree in Mathematics Education.

Researcher: What subjects are you teaching?

Lebo: Physical Sciences and Mathematics.

Researcher: How long have you been teaching the subject (s) you are teaching?

Lebo: Five years

Researcher: What Grade(s) do you teach?

Lebo: Physical Sciences grades 10-12 and Mathematics grade 9.

Researcher: How would you define and describe inquiry-based learning in the context of teaching Physical Sciences?

Lebo: So, for us essentially, it's just a teaching approach, or using education terms, it will be a teaching instruction which is learner-centred, and it is where a teacher comes up with maybe a set of questions, and then the learners get to engage in some of the questions and try to explore.

Researcher: Can you describe how you implement inquiry-based learning strategies when guiding learners through practical work in your Physical Sciences lessons?

Lebo: So, we did preparations beforehand, providing them with worksheets, looking at the list of the apparatus we needed, and making sure that all the apparatus was available for them. I will design an investigative question for the topic first, then come up with a set of questions. It will be a safe way for the learners to be engaged in the topic. So, in our planning, we will come up with resources that we are going to use and the materials that we are going to use. I will do holistic teaching. I will group the learners and try to assign roles based on their skills, based on what they can put on the table. So, like I indicated before, with us assigning different responsibilities, we then obviously, based on their skills, we say okay, we are going to assign you this role, we take a learner and say okay, we are going to put you in this role, some opening the tap, some shaking, some checking the endpoint.

Researcher: What factors influenced your decision to incorporate inquiry-based learning strategies in your teaching of practical work in the Physical Sciences?

Lebo: Inquiry-based, learner-centred practical work is highly effective for engagement. Learners become more interested as they actively see concepts in action, such as acids reacting with bases. This hands-on approach helps them connect theory to practice, making abstract topics more concrete and understandable.

Researcher: How do you design and plan for an inquiry-based practical work? What considerations do you take into account?

Lebo: The primary thing that we follow is to teach first. So yes, teaching is the one thing that we are trying to balance in our planning. After laying the conceptual foundation through traditional teaching, I use practical work not just to reinforce content, but to allow learners to engage in inquiry by posing questions and testing their ideas. This way, the practical activities become a bridge between curriculum coverage and inquiry-based learning objectives, promoting both understanding and critical thinking.

Researcher: How do you assess learners' understanding and performance during practical work?

Lebo: We assess learners' understanding during practical work by observing their commitment and performance with the full practical work process. Additionally, we provide structured questions for them to explore, ensuring they actively interact with the experiment and demonstrate understanding of what they are doing.

Researcher: How do you balance inquiry-based learning with more traditional teaching methods when it comes to practical work in Physical Sciences?

Lebo: Okay. I provide an investigative question for the topic, followed by questions designed to engage learners. I consider different teaching and learning styles and facilitate experiments based on available resources and chemicals. Starting with an investigative question helps establish a clear focus for the lesson and encourages learners' thinking. The subsequent questions act as scaffolds, gradually guiding learners from simple engagement to more in-depth investigation. The sequence moves from posing questions to selecting resources and then to hands-on experimentation, creating a logical flow that supports inquiry, safety, and clarity.”

Researcher: In what ways do you encourage learner collaboration and engagement during inquiry-based learning activities related to practical work in the Physical Sciences?

Lebo: We encourage learner collaboration during practical work by forming mixed-ability groups where each learner has a specific responsibility, such as mixing chemicals or recording observations. This reflects real-life scientific teamwork and allows different skills to surface. Grouping learners strategically ensures they learn from one another, support peers who struggle, and engage more effectively with inquiry-based activities.

Researcher: How do you differentiate instruction to meet the diverse needs of learners when implementing inquiry-based learning strategies for practical work?

Lebo: In practical work, we assign roles based on each learner’s skills and strengths. For example, some handle calculations, others perform hands-on tasks, and some record observations. This role-based approach ensures every learner contributes meaningfully, and together they achieve a holistic outcome for the experiment or project.

Researcher: Have you observed any changes in learners' attitudes towards learning Physical Sciences due to incorporating inquiry-based approaches? If so, can you describe these changes?

Lebo: Learners respond positively to practical work, showing increased excitement and engagement compared to purely theoretical lessons. This interest translates into better understanding and improved results, with visible performance differences between terms when practicals are included versus when they are not.

Researcher: How do you stay updated on new research or best practices related to inquiry-based learning in the Physical Sciences?

Lebo: I stay updated on inquiry-based learning through personal research, attending departmental workshops, and participating in Professional Learning Community (PLC) meetings with peers both within and outside the district. These activities, along with employer-led teacher development workshops, help me refine my teaching and stay informed on effective strategies.

Researcher: Can you share a success story or positive outcome from your experience with implementing inquiry-based learning strategies in the Physical Sciences classroom?

Lebo: One learner who initially struggled with Chemistry showed significant improvement after participating in practical, inquiry-based experiments. These activities helped them understand concepts more clearly, improved their results, and increased their excitement and engagement with the subject, showing how theory can be applied practically and connected to the real-world.

Researcher: What challenges have you encountered when designing an inquiry-based lesson, particularly about practical work?

Lebo: One of the major challenges is the lack of resources and the amount of time it takes to prepare for a full inquiry-based learning practical. It requires a lot of preparation and classroom time, which can be difficult to manage. Although the school and departmental heads are supportive and try to provide the necessary materials and encourage teacher development through workshops, resource limitations and time constraints still pose significant challenges.

Researcher: How did you plan this lesson? Did you achieve the main objectives you aimed to achieve?

Lebo: For this lesson, I prepared by delivering the theoretical content, providing worksheets, and ensuring all necessary apparatus and chemicals, like sodium hydroxide and acetic acid, were available. The main objectives were achieved, as learners successfully determined unknown concentrations, observed colour changes, identified endpoints and equivalence points, and applied their observations to perform quantitative calculations, meeting the practical goals of the experiment.

Researcher: What challenges did you encounter during the lesson, and how did you deal with them?

Lebo: We encountered several challenges that affected the flow of the practical work. Some learners took a long time to prepare the standard solution, partly due to the large group size and time constraints. To support accurate measurements, we provided digital scales. Additionally, some students mishandled the burette by opening the tap too much, so we had to demonstrate the correct technique. Another challenge was that some learners struggled to interpret their results. To address this, we paired them with groups that had completed the experiment, allowing them to observe and understand the expected outcomes. Despite these obstacles, we managed to navigate the challenges and support learners throughout the process.

Researcher: Thank you so much for your time. This brings us to the end of our interview

APPENDIX N: LANGUAGE EDITING CERTIFICATE

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DECLARATION OF PROFESSIONAL EDIT

I declare that I have edited and proofread a Master's Dissertation entitled: **IMPLEMENTATION OF INQUIRY-BASED LEARNING STRATEGIES BY TEACHERS FOR PRACTICAL WORK IN PHYSICAL SCIENCES: A CASE STUDY IN TSHWANE SOUTH DISTRICT by LESIBA FRANS PHALANE.**

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