THE INFLUENCE OF SCIENTIFIC INVESTIGATION WORKSHOPS ON LIFE SCIENCE TEACHERS' ATTITUDEs TOWARDS SCIENTIFIC INVESTIGATIONS

By

Shani Smit

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Supervisor: Professor JPH Pretorius

DECLARATION

"I, Shani Smit, declare that the Master's degree research dissertation that I submit for the qualification M.ED Curriculum Studies at the University of the Free State is my independent work.

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ABSTRACT

Life Science teachers' attitudes play a vital role in successful scientific investigations. Some Life Science teachers situated in the central part of South Africa might experience challenges that include a lack of the necessary scientific knowledge and skills that hinder scientific investigations. These challenges might adversely influence Life Science teachers' attitudes towards conducting scientific investigations, which might result in them conducting the minimum number of investigations with their learners. Professional, in-service training workshops allow teachers to develop the necessary scientific knowledge and skills to successfully conduct scientific investigations. This study aimed to understand how a scientific investigation workshop might affect Life Science teachers' attitudes by measuring the ABC attitude model's affective, cognitive and behavioural components. This research provided information on how vital in-service training programmes such as this scientific investigation workshop are in fostering positive attitudes toward scientific investigations. The findings that emerged from this study imply that implementing this scientific investigation workshop has developed Life Science teachers' confidence in their science skills and knowledge to facilitate scientific investigations. The findings also indicate that this scientific investigation workshop caused a significant improvement in teachers' intended behaviours in implementing scientific apparatus in the science classroom, as they gained valuable knowledge and skills regarding the science apparatus.

Keywords: attitudes, behaviours, beliefs, equipment, in-service training, inquiry-based, knowledge, laboratory, Life Science, scientific investigations, skills teachers, thoughts , and workshop

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Chapter 1

1.1. Introduction:

Scientific investigations play a vital part in learning and teaching Life Science; it is critical for the theory to be brought to life (Isozaki, 2017:101). Kambaila, Kasali and Kayamba (2019:116) posit that scientific investigations in the science classroom can contribute to learners' appreciation of science, promote exploration and manipulation, and develop concepts.

Educators and researchers have studied the value and importance of scientific investigation work since the beginning of the 18th century. According to Sshana and Abulibdeh (2020:199), studies have found that practical work offers many advantages, such as improving laboratory skills and scientific knowledge and promoting an understanding of science theories and concepts.

Scientific investigations are processes of asking questions and testing possible answers through experiments, observations or dissections (Kambaila, Kasali & Kayamba, 2019:116). These hands-on activities provide practical experience through which learners and teachers develop scientific skills (Kambaila, Kasali & Kayamba, 2019:116).

Sshana and Abulibdeh (2020: 199) and Heeralal (2014:796) state that learners design better investigations when they conduct the scientific investigations themselves instead of observing or taking notes during the investigation. Learners and teachers achieve a deeper level of comprehension by experimenting with different techniques and methods, as they discover things for themselves.

Scientific investigation activities also promote positive attitudes and motivate the effective learning and teaching of a science subject (Okam & Zakari, 2017:120). A positive attitude toward scientific investigations might affect teachers' and learners' achievements in science (Hinneh, 2017:7)

Teachers are essential to learners' science education (Demir, 2016:582). When learners graduate from high school, learners should have developed an appreciation for science's magnificence and wonder. This appreciation for science stems from gaining sufficient knowledge to enable participation in public discussions regarding scientific knowledge and becoming consumers of scientific information related to their everyday lives.

According to Demir (2016:582), not much has changed in Life Science teachers' practices, despite the 21st-century classrooms being better equipped with technology and laboratory equipment. Traditional teaching follows a step-by-step approach in which learners spend most of their time passively taking notes, working on worksheets and listening to the teacher (Constantinou, Rybska & Tsivitanidou, 2018:10).

Many South African teachers are unenthusiastic about experiments and limit the number of scientific investigations they perform with their learners (Mwangu & Sibanda, 2017:48). Although some Life Science teachers in South Africa have access to the necessary laboratory equipment and resources, they do not acquire the essential knowledge and skills required to conduct scientific investigations with their learners (Ramnarain & Hlatswayo, 2018:2; Preethlall, 2015:8). Research conducted in the Gauteng Province in South Africa revealed that only a few teachers involve their learners in scientific investigations because they do not have the necessary knowledge and skills to do so confidently (Heeralal, 2014:796).

In-service training programmes can be a possible solution to this problem. In-service education and training can be defined as a suitable and related course of activities in which a teacher participates to improve and upgrade his/her professional skills, knowledge and competence in a specific teaching profession (Osamwonyi, 2016:83).

This research centred on such a professional development programme designed by the Faculty of Education at the University of the Free State, which is in the centre of South-Africa. This professional development programme (workshop) aims to offer Life Science teachers the opportunity to advance and develop their scientific investigation knowledge and skills by integrating experiential activities. This study also aimed to examine Life Science teachers' attitudes toward scientific investigation before and after the workshop to determine the effect of the workshop on those teachers' attitudes.

1.2. Background

Mogofe and Kibirige (2017:426) state that science is incomplete without the practical part of the subject, which is why science syllabuses worldwide emphasise and motivate the involvement of learners in scientific investigations. European countries such as the Netherlands, Romania, the United Kingdom, France and Ireland are working under the umbrella of science Education to Develop European citizenship (SEDEC). This project focuses on evolving learners' scientific process skills by integrating scientific investigations into their science lessons (Kibirige, Teffo & Singh, 2022:1; Mogofe & Kibirige, 2017:427).

According to Omeodu and Amadi (2018:2), attaining scientific knowledge benefits learners, teachers and the society in which they live because scientific knowledge helps them to comprehend the world around them through observation and conclusions. The government in

Nigeria acknowledged science's impact on the economy and social development; this led to the recognition of the need to develop human resources, which led to new ideas being generated through science to create innovative ways of transferring this knowledge to the younger generation (Omeodu & Amadi, 2018:2).

It seems that scientific investigations contribute to effective science learning, and there should, therefore, be a variety of cognitive and scientific skills taught in the Life Science classroom (Okam & Zakari, 2017:113). South Africa's Department of Basic Education states in the Life Science Curriculum and Assessment Policy (hereafter CAPS LS) Statement, Grades 10-12 that teachers must conduct scientific investigations with their learners to enhance their scientific skills (RSA DBE, 2011:s.2(2.3)).

According to studies, numerous countries, especially developing countries, have difficulty implementing scientific investigations effectively (Cossa & Uamusse, 2015:153). Cossa and Uamusse (2015:154) argue that there are several reasons for this, such as a shortage of the necessary equipment and laboratory materials, the safe disposal of the chemicals and tools, inadequate conditions, a lack of financial resources, poor preparation by the teachers, and most significantly, teachers' lack of scientific knowledge and skills.

Teachers' attitudes toward scientific investigations must be positive when teaching a scientific subject (Cossa & Uamusse, 2015:153). Kibirige, Teffo and Singh, (2022:9), and Mogofe and Kibirige (2017:427) argue that, as in many countries, South Africa's scientific investigation work is failing because of teachers' negative attitudes.

Teachers' lack of scientific skills, knowledge and resources and conducive laboratory environments (Heeralal, 2014:797) lead to their being unenthusiastic about performing scientific investigation work or doing so sparingly because of the unavailability of resources and motivation. They regard the practical part of the subject as not being as vital as the theoretical part, and this does not promote positive attitudes toward scientific investigations in general (Cossa & Uamusse, 2015:154).

According to Omeodu and Amadi (2018:2), science teachers are often perceived as lifelong learners because their scientific knowledge continues to develop and they require support and opportunities to develop their professional education. In-service training workshops can present such opportunities.

In-service training workshops are programmes that provide opportunities for teachers to develop their knowledge and skills and learn about the new developments in their occupation

(Omeodu & Amadi, 2018:2). A study conducted in China found that in-service training and workshops lead to teachers' development and that teachers need regular training to develop their profession and foster positive attitudes toward their occupation (Donkor & Banki, 2017:66).

The foregoing introduction and background gave rise to the research problem and questions which guided the researcher throughout the study to gain valuable information to support Life Science teachers in developing positive attitudes toward scientific investigations.

1.3. Research problem and research questions

Life Science teachers working within some secondary schools in South Africa face numerous challenges in connection with conducting scientific investigations. The most significant challenge seems to be their lack of knowledge and skills concerning scientific investigations (Kibirige, Teffo & Singh, 2022:9), which negatively influences their attitudes towards scientific investigations and their confidence to teach scientific investigation activities.

Kibirige et al. (2022:2) and Heeralal (2014:797) report that the lack of equipment, resources and facilities seem to adversely influence teachers' attitudes toward scientific investigations in the Gauteng Province. This study is the first to investigate central South African Life Science teachers' attitudes toward scientific investigations.

A teacher's attitude is a critical factor in that teacher's success or failure (Gecer & Zengin, 2015:145). The information, capabilities and attitudes to be conveyed to learners through scientific investigation work are directly related to a teacher's abilities, knowledge and attitude toward Life Science (Gecer & Zengin, 2015:144). Teachers with a negative attitude towards scientific investigation work will adversely affect the learners' attitudes and learning.

Ukachukwu (2016:24) and Drew (2021:1) define attitude as an evaluation statement that can be favourable or unfavourable toward items, activities or events. Vishal (2014:1) posits that an attitude stems from an individual's worldview pertaining to people, objects and diverse behaviours. Drew (2021:6) argues that how individuals respond to various situations and settings regulates their attitudes; an attitude is a set of responses related to one's psychological state and affects one's interaction with the situation (Karim, Ayub, Khurshid & Akram, 2017:275).

The ABC model of attitude best describes attitudes and the components thereof in the context of this study and was, therefore, used in this study to guide the exploration of how the Life Science investigation workshop will affect teachers' attitudes (Drew, 2021:3).. This model proposes that attitudes comprise three components: an affective component, a behavioural component and a cognitive component (Drew, 2021:3). The ABC model of attitude and its three components are discussed in depth in Chapter Two of this study.

A teacher's attitude can be either a negative or positive perception; a mental state of readiness to cope with a situation (Ukachukwu, 2016:24-29). In the context of this research, the situations in which some secondary Life Science teachers find themselves define their attitudes towards the inclusion of scientific investigations in the science classroom.

1.3.1. Primary reserach question

What influence do scientific investigation workshops have on the Life Science teachers' attitudes toward scientific investigations?

1.3.2. Supporting resreach questions

What effect will a scientific investigation workshop have on the affective component of Life Science teachers' attitudes?

What effect will a scientific investigation workshop have on the behavioural component of Life Science teachers' attitudes?

What effect will a scientific investigation workshop have on the cognitive component of Life Science teachers' attitudes?

1.3.3. The aim and objective of the study

The research aimed to investigate the effect scientific investigation workshops have on Life Science teachers' attitudes toward scientific investigations and advance recommendations that will aid teachers in improving their knowledge and skills regarding scientific investigations. To assist in achieving this goal, the secondary objectives listed hereunder were established.

1. To understand the effect of scientific investigation workshops on the affective component of Life Science teachers' attitudes.
2. To understand the effect of scientific investigation workshops on the cognitive component of Life Science teachers' attitudes.
3. To understand the effect of scientific investigation workshops on the behavioural components of Life Science teachers' attitudes.

Chapter 2

2.1. Introduction

This chapter presents a review of literature based on previous studies that utilised the Attitude Behaviour and Cognitive (ABC) model of attitude, professional development programmes (workshops), and the inquiry-based approach vs the lecture-based approach in the Life Science classroom (Drew, 2021:3).

As highlighted in Chapter One, teachers' positive attitudes toward scientific investigations are vital for the successful implementation of scientific investigations in the classroom. However, numerous challenges hinder the conduction of investigations and might contribute to Life Science teachers' negative attitudes (Kibirige, Teffo & Singh, 2022:9; Heeralal, 2014:797).

Teachers' attitudes influence how they teach, convey information and appreciate a subject and it is, therefore, essential to understanding the importance thereof when considering how to improve Life Science Education (Gecer & Zengin, 2015:144).

According to Heeralal (2014: 796), some schools do not have favourable conditions, meaning they do not have the neccasy resources, scientific equipment of facilities, to teach science education to learners. Science teachers often face challenges regarding resources, equipment and knowledge. Du Plessis and Mestry (2019:2) state that South Africans find it problematic to source quality education services, and factors such as a lack of knowledge, skills, equipment, resources and qualified teachers weaken the quality of science learning and teaching in the classroom.

Du Plessis and Mestry (2019:2) & Zulkifli, (2014:1), argue that the quality of education in South Africa might be declining, with teachers often experiencing a lack of support and fewer opportunities to attend in-service training programmes that might improve their skills, attitudes and knowledge to convey the necessary scientific information to their learners

In-service training programmes might also enable teachers to carry out their teaching responsibilities more effectively and undertake more significant and more demanding roles in teaching science (Zulkifli, 2014:2). In-service training programmes are, therefore, perceived to play a vital part in overcoming the challenges encountered in the workplace and supporting teachers to cater to the learners' needs.

Since inquiry-based teaching is a pivotal factor in science education, teachers should effectively implement this method of teaching (Bulba, 2021). The investigative approach allows learners to apply science process skills such as hypothesising, investigating, exploring, observing and creative thinking in the science classroom. The inquiry approach is recognised as teaching and learning that focuses on the process of doing science. Science curricula worldwide emphasise that learners should also learn about how science is constructed and developed (Sjoberg, 2018:195) and teachers must understand the importance of presenting inquiry-based lessons. Teachers who are unsure of how to incorporate and implement inquiry-based teaching methods in the classroom will benefit from attending regular in-service training programmes.

Research conducted in South Africa established that some secondary Life Science teachers are unenthusiastic about conducting scientific investigations with their learners. They feel that they do not have the necessary knowledge and skills to do so successfully (Mwangu & Sibanda, 2017:48).

2.2. Attitude theory

According to Ukachukwu (2016:24-29) and Drew (2021:1), attitudes are defined as evaluation statements, unfavourable or favourable, concerning objects, people or events. In this context, one can evaluate a situation positively (happy and comfortable) or negatively (unsatisfied and uncomfortable). One’s attitude is also linked to the readiness of the psyche to react and act in specific ways (Ramnarain & Hlatswayo, 2018:4; Vishal, 2014:1).

Vishal (2014:1) posits that an attitude originates from an individual’s world; this world encompasses other people, physical objects, different behaviours and policies. How individuals react to their environment and settings determines their attitudes (Drew, 2021:6). This is to say that attitudes are responses associated with one’s mental state and affect one’s interaction with the environment (Karim, Ayub, Khurshid & Akram, 2017:275).

An individual’s attitude can be either a negative or positive perception or a mental state of readiness to cope with a situation, person or object (Ukachukwu, 2016:24). This study argued that their experience and the world in which some Life Science teachers might find themselves define their attitudes and how they perceive the presentation of scientific investigations.

The ABC model of attitude is best suited to describe attitudes and the components thereof (Mzomwe, 2019:210; Vishal, 2014:1). It supports the comprehension process of an attitude and how attitudes affect everyday life (Mzomwe, 2019:210; Vishal, 2014:1). The ABC model is also one of the most often cited models when discussing attitudes (Vishal, 2014:1). This model proposes that attitudes comprise three main components: an affective component, a behavioural component and a cognitive component. Understanding these three components will aid in comprehending teachers' attitudes toward scientific investigations and why they feel reluctant to conduct such investigations (see Figure 2.1).

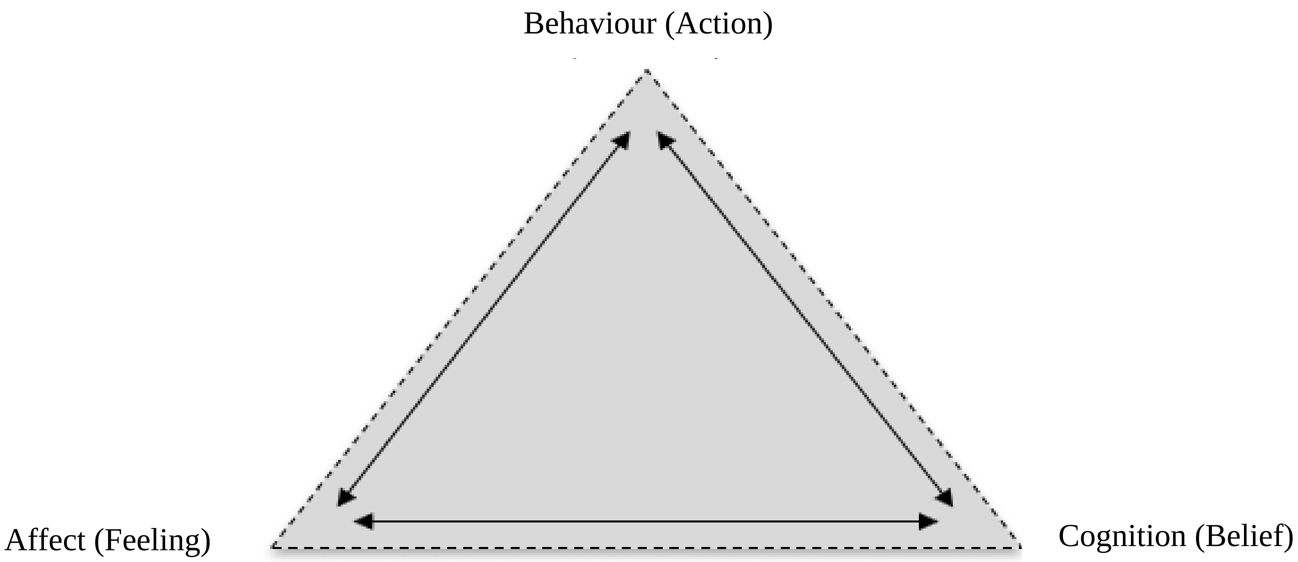

Figure 2.1: Components of attitude, where the arrows indicate the mutual interactions between the components

Source: Drew (2021:5) and Ukachukwu (2016:28)

The cognitive component (see Figure 2.1) comprises one's beliefs; it also refers to an individual's (teacher's) thoughts (Mzomwe, 2019:210; Vishal, 2014:4). Teachers' thoughts are deemed a crucial aspect of the cognitive component and are conveyed as either negative or positive observations held by teachers towards objects or situations, such as the facilitation of scientific investigations (Ukachukwu, 2016:26). However, it is essential to understand that individuals' attitudes concerning an object cannot be described by solely classifying their beliefs and thoughts about something, as feelings operate simultaneously with the cognitive process (Mzomwe, 2019: 210; Vishal, 2014:1-5).

The affective component (see Figure 2.1) describes a person's (teacher's) emotional feelings. It reflects how one feels about a particular something; disliking or liking it (Mzomwe, 2019:210; Vishal, 2014:4). In this study, the affective component referred to teachers' feelings about conducting scientific investigations in Life Science classrooms. Some teachers might feel they lack the relevant knowledge and skills to conduct scientific investigations (Kambaila, Kasali & Kayamba, 2019; Heeralal, 2014:797). Gecer and Zengin (2015:144) posit that numerous challenges faced by Life Science teachers contribute to why teachers feel they cannot present scientific investigations. According to Ukachukwu (2016:26), when teachers cultivate negative feelings, such as self-doubt, toward any part of a subject, it significantly affects their behaviour (see Figure 2.1).

The behavioural component (see Figure 2.1) is the overt or verbal tendency that comprises observable responses and actions (Vishal, 2014:4). This component encompasses an individual's (teacher's) decision (unfavourable/favourable) to take action (Ukachukwu, 2016:27).

An example that illustrates the interaction between the three components of attitude is the positive/negative emotion or feeling an individual develops towards a particular situation. For example, the starch test is seen as the situation, and Life Science teachers who do not know how this experiment is conducted and/or do not have the necessary skills to use apparatus such as a Bunsen burner might cultivate negative feelings or feelings of uncertainty. The affective component influences the cognitive component; what they think and believe. Teachers probably believe that they are unskilled and think that they are not able to conduct this experiment successfully, which in turn influences the behavioural component, which is how they behave. Teachers might then refrain from performing the starch test experiment and resort to showing their learners video clips of how the experiment is performed or they might prefer to read through the experiment activity in the textbook (Ukachukwu, 2016:27).

With the foregoing discussion in mind, it could be argued that one of the foremost obstacles to conducting scientific investigations in Life Science classrooms is the teachers' perception that they lack the necessary knowledge and skills. A teacher who has had little or no training in the facilitation of scientific investigations might feel that they are unable to conduct a scientific investigation successfully and makes a cognitive decision to avoid presenting scientific investigations, resulting in that teacher using a lecture- or textbook-based teaching approach to scientific investigations.

2.3. Life Science teachers' attitudes toward scientific investigations

Karim, Ayub, Khurshid and Akram (2017:275) state that attitudes consist of significant factors that influence the learning and teaching processes. Attitudes are not inherited but developed through experiences, which implies that experiences of and exposure to scientific investigations might contribute to teachers developing either positive or negative attitudes (Duban, Aydoğdu & Yüksel, 2019:777).

According to Dal, Harman and Cokelez (2016:283), educational experiences influence teachers' perceptions of scientific investigations' concepts, knowledge and importance. Therefore, it is essential to foster Life Science experiences that promote science comprehension to help teachers to apply practical activities in science classrooms.

According to Dal, Burckin and Aytekin (2016:283), successful teaching and learning occur through experience, active engagement and repetition. When experiences and knowledge fade, teachers' and learners' memorisation kicks in. Memorisation makes transferring knowledge and understanding concepts more challenging (Dal et al., 2016:283). Therefore, creating opportunities within a laboratory environment for teachers to experience and actively engage with science-related equipment and materials is essential. Through repetition and practice, teachers can become more comfortable with laboratory activities in the science classroom, which might favourably impact their attitudes.

Karim, Ayub, Khurshid and Akram (2017:275) further state that attitudes result from different interactions and experiences that Life Science teachers might encounter in their educational environments. Some teachers might experience a supportive environment and others might feel that they are not supported, which could lead to these teachers encountering insufficient interactions with the scientific environment, which might cause negative attitudes; a view supported by Ualesi and Ward (2018:37), who also stated that attitudes toward teaching science could be a result of different experiences. Influences such as the lack of resources at the school and teachers' low self-ability beliefs and confidence can affect their attitudes.

Karim et al. (2017:269) state that a positive attitude marks a good teacher. Life Science teachers who show confidence and optimistic attitudes develop professional teaching capabilities, skills and knowledge to promote successful learning. The science environment should be encouraging, stimulating and supportive to promote and develop positive attitudes among Life Science teachers (Duban, Aydoğdu & Yüksel, 2019:777).
Attitudes also involve personality, interests, social behaviour and appreciation (Duban et al., 2019:777). When Life Science teachers enjoy the scientific investigation process, which includes dissections and experiments, they will likely appreciate the nature of science,

become more interested in life on earth and have more confidence in sharing the practical side of Life Science with others (Duban et al., 2019:777).

Attitudes entail feelings toward activities, people or objects (Ualesi & Ward, 2018:38; Vishal, 2014:3). These feelings can be either positive feelings associated with enjoyment or negative feelings associated with a lack of confidence and fear and these feelings can occur simultaneously (Ualesi & Ward, 2018:38). Teachers might enjoy teaching science but do not always feel confident teaching some parts of the subject. Some teachers resort to teaching the theory part of the subject but do not feel sufficiently confident to teach the practical part of the subject, namely the scientific investigation activities.

Teachers should adopt a cooperative attitude and foster cooperation, as that can eliminate cognitive and skill barriers due to limited experience and narrow perspectives (Nursianawati & Winarno, 2019:840). Collaboration can enable teachers to discover their strengths and weaknesses and work together to support, encourage and learn from one another (Nursianawati & Winarno, 2019:840). Cooperative learning activities might motivate Life Science teachers to change and develop their teaching methods and thoughts, leading to confidence, assurance and a sense of belonging in the science environment (Harman, Cokelez, Dal & Alper, 2016:12).

2.4. Possible challenges affecting Life Science teachers' attitudes toward scientific investigations

Laboratory conditions in some schools are unsuitable for conducting scientific investigations due to a lack of access to the required apparatus, materials and resources (Ndjangala, Abah & Mashebe, 2021:54; Heeralal, 2014:796).

In contrast, some schools with the required equipment might not have science teachers with the necessary skills and knowledge to successfully utilise the equipment and resources to conduct scientific investigations (Ndjangala, Abah & Mashebe, 2021:54; Heeralal, 2014:796). Some Life Science teachers stated that their lack of knowledge and skills prevent them from conducting scientific investigations with their learners (Kibirige, Teffo & Singh, 2022:9; Mogofe & Kibirige, 2017:426).

Mogofe and Kibirige (2017:426) found that some teachers had misconceptions regarding scientific investigations, as they demanded more science equipment despite unused apparatus in storerooms serving as evidence that a lack of equipment and resources was not the only challenge that hinders investigations. The lack of knowledge and skills regarding the teaching methods and use of apparatus and equipment may be the most significant challenges affecting Life Science teachers' attitudes toward scientific investigations (Kibirige, Teffo & Singh, 2022:9; Mogofe & Kibirige, 2017:426; Boakye & Ampiah, 2017:7).

Wibowo (2019:64) and Heeralal (2014:798) indicate that some scientific investigation activities do not require formal equipment and apparatus. Wibowo (2019:64) argues that teachers should also use the natural environment as a valuable learning resource, as it is easily accessible and inexpensive. This might encourage Life Science teachers, especially those teaching in schools with limited science materials and equipment, to be creative and improvise and use the materials available in their surroundings to conduct scientific investigations (Wibowo, 2019:64).

However, this might be difficult to achieve, as most Life Science teachers are inexperienced and lack the knowledge and skills required to innovate in the scientific field. Inexperience, absence of knowledge, skills, practice and familiarisation regarding dissections and investigations may result in teachers fostering negative attitudes and losing confidence in their abilities (Mogofe & Kibirige, 2017:429).

2.5. The effect of teachers' attitudes on their classroom practice

Various factors, such as students' and teachers' beliefs, prior knowledge, orientations, experiences and attitudes influence science teaching and learning (Caleon, Tan & Cho, 2018:118). It has been suggested that classroom practices are directly affected by a teachers' beliefs, opinions, attitudes and teaching methods (Ukachukwu, 2016:34). According to Ukachukwu (2016: 34) and Kim, Tan and Talaue (2013:306), teachers' attitudes and ideas about the curriculum requirements also affect their decision-making and classroom practice both consciously and subconsciously; subsequently, these beliefs and views direct their instructional decisions.

Tufail and Mahmood (2020:335) state that science education is a complex process, and teachers should, therefore, continually adjust their instructional strategies, decision-making skills, presentation and representations of concepts and practical pedagogies to meet learners' needs. There is no simplistic set or structure to prepare science teachers for the different environments that they might face in the science classroom; thus, Tudail and Mahmood (2020:335) encourage teachers to familiarise themselves with diverse teaching and learning methods and choose what best suits their environment.

As science teachers' teaching methods play such a crucial role in the teaching and learning processes, they are advised to implement suitable teaching instructions to meet their learners' needs (Tufail & Mahmood, 2020:333). Tufail and Mahmood (2020:333) motivate science teachers to use teaching methods, teaching knowledge and skills, practical knowledge and real-world knowledge experiences in science lessons to support the scientific process.

However, when teachers face challenges such as a lack of knowledge and skills to utilise equipment and resources successfully to conduct scientific investigations, it impacts their instructional teaching method and results in the unsuccessful implementation of the curriculum, including scientific investigations. Sanders and Ngxoal (2009:122) argue that these teachers may neglect or spend less time on the subject sections they do not understand because they lack the knowledge and skills to facilitate learning. Teachers might resultantly foster negative attitudes toward scientific investigations and then refrain from implementing inquiry-based teaching approaches where learners engage in hands-on science activities.

According to Sanders and Ngxola (2009:122), as cited by Ukachukwu (2016:34), not only does the lack of knowledge and skills influence teachers' attitudes and classroom practice; but other factors such as the school environment, nature of the workplace, principals' and colleagues' attitudes also affect the Life Science teachers' attitudes. Thdail and Mahmood (2020:335) and Ualesi and Ward (2018:46) state that different learning and teaching elements, including organisational skills, learners' understanding, teachers' training and workshops, curriculum knowledge, and skills might all contribute to effective teaching practices.

It is suggested that teachers focus on applying inquiry-based teaching methods in science classes to support learners in developing their conceptual understanding of science (Bulba, 2021; Tufail & Mahmood, 2020: 333). This teaching method prompts the teacher to act as a facilitator or supervisor during activities involving learners actively undertaking their research rather than as an information transfer agent (Granjeiro, 2019:553). Inquiry-based teaching is usually used during scientific investigation activities and can be developed through workshops.

2.6. In-Service Training Workshops

Training workshops are used in organisations to teach people new skills and the knowledge required to perform the tasks demanded by their occupation (Zulkifli, 2014:1). These workshops enable people to carry out their job responsibilities and undertake more demanding roles for effective job performance. Therefore, these training workshops play a vital part in overcoming the challenges encountered in the workplace and supporting employees to achieve the organisation's goals.

Zulkifli (2014:1) refers to the education system as an organisation; therefore, training workshops are essential for teachers to improve the quality of the education that is offered (Atuhumuze, 2019:21; Zulkifli, 2014:1). In-service training programmes and workshops are organised, planned processes whereby teachers – individually or collectively – enhance their effectiveness by gaining new ideas, skills and knowledge to respond to changing circumstances. They assist in advancing the quality of education.

Since 1994, all South African teachers, including Life Science teachers, have been exposed to education policy transformation that has affected the teaching approaches and the Life Science content (Teane, 2019:2). During these reforms, the Department of Basic Education created professional development workshops for in-service teacher training to empower teachers in adjusting to these new policies. These workshops provided opportunities for teachers to develop the necessary skills and knowledge to interpret the curriculum change effectively and contribute to the successful implementation of the curriculum according to the aims, objectives, and requirements of the educational standards.

Teane (2019:4) states that these workshops aim to develop skills, knowledge and professionalism among teachers and create an opportunity to improve learners' performance. Professionalism can be defined as using "know-how" and "know-what" in accordance with situational requirements. According to Donkor and Banki (2017:68) and Zulkifli (2014:2), in-service training programmes such as workshops can enhance teachers' professionalism and contribute to achieving the required teaching and learning outcomes. Atuhumuze and Nzarirwehi (2019:21) and Zulkifli (2014:2) describe in-service training programmes as professional and personal educational activities that can improve teachers' professionalism through improving their efficiency, ability, skills, knowledge and motivation in their professional work.

Training programmes are fundamental in enhancing teachers' professionalism and the quality of their work (Nzarirwehi, 2019:21). However, Teane (2019:4) states that some Life Science teachers lack professionalism in that they do not pursue the knowledge commensurate with a rapidly changing curriculum.

Atuhumuze (2019:22) and Zulkifli (2014:1) state that in-service training has been the driving force behind various changes in the teaching and learning environment, supporting teachers to keep up with the latest concepts, knowledge and skills in the science field. Teachers should respond to social, technological and political change because the world outside the classroom is constantly developing (Atuhumuze, 2019:21).

According to Omeodu and Amadi (2018:2), workshops also serve as a bridge between experienced and prospective educators, where knowledge and skills are shared and transferred, allowing for these peer interaction opportunities within the education system to improve Life Science teachers' performances in the classroom (Osamwonyi, 2016:84).

Atuhumuze (2019:23) and Zulkifli (2014:2) state that these programmes can also develop and advance teachers' careers and help them to recognise where their teaching methods can be improved and modified to support the school at which they teach and maybe improve learners' educational achievements. Since teachers play an essential role in educational success, attending these workshops can support them in successfully guiding their learners toward higher standards of self-development in the science classroom (Omeodu & Amadi, 2018:3; Zulkifli, 2014:1).

In-service training programmes and workshops are also suitable ways to develop teachers' skills, knowledge and attitudes in practical and integrated ways (Zulkifli, 2014:2; Donkor & Banki, 2017: 68). According to Osamwonyi (2016:84), regardless of how outstanding pre-service teaching education courses are, they alone cannot equip teachers with all they need for a lifetime of work in the Life Science classroom. He argues that teachers should become lifelong learners as educators, individuals and professionals.

Subject knowledge and skills, classroom management and the evaluation of teaching methods improved among teachers who attended in-service training programmes such as science workshops (Atuhumuze & Nzarirwehi, 2019:21; Zulkifli, 2014:2). Teachers who attended in-service programmes developed and implemented inquiry-based teaching methods in their classrooms. According to Tufail and Mahmood (2020:343), inquiry-based techniques should be included in teacher-training workshops to remain up-to-date with modern teaching methods and techniques. In-service programmes and workshops support teachers in identifying and critically evaluating their school's culture, bringing change to their teaching methods and developing an appreciation for the nature of science in the educational environment (Nzarirwehi, 2019:21).

2.7. The rationale behind Professional Development Programmes (Workshops) for In-service Life Science Teachers

Teachers should not focus solely on content knowledge in the classroom but must develop creative ways to stimulate the learning and teaching process to counter boredom (Palmer, Burke & Aubusson, 2017:4; Pretorius, De Beer & Rautenbach, 2014:553).

Kurt (2021:5) and Pretorius et al. (2014:553) hold that some teachers still expect their learners to use textbooks and disseminate static information, assess content recollection, and reflect on observations. Some teachers merely evaluate learners, mainly through test and examination scores, despite some teachers having access to laboratory environments where practical test scores can be gathered for assessments (Kurt, 2021:5; Pretorius et al., 2014:553).

Teachers' conceptions are directly and positively associated with a positive conceptual change in learners; hence, a teacher's positive attitude and scientific knowledge and skills result in successful classroom practices and effective learning outcomes (Ukachukwu, 2016:24; Pretorius et al., 2014:554; Lyons & Quinn, 2010). However, according to the Departments of Basic Education and Higher Education and Training (2011:36), South Africa faces a severe concern regarding the low number of qualified science educators teaching at schools. Numerous qualified science teachers prefer to teach a different subject in ex-model C schools or private schools rather than their specialised science subjects in a rural school. Qualified Life Science teachers might teach History or Maths in a privileged school, while English-qualified teachers might teach Life Science at a disadvantaged school (Pretorius et al., 2014:555).

Science has lost its attraction for numerous learners because some teachers are non-specialists in the science field; they teach through chalk and talk teaching methods that depend on textbooks. Learners and teachers use intuitive reasoning in the science classroom instead of scientific reasoning that embraces the nature of science (Pretorius et al., 2014:553). This contributes to a lower quality of scientific learning because qualified Life Science teachers are not teaching in their field of expertise, and teachers not qualified in science, teach Life Science.

Teachers need to reinstate the nature of science (NOS) into the science classroom, as NOS includes the assumptions and values essential to developing scientific knowledge and teachers facilitating an understanding of the science subject matter (van Uum, Verhoeff & Peeters, 2016: 452; Pretorius et al., 2014:553). Although science knowledge is timid, it is also durable, perceptual, subjective and creative, and, therefore, science teachers need to foster an appreciation for the true nature of science among themselves and learners. In addition, teachers should develop an inquiry-based scientific outlook, which can be accomplished by attending in-service training workshops.

2.8. Inquiry-based science education

Inquiry is at the core of philosophers' descriptions of science (Sjoberg, 2018:194). Inquiry is an investigation and process that leads to insightful knowledge (van Uum, Verhoeff & Peeters, 2016:464). Learners must investigate and understand the nature of science and comprehend that science education is more than a mere pile of facts, laws and theories; it is a dynamic process (Sjoberg, 2018:194; Constantinou, Rybska & Tsivitanidou, 2018:18).

Inquiry-based science is an approach to teaching and learning that emphasises investigation (Bulba, 2021; Constantinou et al., 2018:2). This investigative approach allows learners to investigate problems, explore possible solutions, observe, ask questions, test ideas and use their intuition to think creatively. The concept of inquiry is established when learning focuses on the process of "doing" science. Therefore, science curricula worldwide emphasise that students should learn about how science is constructed and developed (Sjoberg, 2018:195).

Inquiry-based science allows learners to explore solutions, create explanations for the investigated phenomena, elaborate on the processes and concepts and assess their understanding of the available evidence (Kibirige, Teffo & Singh, 2022:2; van Uum, et al., 2016:451). Teachers must understand the importance of presenting inquiry-based lessons and should present problems that will challenge learners' conceptual understanding so that they can incorporate abnormal/non-typical thinking to construct new understandings (Constantinou, Rybska & Tsivitanidou, 2018:9; Bulba, 2021). Inquiry-based learning and teaching can result in long-lasting learning outcomes because the learners are more invested during a lesson (Schmid & Bongner, 2019:485).

However, some school settings are challenging; teachers face different individuals with various characteristics, levels of knowledge, abilities and unpredictable responses (Alozie & Mitchell, 2019:501). As a result, teachers use the teaching method best suited for the classroom as a whole (Tufail & Mahmood, 2020:334) and the learners must adapt and process large amounts of information in a short amount of time.

According to Alozie and Mitchell (2019:501), some Life Science teachers are challenged with integrating "scientific talk" into the inquiry-based learning experience and as a result, some learners and teachers may not be able to participate or contribute to the scientific discourse (Alozie & Mitchell, 2019:501).

Teachers should focus on a student-centred teaching method when implementing the inquiry-based approach (Gatt & Buttigeig, 2018:375). They also argue that teachers must encourage discussion and the initiation of questions among learners by guiding rather than leading classroom discussions. Actively engaging learners in classroom activities through reading, resources and activities will ensure that they explore their knowledge of topics and allow them to build on their science knowledge (Alozie & Mitchell, 2019:503).

According to Constantinou et al. (2018:6), inquiry-based teaching involves teachers verbally engaging with their learners while keeping track of their responses and listening to their reflections. An inquiry-based approach supports learners individually by allowing them to share their thoughts in groups or with a partner before addressing the class. Follow-up questions asked by the teachers support the learners' understanding and help them to think critically and reflect on why they know and understand concepts (Alozie & Mitchell, 2019:502).

According to Alozie and Mitchell (2019:501), scientific communication in the classroom facilitates the inquiry-based teaching and learning approach. Alozie and Mitchell (2019:501) argue that oral exchange is necessary to master inquiry-based learning. Engaging learners in classroom discussions will introduce them to the scientific community. Learners will learn how to find solutions to real problems by asking questions, designing and conducting investigations, gathering and analysing data and drawing conclusions (Constantinou et al., 2018:4).

Innovative pedagogical approaches, such as inquiry-based learning, are based on the constructivist approach that places learners at the centre of the teaching and learning process (Gatt & Buttigeig, 2018:375). Successful learning starts when teachers encourage their learners to think about what they will be learning by accessing their prior knowledge and understanding of a topic; this allows them to relate to science on a personal level (Alozie & Mitchell, 2019:502).

2.9. Seven phases within the four domains of inquiry-based science education (IBSE)

A study conducted in the Netherlands found that although inquiry-based science education (IBSE) has positively affected learners' outcomes, some teachers experience difficulty in guiding learners through the process of inquiry (van Uum, Verhoeff & Peeters, 2016:451). According to van Uum et al. (2016:451), IBSE is based on four domains that teachers can utilise to support their learners. Researchers differentiated between four domains of scientific knowledge reflecting different levels based on the synthesis of literature studies within science education.

2.9.1. The conceptual domain

The conceptual domain signifies the current understanding of natural systems, such as the phenomenon of sound and light. The inquiry method focuses on the process of scientific investigation rather than the curriculum content (Shanmugavelu, Parasuraman, Ariffin, Vadivelu, 2020:6). Inquiry is conceptual rather than factual. Researchers with practical experience hold that learners need conceptual knowledge and understanding regarding the topic of investigation to perform the inquiry processes, such as formulating research questions (van Uum et al., 2016:452). Shanmugavelu et al. (2020:6) agree and state that the inquiry method focuses on knowledge regarding the "how" and not "about", which signifies that how knowledge is gained is important. Tufail and Mahmood (2020:343) encourage teachers to include real-world scenarios in their teaching to help learners to implement the knowledge and skills they have acquired in real life.

2.9.2. The epistemic domain

The epistemic domain refers to the nature of science (NOS), which indicates a learner's belief about what scientific knowledge is and how scientific knowledge is prompted (van Uum, Verhoeff & Peeters, 2016:452). Scientific knowledge is generated through observation, critical thinking, measuring and scientific reasoning (Kibirige, Teffo & Singh, 2022:3; Schmid & Bongner, 2019:485; van Uum et al., 2016:452). The epistemic domain includes how learners reflect on science and generate scientific knowledge. It is crucial to understand that inquiry-based education involves learners as active thinkers, inquisitors, seekers and processors of the information that they gather (Shanmugavelu, Parasuraman, Ariffin & Vadivelu 2020:7).

2.9.3. The social domain

The social domain refers to researchers' valuable scientific attributes, as they critically review their work and the work of others; sharing findings and participating in discussions (van Uum et al., 2016:452). Researchers often work together in research projects to elaborate on theories and results. Collaboration and communication can be encouraged in the science classroom by assigning different responsibilities and roles to learners during group activities and focusing on collective activity and shared ideas (Kibirige et al., 2022:2; Alozie & Mitchell, 2019:501). Exploratory conversations are crucial in improving learners' scientific reasoning and the formulation of constructive feedback; the learners are empowered to negotiate challenges and alternative ideas.

Socialising in the science classroom can encourage learners to communicate openly, as they must explain their actions and decisions, regarding their investigation, to their classmates and teachers (van Uum et al., 2016:452). Tufail and Mahmood (2020:336) support social interaction within the science classroom by stating that teachers could use discussions in the classroom to explore learners' prior knowledge, evaluate their current understanding of knowledge, and involve them as active participants, as they might think about possible answers to classmates' questions.

2.9.4. The procedural domain

Shanmugavelu, Parasuraman, Ariffin and Vadivelu (2020:6) state that the inquiry method focuses on knowledge relating to the "how" and not "about", which implies that teachers and learners should appreciate how knowledge is acquired and not the knowledge itself. The procedural domain refers to knowing how to use knowledge and how to proceed. This domain will support learners in adequately addressing the inquiry procedures, such as formulating research questions and generating conclusions (van Uum, Verhoeff & Peeters, 2016:453). According to Shanmugavelu et al. (2020:6), inquiry-based teaching should instil curiosity in learners about a science topic. Learners can use their knowledge to question the truth and the precision of the data they obtain during an investigation. Learners must understand what they have learned to understand the content (Shanmugavelu et al., 2020:6).

2.10. Phases of inquiry

The phases of inquiry are exploration, introduction, designing the investigation, conducting the investigation, drawing conclusions and presenting the results (Constantinou, Rybska & Tsivitanidou, 2018:4; van Uum et al., 2016:452).

Van Uum et al. (2016:462) argue that it is essential that teachers support their learners' inquiry process by addressing a specific domain of scientific knowledge in each phase of inquiry. For example, teachers can focus on the epistemic domain during the introduction phase by encouraging enthusiasm for inquiry by discussing relatable research and science concepts. As a result, the learners will understand the background and context of the science lessons and might be more motivated to participate. During the exploration phase, teachers can address the conceptual domain by questioning the learners, prompting them to retrieve prior knowledge, and linking new concepts with their previous experiences.

Kibirige, Teffo and Singh (2022:3) and Van Uum et al. (2016:463) suggest that teachers need to scaffold the procedure of formulating research questions by questioning learners to trigger their critical thinking characterised by the procedural domain. Teachers can touch on the epistemic domain by explaining the design criteria and rubric for a scientific investigation and helping learners to consider the number of research subjects, variables and other aspects of their investigation.

Motivating learners to collaborate and work in groups in which they each play a role will teach learners that they should work together in the inquiry process to conclude the investigation and address the social domain of the inquiry phase.

In the fourth phase of the investigation, teachers can focus on the procedural domain. During scientific investigation activities, teachers can explain how to conduct scientific procedures such as measuring, taking notes, and observing. Teachers should guide learners during this phase and not lead them (van Uum et al., 2016: 463). During this phase, the learners will understand the importance of carrying out specific procedures correctly, as errors can affect an investigation's outcomes.

The concluding phase is where teachers should still address the procedural domain. Teachers can discuss the relevant, everyday context and refer to the research questions to help them to draw conclusions. This phase includes the epistemic domain, where teachers can question the learners about their results and ask them to explain their findings. During this phase, learners can differentiate between results, conclusions, and discussions (van Uum et al., 2016:463).

According to Van Uum et al. (2016:463), presentation and communication is the sixth phase that focuses solely on the social phase. Teachers can create a classroom environment in which the learners feel comfortable sharing their reflections and providing feedback on their findings; allowing them to explain their investigation to an audience/classroom will result in their paying attention to different inquiry components (Kibirige, Teffo & Singh, 2022:2).

Finally, teachers should create scientific investigation lessons that require hands-on science activities combined with minds-on reflections (Kibirige et al., 2022:2). According to Van Uum et al. (2016:4630), learners will be able to differentiate between acquired knowledge and the knowledge they want to gain from the lesson to conduct successful inquiry-based research activities.

However, some teachers lack the knowledge and skills required to conduct these phases of IBSE with the different domains in science and laboratory classrooms. As mentioned previously, such teachers might resort to the lecture-based approach and IBSE is not successfully implemented in the science classroom.

2.11. Inquiry-based approach as a constructivist theory in education

2.11.1. Teachers' role in the inquiry-based approach

Teachers play a pivotal role in the inquiry-based approach (Kibirige, Teffo & Singh, 2022:1; Gatt & Buttigeig, 2018:374). Regardless of age, a learner needs a role model that fosters inquisitiveness in the science classroom (Gatt & Buttigeig, 2018:374). Teachers promote inquiry in the classroom because they are perceived to be experts at asking questions, gathering information through observation, designing investigations, reflecting and drawing conclusions from the evidence. Gatt and Buttigeig (2018:374) state that teachers must be good inquirers before using the inquiry-based method successfully.

The constructivism theory revolves around how knowledge is constructed and influences the teaching and learning process (Constantinou, Rybska & Tsivitanidou, 2018:2). Teachers should acknowledge these principles to create a classroom environment where learners are actively engaged; it is not enough to know and understand the constructivism theory; teachers should also know how to implement it in the science classroom and act as facilitators (Constantinou et al., 2018:16). Teachers must understand that they share equal responsibilities and authority with the learners in the classroom and that knowledge is shared between learners and teachers.

The constructivist theory focuses on how knowledge is constructed in a learner's mind and how teachers can make learning contextual (Constantinou et al., 2018:2). People learn by forging connections between what they already know and have and what they believe. Favourable situations where learners can apply science in their everyday lives, or where a scientific concept applies to them, will support the learning process.

Firstly, knowledge is constructed through a learner's journey; building on pre-existing knowledge (Bozkurt, 2017:210). The constructivist theory revolves around learners actively participating in their learning journey because knowledge is constructed through experience (Kurt, 2021:1; Bozkurt, 2017:210). Kurt (2021:1) also states that learners reflect on their experiences and incorporate new ideas with prior knowledge as events occur, thus allowing them to develop schemas to organise newly acquired knowledge.

Teachers must appreciate that the core of constructivism is that learners actively construct knowledge; they build and add new experiences on top of their present foundation of understanding (Constantinou et al., 2018:16). Teachers must also appreciate that each learner who enters the classroom has a unique perspective on life, concepts, and topics created by their unique experiences that impact their learning process. Learners select the experiences and information to add, resulting in the creation and development of unique knowledge (Kurt, 2021:2).

Secondly, learning is a social activity and learners should construct their knowledge by interacting with other learners. Incorporating group work, discussions, interactions and classroom conversations will ensure that learners reflect on relationships when creating understanding (Constantinou et al., 2018:6). According to an online source (IdeaLab, 2020), teachers should still support a student's learning experience during and after the Covid-19 pandemic. Although we are currently post-pandemic, teachers should still find safe ways to include social interactions in their classrooms, perhaps by using smaller groups (IdeaLab, 2020). Group work and learner discussions are critical areas to focus on when implementing constructivism in science learning (Kurt, 2021:4). Teachers can use outdoor spaces, when students work in groups, to learn about nature and other science phenomena (IdeaLab, 2020).

Thirdly, learning is an active process, and learners should, therefore, actively engage in discussions and activities through sensory responses. This entails activities where learners experience touching, feeling, speaking, hearing, and seeing during activities. Learners cannot retain new information when they take on a passive role (Bozkurt, 2017:210; Kurt, 2021:3).

2.11.2. Theory and science literacy as an inquiry-based approach to scientific investigations

The inquiry-based approach requires creative teaching methods that motivate and encourage learners to apply critical thinking when carrying out scientific investigation activities (Kibirige, Teffo & Singh, 2022:3; Gatt & Buttigeig, 2018:375). Teachers who face challenges such as a lack of equipment and resources can use science literacy in the classroom to implement inquiry-based teaching. Creative approaches that stimulate learners' interest and promote a positive attitude toward science include role-play, stories and open-ended investigations (Gatt & Buttigeig, 2018:375; Schmid & Bongner, 2019:485). Gatt & Buttigeig, (2018:375) and Schmid & Bongner (2019:485) argue that scientific investigations should include hands-on activities as this consolidates learning by applying the new knowledge to new scenarios and situations.

Gatt and Buttigeig (2018:376) argue that literacy and science can simultaneously be presented in meaningful ways. Science literacy and vocabulary are critical factors, as they represent connections between the science classroom and real-life situations. Science is not an abstract idea anymore, as learners apply their scientific knowledge to everyday situations, laboratory situations, the classroom and textbook experiences (Gatt & Buttigeig, 2018:376). Theory can also promote inquiry learning because theory and stories address learners' interests and questions while building their science vocabulary.

Story-based case studies are beneficial as they use language familiar to learners; when science is presented in everyday language, learners become more comfortable exploring their scientific ideas and participating in discussions, making them more likely to retain new information (Gatt & Buttigeig, 2018:376).

Teachers can use science-themed case studies to teach new science concepts through literature and present inquiry-based questions to analyse, synthesise, and critically evaluate ideas to predict study outcomes. Teachers can organise reading activities such as science case studies before, during and after lessons. For example, teachers can provide learners with a case study that includes pictures; before the activity begins, the learners can provide a hypothesis or title by looking at the pictures. Afterwards, the teachers can ask inquiry-based questions to stimulate the learners' creative thinking (Gatt & Buttigeig, 2018:376). Teachers can encourage learners to predict the results or outcomes of the investigations during the scientific investigation lessons by sharing their thoughts on the science concepts before conducting the investigation. Once the investigation has been completed, the teachers can also provide the learners with a case study related to the investigation; this will support the learning process by allowing the learners to apply their newly acquired knowledge.

This approach contrasts with the traditional approach, where the teachers and learners must follow a strict curriculum, and textbooks and workbooks are the primary materials used in learning activities. The traditional approach is based on learning skills, and the curriculum should be taught in parts to impart a whole idea. The teachers are responsible for direct learning and take an authoritative role in the traditional classroom, where they communicate information to the learners and the learners passively receive the new knowledge independently. After the learners have acquired knowledge through repetitive practice, the knowledge remains stagnant and tests and evaluations are employed to ascertain the learners' understanding of concepts (Kurt, 2021:5).

As discussed, constructivism differs significantly from a traditional classroom. In a constructivist classroom, teachers and learners pursue their interests and ask questions while using manipulative and primary materials for teaching and learning. Learning is established concerning important ideas and these are explored in smaller groups, where the teacher guides the interaction between the learners. The inquiry-based process is essential; therefore, teachers must motivate learners to evaluate, observe and participate in group work (Kibirige, Teffo & Singh, 2022:1, 3)

2.12. The lecture-based approach in the science classroom

Some science teachers are restricted in their options of teaching methods and have to choose an appropriate teaching method tailored to their available resources such as science equipment and apparatus. Thus, the lecture-based teaching approach is science teachers' most commonly used teaching strategy (Tufail & Mahmood, 2020:334).

Tufail and Mahmood (2020:334) argue that some schools in developed countries have the necessary support in laboratories and different teaching resources that enhance teaching and learning experiences. In contrast, schools in developing counties often only have two factors: teachers and learners to stimulate the teaching and learning experience (Tufail & Mahmood, 2020:334), and teachers encourage learners to memorise science concepts from their textbooks to succeed in assessments and examinations (Tufail & Mahmood, 2020:334).

As some teachers lack knowledge and skills, they prefer lecture-type teaching methods to teach science theory and investigations. Some teachers who lack knowledge and skills regarding the laboratory environment and scientific investigations encourage learners to learn and discover the wonders of science through rote memorisation and passive note-taking rather than hands-on engagement and active participation.

According to Tufail and Mahmood (2020:335), the traditional teaching method is based on the behaviourist approach and includes teacher-led teaching, where the teachers are perceived as the dominant role-players throughout the lessons.

Teachers using the lecture-based method usually stand in front of their learners and verbally provide them with pieces of information; they sometimes utilise audio-visual aids to explain new science concepts. As the lecture method is a one-way flow of information, students' minds are not creatively involved and engaged in exploring science and developing meaningful ideas (Tufail & Mahmood, 2020:335).

Tufail and Mahmood (2020:343) found that the inquiry method is not as popular as the lecture-type textbook method in the science classroom because inquiry-based teaching is a highly structured approach and science teachers with negative attitudes and/or a lack of confidence in employing the inquiry-based approach, might refrain from using this method to teach scientific investigations.

According to Tufail and Mahmood (2020:343), the teaching methods that professionals and scientists recommend, promote a better understanding of scientific concepts. Teachers who have successfully implemented the inquiry-based teaching method have received training and experience or used the technique through which they were taught. Therefore, in-service training programmes should include the inquiry-based teaching method to support science teachers with 21st-century teaching.

Chapter 3

3.1. Introduction

Chapter Two presented a review and discussion of the literature relevant to teachers' attitudes, lack of knowledge and skills amongst Life Science teachers, the inquiry-based teaching approach and workshops.

This chapter presents a discussion of the research methodology that was implemented for collecting data pertaining to Life Science teachers' attitudes towards scientific investigations. A quantitative research method is a powerful tool often used in educational and social research. The quantitative research method guided the researcher to test theories to establish a connection between the dependent (possible change in Life Science teachers' attitudes toward scientific investigations) and the independent (scientific investigation workshops) variables (Morgan, 2017:4).

The quantitative research methodology was best suited for this study as it aims to explain phenomena through the collection of numerical data, which is then analysed using statistical methods (Boru, 2018:10).

3.2. Conceptual Framework

This study adopted a conceptual framework to identify factors that might influence attitudes toward scientific investigations and understand the relationships between the variables. This section focuses on how the conceptual framework for this study was built based on the attitude model and factors identified from the literature that influence Life Science teachers' attitudes.

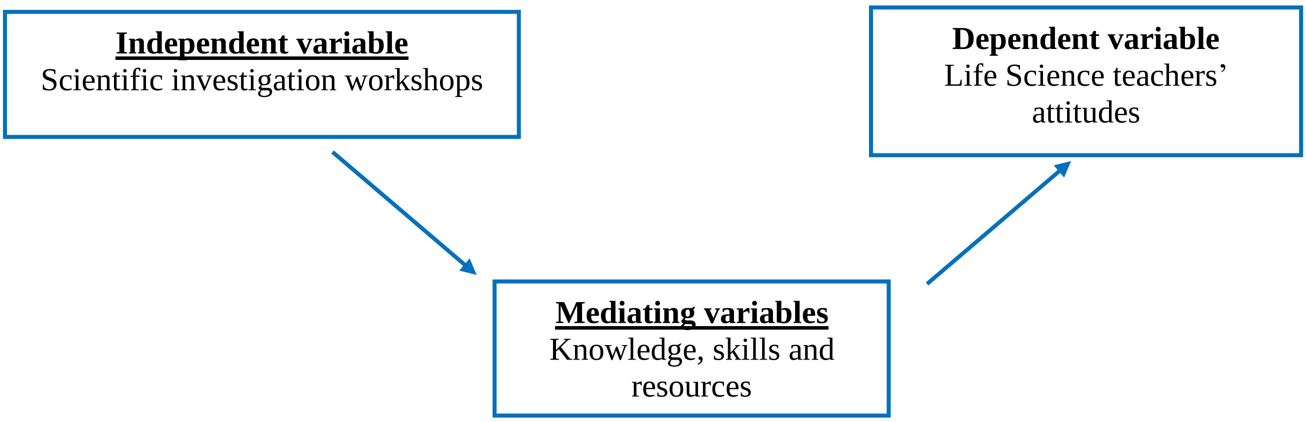

Figure 3.1: Components of the conceptual framework for this study where the arrows indicate the effects of the variables on one another.

The dependent variable was defined as the variable which might be affected by another variable (Abiodun-Oyebanji, 2017:48). The dependent variable in this study was identified as Life Science teachers' attitudes.

According to Shukla (2018:1), the independent variable affects the value of another variable. The scientific investigation workshop (see Figure 3.1) was identified as the independent variable in this study. In this study the workshop can be seen as the intervention since interventions are used to evaluate if change occurred. The independent variable (scientific investigation workshops) can affect the dependent variable (teachers' attitudes), as teachers might feel more confident after attending the Life Science scientific investigation workshop.

A mediator is defined as how an independent variable (scientific investigation workshop) might impact the dependent variable (teachers' attitudes) (Abiodun-Oyebanji, 2017:49). According to Abiodun-Oyebanji (2017:50), the mediating variable is perceived as the causal pathway of an effect caused by the independent variable. The independent variable can also affect the teachers' knowledge and skills, which might indicate that the correlation between the workshops and the teacher's attitudes is more significant when knowledge and skills are taken into account (see Figure 3.1).

The dependent variable's value might change due to changes in the mediating variables (Shukla, 2018:1). If the scientific investigation workshop influences teachers' knowledge and skills, which can be of value to the Life Science teachers, it might contribute to them changing their attitudes. The mediating variable links the independent and dependent variables, allowing the relationship to be better explained (Shukla, 2018:2). In this case, the mediator explains why a scientific investigation workshop might lead to positive attitudes.

Scientific investigation workshops can develop teachers' skills and knowledge (see Figure 3.1) regarding Life Science classroom investigations. Their knowledge and skills were identified as the mediating variable (see Figure 3.1).

The scientific investigation workshop might impact Life Science teachers' knowledge and skills. Knowledge can be defined as the condition of being aware of something and the cognitive processing of information (Boslisani & Bratianu, 2018:4). This process includes recalling, recognising, comprehending and applying and evaluating patterns, concepts and facts. Knowledge can be measured with practical, oral or written examinations where individuals document or explain what they know and understand about a topic (Kassema, 2019:5).

According to Boslisani and Bratianu (2018:5), knowledge of information forms the foundation for applying the skills required to perform a particular task or the modification of an attitude. Therefore, an individual needs to have basic knowledge of a subject before developing his or her skills and attitudes (Kassema, 2019:5). A teacher would first need to learn the functions of the apparatus used in scientific investigations and the steps involved in performing the investigations; after that, they would need to learn how to use the apparatus to carry out the skill.

Skills relate to physically performing a task or activity, including physical movement, coordination, and the application of knowledge. Individuals must train and practice to achieve competency and proficiency in executing skills (Kassema, 2019:8). As skills are learned through the transfer of knowledge, teachers should acquire the subject knowledge of how to perform an investigation and then perform the investigation in the workshops.

The knowledge and skills might, in turn, impact the Life Science teachers' attitudes (see Figure 3.1). Attitudes, as mentioned previously, are a way of thinking, feeling and behaving toward something or someone. An attitude comprises how an individual may deal with things cognitively and affectively, which is often reflected in their behaviour (Karim et al., 2017:275).

The development or adjustment of an individual's attitude may require substantial effort and time; it is often not easy to change an individual's attitude after being shaped over a long time. However, regularly attending scientific investigation workshops might help teachers to develop their knowledge and provide a platform to practice their skills. This might build Life Science teachers' confidence and motivation to undertake scientific investigations, thereby improving their attitudes.

For example, a teacher might not know how to use a pipette. This teacher has never acquired the knowledge or the skill to use it scientifically and has developed a negative attitude toward using a pipette and will avoid presenting experiments if a pipette must be used.

During the scientific investigation workshop, the use of a pipette will be demonstrated. The teacher now has the required knowledge but has not yet acquired the skill to use the instrument. This must be acquired by *practising* how to use it. There is no other conceivable way to acquire this specific skill.

After sufficient practice, knowledge about using the pipette has been converted into a physical skill. The teacher will probably be sufficiently confident to use the pipette during investigations and might have acquired a positive attitude towards its use. The teacher's attitude has possibly improved. This study argues that this is the theoretical mechanism by means of which teachers' attitudes toward scientific investigations can be improved.

3.3. Research paradigm

The positivist paradigm informed the research design. Positivism focuses on the scientific research method and embodies a realist orientation (Okwara, 2021:98). According to Wang (2020:725), positivists believe in objectivism and claim that knowledge exists independently of people's consciousness and experiences. Wang (2020:725) states that researchers use the positivism paradigm because they believe that objective truth and meaning can be obtained and measured through scientific research. Okwara (2021:98) states that positivist research has a realist orientation and focuses on scientific research methods.

Bloomfield and Fisher (2019:27) argue that it is difficult for a researcher to observe a world of which they are a part and maintain an objective view. It is suggested that a researcher can remain objective by using reliable, standardised measuring instruments to collect data as they cannot otherwise completely detach themselves from the research (Bloomfield & Fisher, 2019:27). Consequently, the researcher designed the standardised pre- and post-survey and controlled the questions used for the surveys.

Implementing the pre-experimental design in this study helped the researcher to control the external factors that might impact the research outcomes and validity (Okwara, 2021:99) by keeping situational factors such as the location, time of day and location in mind when setting up the scientific investigation workshop, as such factors can affect the external validity (Cuncic, 2021). This study adopted a field experiment setting, which is a study conducted in a natural setting; a Life Science classroom at a secondary school (Cuncic, 2021).

3.4. Research Design

3.4.1. The quantitative research methodology

The research design can be defined as the framework that guides the researcher during the planning and implementation of the research study (Ukachukwu, 2016:39). According to Asenahabi (2019:77), the research design is connected to achieving the research's objectives by addressing the research questions. As described in Chapter One, this research strove to achieve the secondary objectives listed hereunder.

These objectives were constructed from the study's secondary research questions.

4. What effect will the scientific investigation workshop have on the cognitive component of Life Science teachers' attitudes?
5. What effect will the scientific investigation workshop have on the affective component of Life Science teachers' attitudes?
6. What effect will the scientific investigation workshop have on the behavioural component of Life Science teachers' attitudes?

The research methodology defines the research process employed to collect data (Ukachukwu, 2016:53). The quantitative research design is often used in educational and social research. The main features of the quantitative design, as implemented in this study, are to test theories to establish a connection between the dependent (possible change in the Life Science teachers' attitudes toward scientific investigations) and the independent (scientific investigation workshops) variables (Morgan, 2017:4).

The quantitative research methodology was best suited for this study as it aims to explain phenomena through the collection of numerical data, which is then analysed using a statistical method (Boru, 2018:10). The design of this study emphasised objectivity through constructs that can be measured, so the results obtained in the study did not depend on beliefs alone (Morgan, 2017:4).

As this study aimed to describe variables, test relationships, and explore cause-and-effect relationships, the researcher followed the quantitative, pre-experimental research design (Okwara, 2021:97). The pre-experimental design facilitated the establishment of a connection between the intervention (the use of Life Science investigation workshops) and the outcome .

The research methodology also defined the research procedure and the instruments utilised to obtain data (Ukachukwu, 2016:40). In this study, standardised pre- and post-surveys were employed as the research instruments (see Annexure A). This research methodology ensures objectivity and generalising the results to a broader population.

The researcher employed the one-group pretest-posttest pre-experimental design because one group of participants received the pre-survey before attending the independent variable (the Life Science scientific investigation workshop). The same group received the post-survey to complete after their exposure to the independent variable. These surveys were then used to evaluate if there was any change in the dependent variable (the Life science teachers' attitudes toward scientific investigations). Using the pretest-posttest pre-experimental design decreases the possibility that a factor other than the independent variable (workshop) might cause a change in the teachers' attitude between the pre-test and post-test results (Babbie, 2020:237).

This study adopted the pre-experimental research design because conditions for a full-fledged experimental design were not favourable in this research circumstance (Babbie, 2020:237). An invitation was sent to Life Science teachers in the Motheo District to attend the registered Life Science scientific investigation workshop, where they could develop their scientific investigation knowledge and skills and obtain Continuing Professional Development (CPD) points when participating.

The researcher opposed implementing the experimental design because randomised sampling would have been used to divide the participants into two groups; one group of teachers would be the control group and would not receive the same experience and training as the intervention group (Babbie, 2020:235). Therefore, the one-group pretest-posttest design was best suited because all of the teachers had costs associated with travelling to the workshop and it was, therefore, fair to let all the participants receive the same quality workshop experience.

3.5. The research location

This research was conducted in the Motheo District of the Free State and the Life Science scientific investigation workshop was held at a secondary school situated in Bloemfontein. As this school's Life Science classroom captured the essence of a laboratory, it was well suited for the occasion. The participants, who were all Life Science teachers, felt comfortable in a familiar classroom setting.

3.6. Population

The population is the group to which the research's findings can be applied and is also defined as the target group to whom the researcher wishes to generalise (Shukla, 2020:1; Babbie, 2020:199). The population for this research were all secondary school Life Science teachers situated in the Free State Province.

The population was identified using three applicable parameters: (i) they were all secondary school teachers, (ii) they were all Life Science educators, and (iii) they were all teaching at various secondary schools within the Free State Province. These parameters helped the researcher to define the population and eliminate subjects with unwanted characteristics (Shukla, 2020:1; Babbie, 2020:199).

3.7. Sampling

According to Showkat and Parveen (2017:1), sampling involves the selection of units that are representatives of the chosen population. The researcher implemented non-probability sampling. Showkat and Parveen (2017:5) define non-probability sampling as a non-random sampling method in that the participants are selected because they have the required characteristics. The researcher implemented volunteer sampling, as this method involves members of the population choosing to participate in the study (Mohsin, 2016:28). This sampling method has shortcomings, for example, the findings might not be generalisable to the entire population (Showkat & Parveen, 2017:6). However, the non-probability sampling method was best suited for this study as it can provide valuable insights into the phenomena under investigation and is considered less expensive than other methods.

Sampling was performed by the researcher contacting the Deputy Chief Educational Specialist for the Life Science and Agricultural subjects within the Free State Department of Education. The researcher attached an invitation to the email containing all the relevant information about the scientific investigation workshop, which the deputy chief was asked to distribute to the secondary schools in the Motheo District. The Motheo District consist of the Mangaung, Mantsopa, and Naledi local municipalities. These three municipalities consist of 11 settlements namely, Bloemfontein, Botshabelo, Thaba Nchu, Tweespruit, Ladybrand, Excelsior, Hobhouse, Thana Patchoa, Dewetsdorp, Wepener and Van Stadensrus.

As all the Life Science teachers in the Motheo District had an equal opportunity to participate in the workshop, volunteer sampling was applied, however, 20 Life Science teachers from 25 different schools volunteered to participate in the study. Both public and private school teachers were invited to participate in the study. The 20 Life Science teachers who indicated their willingness to participate in the workshop were accepted as participants and the sample size was set at 20 participants for this study.

3.8. Data collection

According to Asenahabi (2019:79), an attitude survey is a type of research instrument that offers a numeric explanation for attitudes, trends or beliefs by studying the sample population. Surveys are also data collection tools utilised to gather participants' responses to open- and closed-ended questions or items, and these responses are easily translated into statistics for further analysis (Asenahabi, 2019:79; Kabir, 2016:206).

This study employed pre- and post-surveys to gather data concerning the teachers' attitudes towards scientific investigations (see Annexure A). It was important for the researcher to understand that the type of questions in attitude surveys should be non-intrusive so that the participants do not feel judged for their answers (Canals, 2017:398).

After designing the surveys, the researcher approached a senior lecturer who is the coordinator for the University of the Free State's statistical and consultation unit to review the pre- and post-surveys used for this study. It was suggested that the researcher incorporate language familiar to the target group instead of language used in a scientific setting. It was also advised that each participant be assigned a number that can be used to link their pre-survey with their post-survey for comparison so that any differences could be detected.

A pilot study was employed, and the researcher asked five Life Science teachers to participate to ensure that the survey items were relevant to Life Science teachers and did not contain ambiguous questions (Babbie, 2020:257). According to Fraser, Fahlman, Arscott and Guillot (2018:263), a researcher runs a pilot study to assess the clarity of the items used in the official research study to ensure that the instrument is reliable and valid within the educational setting before undertaking the main study.

A Likert-type, five-point scale was used for the 20 pre-surveys and the same for the 20 post-surveys that were completed and collected for analysis. The participants were encouraged to be honest when completing the surveys, as their names and schools' name would remain anonymous.

The first part of the survey was divided into three sections and included a Likert-type scale used to collect data about the teachers' attitudes towards their knowledge and skills in scientific investigations. The teachers were required to indicate to what extent they agreed or disagreed with the survey items by choosing from the available options, namely Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree (McLeod, 2019:3).

Section A of the survey contained items concerning the affective component of the ABC attitude model mentioned in Chapter Two, Figure 2.1. The affective component covered items that focused on emotions and feelings concerning a particular subject (Mzomwe, 2019:210; Vishal, 2014:1-5). Section B focused on items concerning the cognitive component (see Figure 2.1), which included the teachers' thoughts (Mzomwe, 2019:210; Vishal, 2014:1-5). Section C, the last section, contained items related to the behavioural component. The behavioural component (see Figure 2.1) is the tendency that comprises noticeable responses and actions (Vishal, 2014:1). This component included a teacher's decision to take action (Ukachukwu, 2016:24-29). These three sections elicited data to analyse to achieve the research's objectives and answer the research questions.

The second part of the survey elicited biographical data about the participants. According to Teelaw, Price and Osatuke (2012:281), placing the biographical questions at the end of a survey is advantageous as it might help the researcher to build rapport with the participants before encountering the "boring" questions. The biographical data included in the research focused on the highest level of education that the teacher had achieved, as that was used to link to the responses to the survey items. The survey also required the participants to indicate their years of teaching Life Science. The researcher used this biographical data to ascertain if these aspects correlated with the participant's responses in the first part.

3.9. The rationale behind the choice of Likert scale surveys

Likert scales are among the most frequently used measuring instruments in the sociology, psychology and education research fields (Taherdoost, 2019:3). Taherdoost (2019:4) continues to state that a Likert scale includes a set of items regarding the research objectives where participants must indicate their level of agreement or disagreement with these given items.

The advantage of using a Likert scale is that the participants are not expected to provide a simple yes or no answer; the scale allows for a variation of opinions (McLeod, 2019:4). The Likert scale is also likely to produce a highly dependable scale that is simple to create (Taherdoost, 2019:4).

Using a survey as a data collection instrument has several advantages: surveys are standardised; can be set up and then distributed to several people as a pilot study to review the survey and identify bias or ambiguous statements and items. In this research, the pilot study helped the researcher to improve the survey in advance of the main study. Open-ended questions can produce vast amounts of data that can take time to analyse; therefore, using closed-ended questions in a Likert scale survey ensures more rapid data analysis (Taherdoost, 2019:4).

Likert scales also have disadvantages: it might be challenging to demonstrate validity using this scale, as there might be a lack of reproducibility (Taherdoost, 2019:4). Participants might also avoid using extreme responses, which might cause a central tendency bias. Another weakness is that some participants might want to portray themselves in a favourable light and, therefore, not be honest when completing the survey (Taherdoost, 2019:4).

3.10. Attitude surveys corresponding to the research objectives

3.11. Pre-survey

For the research to successfully address this study's objectives and answer the research questions, the pre- and post-survey items were designed to align with the research objectives and questions. The tables below indicates how each survey section aligned with the research objectives and questions.

<table>
<tr><th colspan="3">Section A of the survey: Affective Component</th></tr>
<tr><th></th><th>Items</th><td rowspan="19">Objective 1:
To measure and explain the effect of scientific investigation workshops on the affective component of the Life Science teachers' attitudes.

Research question 1:
What effect will the scientific investigation workshop have on the affective component of the attitudes of Life Science teachers</td></tr>
<tr><td>1</td><td>I am motivated to teach scientific investigations.</td></tr>
<tr><td>2</td><td>Scientific information is gained through experimentation.</td></tr>
<tr><td>3</td><td>Practical work is important in teaching science.</td></tr>
<tr><td>4</td><td>I enjoy carrying out scientific investigations.</td></tr>
<tr><td>5</td><td>Tactile modes are the best to understand science content.</td></tr>
<tr><td>6</td><td>Professional development workshops developed my scientific investigation knowledge.</td></tr>
<tr><td>7</td><td>I have enough science resources for scientific investigations.</td></tr>
<tr><td>8</td><td>I have the science skills to facilitate a scientific investigation.</td></tr>
<tr><td>9</td><td>Reflection is a valuable part of scientific investigations.</td></tr>
<tr><td>10</td><td>My colleagues support me in scientific investigation lesson planning.</td></tr>
<tr><td>11</td><td>Inquiry is a successful method of gaining scientific investigation skills.</td></tr>
<tr><td>12</td><td>Professional development workshops develop my scientific investigation skills.</td></tr>
<tr><td>13</td><td>My pre-service course prepared me to do scientific investigations at a high school level.</td></tr>
<tr><td>14</td><td>Life Science is best taught through a lecture-style teaching method.</td></tr>
<tr><td>15</td><td>Oral questioning is enough when developing learners' inquiry.</td></tr>
<tr><td>16</td><td>Our laboratory is used as a storeroom for science materials.</td></tr>
<tr><td>17</td><td>Group work amongst learners is important when doing scientific investigations.</td></tr>
<tr><td>18</td><td>I have enough content knowledge to conduct scientific investigations.</td></tr>
</table>

<table>
<tr><th colspan="3">Section B of the survey: Cognitive Component</th></tr>
<tr><th></th><th>Items</th><td rowspan="18"><u>Objective 2:</u>
To measure and explain the effect of scientific investigation workshops on the cognitive component of the Life Science teachers' attitudes.

<u>Research question 2:</u>
What effect will the scientific investigation workshop have on the cognitive component of the attitudes of Life Science teachers?</td></tr>
<tr><td>1</td><td>I learn scientific investigation skills when working with Life Science teachers.</td></tr>
<tr><td>2</td><td>I know how to conduct all scientific investigations required in the CAPS.</td></tr>
<tr><td>3</td><td>I know how to use all the scientific equipment at my school.</td></tr>
<tr><td>4</td><td>The lecture-style teaching method is suited to teach scientific investigations.</td></tr>
<tr><td>5</td><td>I learn scientific investigation knowledge when working with Life Science teachers.</td></tr>
<tr><td>6</td><td>I know all the steps of the scientific method.</td></tr>
<tr><td>7</td><td>I know how to interpret data after a scientific investigation.</td></tr>
<tr><td>8</td><td>I know the function of each chemical used in scientific investigations prescribed in the CAPS.</td></tr>
<tr><td>9</td><td>Scientific investigations are a learner-centered process.</td></tr>
<tr><td>10</td><td>Science educators need to have both science skills and content knowledge.</td></tr>
<tr><td>11</td><td>I know how to formulate a hypothesis for a scientific investigation.</td></tr>
<tr><td>12</td><td>I analyze data after a scientific investigation.</td></tr>
<tr><td>13</td><td>I can provide explanations to support my scientific conclusions.</td></tr>
<tr><td>14</td><td>Science is a set of procedures to be memorized.</td></tr>
<tr><td>15</td><td>Scientific investigations, practical work and inquiry are synonyms.</td></tr>
<tr><td>16</td><td>Every hands-on practical is a scientific investigation.</td></tr>
<tr><td>17</td><td>Learners use the cognitive process to solve scientific investigation problems.</td></tr>
</table>

<table>
<tr><th colspan="3">Section C of the survey: Behavioural Component</th></tr>
<tr><th></th><th>Items</th><td rowspan="21"><u>Objective 3:</u>
To understand the effect of scientific investigation workshops on the behavioural components of Life Science teachers' attitudes.

<u>Research question 3:</u>
What effect will the scientific investigation workshop have on the behavioural component of the attitudes of Life Science teachers</td></tr>
<tr><td>1</td><td>I demonstrate scientific investigations to my learners.</td></tr>
<tr><td>2</td><td>My learners conduct scientific investigations themselves.</td></tr>
<tr><td>3</td><td>I have used scientific apparatus to do experiments.</td></tr>
<tr><td>4</td><td>My learners participate in scientific investigation lessons.</td></tr>
<tr><td>5</td><td>I have subject meetings with my colleagues to plan scientific investigations.</td></tr>
<tr><td>6</td><td>I attend Life Science in-service training workshops.</td></tr>
<tr><td>7</td><td>I only use textbooks to teach scientific investigations.</td></tr>
<tr><td>8</td><td>I include practical's preparation time into my time schedule.</td></tr>
<tr><td>9</td><td>I only use the Teacher Edition Textbook when planning scientific investigations.</td></tr>
<tr><td>10</td><td>I design worksheets for my learners to complete during scientific investigations.</td></tr>
<tr><td>11</td><td>The lack of scientific investigation equipment discourages me from improvising.</td></tr>
<tr><td>12</td><td>My learners conduct scientific investigations in groups.</td></tr>
<tr><td>13</td><td>My learners are actively involved when I present scientific investigations.</td></tr>
<tr><td>14</td><td>I often walk around to monitor my learners as they do scientific investigations.</td></tr>
<tr><td>15</td><td>I use digital devices to teach scientific investigations.</td></tr>
<tr><td>16</td><td>My learners are passively listening when I teach scientific investigations.</td></tr>
<tr><td>17</td><td>I do scientific investigations in a normal classroom.</td></tr>
<tr><td>18</td><td>I do reflections with my learners at the end of scientific investigations.</td></tr>
<tr><td>19</td><td>The lack of recourse does not stop me from conducting scientific investigations.</td></tr>
<tr><td>20</td><td>I conduct scientific investigations in a laboratory.</td></tr>
</table>

3.12. A scientific investigation workshop as a method for data collection

This in-service training workshop is designed and implemented by the researcher's supervisor which then registered the workshop at SACE, and teachers participating in this workshop receive CPD points (See SACE Annexure B). The workshop focused on Life Science scientific investigation required by CAPS to be completed with learners in secondary school. The workshop was approximately 6 hours in duration: from 08:00 am to 14:00 pm and was guided by the researcher's supervisor.

This workshop is structured around the inquiry-based teaching method as the teachers are guided to investigate scientific problems, explore possible solutions, observe, ask questions, test their ideas, and use their intuition to think creatively (Bulba, 2021; Constantinou et al., 2018:2). Inquiry-based science teaching focuses on performing science, and, therefore, Life Science teachers must understand the significance of facilitating inquiry-based lessons (Kibirige, Teffo & Singh, 2022:1; Constantinou et al., 2018:9; Bulba, 2021).

Exploratory conversations are crucial in the inquiry-based approach to improve scientific reasoning and formulation, therefore the teachers had the opportunity to have discussions and collaborations throughout the workshop. Collaboration and communication can be addressed in the science classroom by assigning different responsibilities and roles to the learners during group activities and collectively sharing their findings and ideas (Alozie & Mitchell, 2019:501). Therefore, in the workshop, the teachers were asked to arrange themselves into four groups of five teachers each to work together and discuss their findings in these groups throughout the workshop. The group structured can be seen as an informal structure since teachers had the choice of who they would like to group with.

Teachers had the opportunity to avail themselves for different roles, in their groups, during the workshop. For instance, one teacher took the responsibility of conducting an investigation, with the support of the other group members, while another teacher took the role of writing up the findings and another teacher had the responsibility of presenting their findings to the other groups. With the next investigation, the teachers can then take different roles and responsibility for them to experience all the aspects of investigations. Socialising in the science classroom can support teachers to communicate openly, as they need to clearly explain their actions and decisions regarding their investigation to their class (van Uum et al., 2016:452).

The teachers received a workbook (see Annexure C) containing the Life Science scientific investigation experiments that had to be conducted during the workshop.The workbook is designed by following the short learning structure and was credited by SACE in order for the workshop to be worth the 10 CPD points. This workbook guided the teachers through each experiment, explaining each experiment's method, apparatus and steps. Each experiment had follow-up questions that guided the teachers to investigate the experiments, explain what they had observed and reflect on what they had found. These activities included experiments, microscope work and dissections (see Table 3.1).

Table 3.1: The activities included in the workbook		
Testing	Demonstration	Dissection
• Test for the presence of glucose. • Test for the presence of starch in a leaf. • Test for the presence of protein. • Test for the presence of lipids (fats, including oils).	• Demonstrate the phenomenon of osmosis in animal cells. • Investigate the effect of different solution concentrations on the length, mass, osmotic potential and turgor of potato tissue. • Prepare a wet mount of an animal cell. • Investigate the phenomenon of plasmolysis by ex-osmosis. • Investigate the rate of transpiration of a plant under different environmental conditions with a photometer.	• Dissect an eye • Investigate a mammal's kidney through dissection • Investigate a sheep's heart through dissection

The participating teachers also received a basic set of scientific equipment, and chemicals were provided to each teacher to take home with basic scientific investigation equipment they could use in their classrooms (see Table 3.2).

Table 3.2: These basic sets contained the following:	
Apparatus included:	Chemicals included:
• 2 x microscope slides • 5 x microscope coverslips	• 1x 10ml Benedict's reagent • 1x 2ml Millon's reagent • 1x 20ml ether

• 4 x test tubes • 2 x laundry pins to hold the test tubes • 1 x ice cream sticks • 5 x filter paper • 4 x toothpicks • 1 x DVD containing videos and photos of the experiments • 1 x syringe	• 1x 10ml iodine solution. • 1x 20ml alcohol

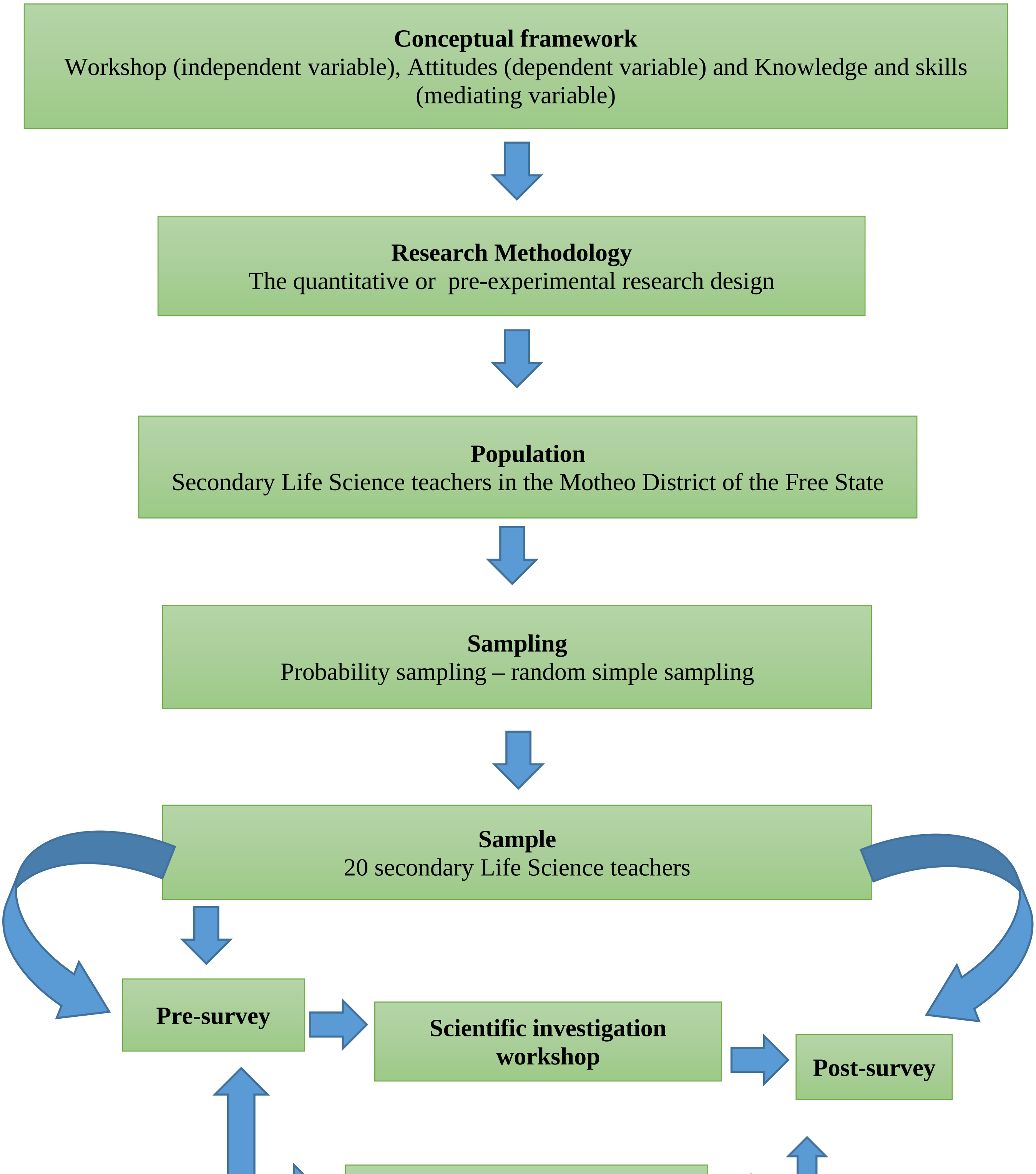

Figure 3.2. Study overview of the research design, methodology, and data collection.

3.13. Ethical Considerations

Before the study commenced, the researcher applied for ethical clearance and approval from the Free State Department of Education and the University of the Free State Ethical Committee to conduct the study (see Annexure F). The researcher informed the Free State Department of Education and the University about the research's aims and objectives and the procedures to be employed in the study. Previous literature, research methods, and the study's value were explained in detail for ethical clearance approval.

The participants were assured that confidentiality would be maintained during the study and they were informed that they were not required to provide any personal information and that their participation in this research was entirely voluntary and they could withdraw from the research at any point.

As the surveys and information provided by the participants were paper-based, they are being stored securely in the researcher's office, and only the researcher and research supervisor can access the data. The surveys are also recorded on the researcher's laptop, which is password protected. The surveys will be stored for five years after publication of this study in case the researcher would like to re-analyse the data and publish again. During the workshop, the researcher reassured the participants that their information was anonymous and would only be used for this research.

Given the above-mentioned ethical considerations, the researcher informed every participant about how the study would be conducted and what they could expect. The researcher also provided each participant with an informed consent form explaining how their information would be used. The information in the consent form stated that the study aimed to provide insights into scientific investigation workshops' usage to change Life Science teachers' attitudes toward scientific investigations. This workshop is viewed as a professional development programme that provides a platform for Life Science teachers to develop, upgrade and improve their skills, knowledge and attitudes regarding scientific investigations. The workshop also allowed the teachers to acquire new techniques and use basic science equipment. The researcher only used the data collected from the pre- and post-surveys to compare the information provided by the teachers.

Before the workshop commenced, a consent form was circulated among the teachers where they indicated that they had read the information and were welcome to ask any questions about the scientific investigation workshop and how the data would be used.

The participants had to provide their consent to answer the pre-survey, and after participating in the Life Science scientific investigation workshop, which included group work and participation in experiments and dissections, complete the post-survey. The participants needed to consent that the information they provided could be shared with the researcher's supervisor and the Free State Department of Education and that the anonymous surveys could be published as part of the researcher's thesis, which may be published online.

As the scientific investigation workshop was presented during the Covid-19 pandemic, strict safety measures were implemented. The workshop was in a spacious science classroom/laboratory environment where social distancing could be applied. Covid-19 protocols were in place and the participants had to adhere to these regulations. The wearing of masks was compulsory and regular sanitation was encouraged throughout the workshop. Proof of vaccination was required to be shown upon arrival to ensure a safe learning environment.

Chapter 4

Results

Teachers' attitudes toward scientific investigations

4.1. Introduction

Chapter Three presented a discussion of the research methodology and design that were implemented in this study. The researcher also elaborated on the data collection method, namely the pre- and post- attitude surveys. These surveys were completed by Life Science teachers who participated in this research's scientific investigation workshop. This specific scientific investigation workshop's structure, aim and objectives were also explained.

In this chapter, the quantitative data gathered from the Life Science teachers is analysed, interpreted and compared to previous data obtained from other studies that were reviewed. In this chapter, the researcher attempts to discover if there is a statistically significant correlation between the Life Science teachers' attitudes and the intervention of the scientific investigation workshop.

4.2. Analysis and interpretation of the pre- and post-attitudes surveys

The results of the surveys are presented in this segment. The gender distribution of the participants in this study was 9 females and 11 males. Concerning the highest level of qualification, ten had a B.Ed. Degree with Life Science as their main subject, three had a B.Ed. Honours Degree and seven of the 20 participants had Bachelor's Degrees in another field with a Post Graduate Diploma in Education (PGDE). The participants were also asked to indicate the number of years that they had been teaching.

Of the 20 participants, 12 indicated that they had 1-5 years of teaching experience; three had 6-10 years of experience; zero participants had 11-15 years of experience; one participant had 15-20 years of experience; one had 21-25 years of experience; one had 26-30 years of experience and two indicated that they had more than 30 years of teaching experience. This study did not contain any form of bias, as Simundic (2013:13) indicated that a study should include all age groups, both male and female participants and participants with various years of experience in different schools.

The respondents were asked to complete a Likert-type attitude survey (see Appendix A) to supply data regarding their attitudes toward scientific investigations, where 1 was Strongly Disagree, 2 was Disagree, 3 was Neither Agree nor Disagree, 4 was Agree and 5 was Strongly Agree. A scale of -4 to 4 was used to assess if there was a change in an individual's responses. This assessment was possible when the responses from the pre-survey were compared to the responses from the post-survey, where the responses could range from -4 (Strongly Disagree) to 4 (Strongly Agree). A 0 on the scale indicated no change in a participant's opinions after attending the workshop.

The responses were categorised into three sections: Section A represented all the statements regarding the affective component of the participants' attitudes, and what the teachers felt about specific items; Section B represented the cognitive component that symbolised how teachers think about specific items; and Section C, the behavioural component, which represented the teacher's actions. These three sections relate to the ABC attitude model mentioned and discussed in **Chapter Two**, **Figure 2.1**.

The researcher chose to analyse these three components separately to facilitate an understanding of each component of teachers' attitudes toward scientific investigations (see Figure 2.1 in Chapter Two) and how the components influence one another. The results are discussed according to these three sections, and the researcher differentiated between the three sections by designating a different colour for each section.

Descriptive statistics encompassing the count, mean, standard deviation and minimum and maximum for demographical measures related to age, years of experience and qualifications were implemented in this study (Loeb, Morris, Dynarski, McFarland, Reardon & Reber, 2017:22). For each Likert scale statement, a t-test was performed to test the null hypothesis, where the mean differences between the paired data were considered significant when the results were less than or equal to the alpha set or p-value of 0.05. The Holm-Bonferroni method was applied.

By cross-referencing the responses to the demographic items, the assumption was made that the expected number of responses in every category (agree, disagree, etc.) was not affected by the demographic factor (Loeb et al., 2017:19).

The researcher also analysed the data by calculating the probability of seeing differences in the categories as large as, or more significant, than observed under the assumption. If this probability is small, the conclusion is that there is evidence of grouping and dependence.

However, no significant statistical difference was found, so it was assumed that no further discussion was needed.

4.3. Discussion of the affective component (Section A)

The affective component survey was used to gather data relating to the participants' feelings and emotions toward scientific investigations.

According to Ukachukwu (2016:24), a teacher's enjoyment of teaching scientific investigations stems from various factors that include their skills, knowledge, and beliefs about their competency in conducting a scientific investigation.

As indicated in **Chapter Three,** this section aligns with achieving the research objective to measure and explain the effect of scientific investigation workshops on the affective component of Life Science teachers' attitudes. This objective was constructed from the main research question concerning the effect the scientific investigation workshop would have on Life Science teachers' attitudes toward scientific investigations.

As mentioned in **Chapter Three**, the pre-experimental design implemented in this research guided the researcher to establish a connection between the intervention (scientific investigation workshops) and the outcome (the possible change in the affective component of the attitude theory toward scientific investigations), as indicated in **Table 4.1**.

4.4. List of Tables

Table 4.1. The results from Section A

1. I am motivated to teach scientific investigations.			
	Pre-Survey	Post-Survey	Difference
Average	4.05	4.7	0.65
StdDev.	0.999	0.571	0.933
t-test (p-value)			0.183
2. Scientific information is gained through experimentation.			
	Pre-Survey	Post-Survey	Difference
Average	4.55	4.75	0.2
StdDev.	0.686	0.444	0.696
t-test (p-value)			1
3. Practical work is important in teaching science			
	Pre-Survey	Post-Survey	Difference
Average	4.7	4.85	0.15
StdDev.	0.923	0.366	1.04
t-test (p-value)			1
4. I enjoy carrying out scientific investigations.			
	Pre-survey	Post-Survey	Difference
Average	4	4.8	0.8

StdDev.	0.795	0.523	0.834
t-test (p-value)			**0.019**
5. Tactile modes are the best to understand science content.			
	Pre-Survey	Post-Survey	Difference
Average	4.05	4.4	0.35
StdDev.	0.759	0.681	0.813
t-test (p-value)			1
6. Professional development workshops developed my scientific investigation knowledge.			
	Pre-Survey	Post-Survey	Difference
Average	4.25	4.8	0.55
StdDev.	1.333	0.41	1.356
t-test (p-value)			1
7. I have enough science resources for scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	2.45	3.6	1.15
StdDev.	1.234	1.046	1.565
t-test (p-value)			0.136
8. I have the science skills to facilitate a scientific investigation.			
	Pre-survey	Post-survey	Difference
Average	3.9	4.5	0.6
StdDev.	0.553	0.607	0.681
t-test (p-value)			**0.036**
9. Reflection is a valuable part of scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	4.2	4.4	0.2
StdDev.	0.894	0.681	1.005
t-test (p-value)			1
10. My colleagues support me in scientific investigation lesson planning.			
	Pre-survey	Post-survey	Difference
Average	2.9	4.445	1.55
StdDev.	1.252	0.945	1.317
t-test (p-value)			**0.002**
11. Inquiry is a successful method of gaining scientific investigation skills.			
	Pre-survey	Post-survey	Difference
Average	4.55	4.5	-0.05
StdDev.	0.605	0.513	0.605
t-test (p-value)			1
12. Professional development workshops develop my scientific investigation skills.			
	Pre-survey	Post-survey	Difference
Average	4.25	4.7	0.45
StdDev.	1.02	0.571	1.146
t-test (p-value)			1
13. My pre-service course prepared me to perform scientific investigations at a high school level.			
	Pre-survey	Post-survey	Difference
Average	4.2	4.2	0
StdDev.	1.056	0.696	0.918
t-test (p-value)			1

14. *Life Science is best taught through a lecture-style teaching method.*			
	Pre-survey	Post-survey	Difference
Average	2.65	2.8	0.15
StdDev.	1.182	1.105	1.089
t-test (p-value)			1
15. *Oral questioning is enough when developing learners' inquiry.*			
	Pre-survey	Post-survey	Difference
Average	2.75	2.7	-0.05
StdDev.	1.209	1.455	1.504
t-test (p-value)			1
16. *Our laboratory is used as a storeroom for science materials.*			
	Pre-survey	Post-survey	Difference
Average	3.25	3.45	0.2
StdDev.	1.41	1.05	1.281
t-test (p-value)			1
17. *Group work amongst learners is important when performing scientific investigations.*			
	Pre-survey	Post-survey	Difference
Average	4.15	4.6	0.45
StdDev.	1.182	0.821	1.468
t-test (p-value)			1
18. *I have enough content knowledge to conduct scientific investigations.*			
	Pre-survey	Post-survey	Difference
Average	3.632	4.6	0.947
StdDev.	1.012	0.503	0.97
t-test (p-value)			**0.021**

Not all of these item results in Section A were significant, so no further discussion was required. For instance, if one analyses Item 3: *Practical work is important in teaching science:* there was no statistically significant improvement in the post-survey response compared to the pre-survey. The average increased by 0.15 from 4.7 to 4.85 (p-value 1). The researcher concluded that teachers knew the importance of practical work in teaching science before attending this workshop.

A similar conclusion was made in the other items with p-values < 0.05. The researcher concluded that this scientific investigation workshop did not have a statistically significant effect on the participants' feelings regarding motivation to teach scientific investigations. The results also indicated no statistically significant improvement in teachers feeling that scientific information is gained through experimentation. These results similarly indicated no statistically significant change in teachers' feelings that practical work is important in teaching science and that tactile modes are the best way to understand science content.

The results likewise showed no statistically significant improvement in the teachers' perceptions that professional development workshops developed their scientific investigation knowledge, and the participants felt they had sufficient science resources for scientific investigations before the workshop.

There was also no statistically significant improvement in the following items: reflection is a valuable part of scientific investigations; the inquiry method is a successful method of gaining scientific investigation skills; professional development workshops develop scientific investigation skills; the pre-service course prepared them to perform scientific investigations at a high school level.

The results also showed no statistically significant change in the teachers' perceptions that Life Science is best taught through a lecture-style teaching method; oral questioning is enough when developing learners' inquiry skills; their laboratory is used as a storeroom for science materials and group work amongst learners is important when performing scientific investigations.

However, in contrast to these items, in Item 4 (see Table 4.2): *I enjoy carrying out scientific investigations*, one can see a statistically significant difference when comparing the average of the pre-survey result, which was 4, to the average of the post-survey result, which had increased by 0.8 to an average of 4.8 (p-value 0.019, which is < 0.05), which means that the participants enjoyed carrying out scientific investigations more after they had attended this workshop than they did before the workshop.

As the results for Items 4, 8, 10 and 18 all showed p-values < 0.05, one can assume with 95% certainty that there were statistically significant differences in the before and after workshop responses to these items.

Table 4.2: t-test for a change in the responses to the Likert scale item "I enjoy carrying out scientific investigations"

	Pre-Survey	Post-Survey	Difference
Average	4.00	4.8	0.8
StdDev.	0.795	0.523	0.834
t-test (p-value)			0.019

Since in-service training programmes are personal and professional opportunities for teachers to improve their teaching, facilitation, knowledge and skills, their enjoyment might also improve. The Life Science teachers who attended this workshop had an opportunity to develop new skills and knowledge regarding specific investigation activities that might have improved their motivation and perceptions regarding scientific investigations (Zulkifli, 2014:1).

The per-person changes in the responses were analysed (scale of -4 to 4). The results presented in **Table 4.2** indicated a statistically significant increase in the participants' enjoyment of carrying out scientific investigations after the workshop, as the average increased from 4.0 to 4.8. The t-test indicated that the observed difference between the two groupings was significant ($p = 0.019$, p-value < 0, 05); therefore, the null hypothesis that there would be no statistically significant difference between the pre- and post-surveys was rejected, and a conclusion was made that the workshop did cause a statistically significant improvement in enjoyment. The findings imply that these teachers would enjoy conducting scientific investigations more after attending the workshop. This show that

Enjoyment is defined as the state of taking pleasure in something and can also evoke positive feelings among teachers (Hernik & Jaworska, 2018:10-11). According to Karim, Ayub, Khurshid and Akram (2017:275), enjoyment is cultivated when teachers interact with the educational environment. When teachers encounter environments where they feel supported by others and where they can practice their knowledge and skills, they might start experiencing enjoyment concerning scientific investigations. The data indicated a statistically significant increase in the mean responses before and after the workshop (see Table 4.2).

As this scientific investigation workshop focused on social engagement with other teachers and provided an opportunity for teachers to improve their existing skills and learn new skills, their enjoyment in conducting scientific investigations was seemingly enhanced.

When teachers enjoy the scientific investigation process, which includes experiments and dissections, they will be more likely to appreciate the nature of science. Therefore, teachers might become more invested in teaching Life Science and sharing their knowledge and skills regarding the practical side of Life Science with their learners, as indicated later in this chapter.

Table 4.3: t-test for a change in the responses to the Likert scale item "I have the science skills to facilitate a scientific investigation"

	Pre-Survey	Post-Survey	Difference
average	3.9	4.5	0.6
StdDev	0.554	0.607	0.681
t-test (p-value)			0.036

The results presented in **Table 4.3** indicate that after the workshop, there was a statistically significant increase in the respondents' perceptions concerning their skills to facilitate a scientific investigation, as the average increased by 0.6 from 3.9 to 4.5. The t-test indicated that the observed difference between the two groupings was statistically significant (p = 0.036, p-value < 0, 05); therefore, rejecting the null hypothesis and concluding that the workshop caused a statistically significant improvement in the participants' perceptions of their science skills.

The findings signify that attending this scientific investigation workshop developed the Life Science teachers' confidence in having the necessary science skills to facilitate scientific investigations. Therefore, the conclusion can be made that learning and improving scientific investigation skills through workshops might contribute to Life Science teachers having a positive attitude toward scientific investigations.

Kassema (2019:8) explains that skills refer to the physical performance of a task, which includes the application of knowledge. According to Ndjangala, Abah and Mashebe (2021:54) and Heeralal (2014:796), some schools might have good scientific investigation equipment and resources to conduct scientific investigations with their learners but not have teachers with the necessary confidence in their skills to use such apparatus and equipment. Mogofe and Kibirige (2017:426), as seen in Chapter Two, support this statement by affirming that some teachers have demanded more science equipment despite evidence of unused equipment in their store rooms. The data presented in **Table 4.3** supports Kibirige, Teffo and Singh's (2022:2) findings that a lack of equipment and resources might not be the only factor preventing teachers from conducting investigations; a lack of confidence in their skills to use that scientific equipment might be an obstructing factor. Subsequently, as indicated by the findings presented in **Table 4.3**, attending Life Science investigation workshops might improve the perception among teachers that they have developed and improved their science skills.

Table 4.4: t-test for a change in the responses to the Likert scale item "I have enough content knowledge to conduct scientific investigations"

	Pre-Survey	Post-Survey	Difference
Average	3.632	4.6	0.947
StdDev	1.012	0.503	0.947
t-test (p-value)			0.021

The results presented in **Table 4.4** indicate an increase in the affective component of the participants' attitudes toward having sufficient content knowledge to conduct scientific investigations after the workshop. The average increased by 0.94 from 3.62 to 4.6. The t-test indicated that the observed difference between the two groupings was statistically significant (p = 0.021, p-value < 0, 05); therefore, the null hypothesis was rejected, concluding that the workshop caused a significant improvement in the participants' perceptions of their content knowledge. The findings imply that educational experiences, such as this Life Science scientific investigation workshop experience, might positively influence teachers' perceptions regarding their content knowledge. It was observed that the teachers did indeed share their content knowledge with other teachers.

Kibirige, Teffo and Singh (2022:2) and Mwangu and Sibanda (2017:48) state that some South African Life Science teachers do not have the necessary knowledge to conduct scientific investigations successfully, which might explain why they are unenthusiastic about the practical part of Life Science. The findings seem to support Zulkifli's (2014:1) statement that in-service training programmes can improve teachers' knowledge of scientific investigations and that attending in-service workshops might play a part in overcoming the challenges encountered in the classroom.

Table 4.5: t-test for a change in the responses to the Likert scale item "My colleagues support me in scientific investigation lesson planning"

	Pre-Survey	Post-Survey	Difference
Average	2.9	4.45	1.55
StdDev	1.252	0.945	1.317
t-test (p-value)			0.002

The results presented in **Table 4.5** indicate an increase in the perception of support from colleagues during this scientific investigation workshop as the average increased by 1.55 from 2.9 to 4.45. The t-test indicated that the difference between the two groupings was statistically significant (p = 0.002); therefore, the null hypothesis was rejected, and a conclusion was made that the workshop did cause a significant improvement in the teachers' perceptions about being supported by colleagues. It can, therefore, be assumed with 98.2% certainty that there was a statistically significant difference in their perceptions about being supported by their colleagues after this workshop, as the p-value of this item was <0.05.

These findings seemingly support Nursianawati and Winarno's (2019:840) statement that collaboration among Life Science teachers can enable them to discover new strengths and weaknesses and work together to encourage, support and learn from one another. The findings also seem to align with Harman, Cokelez, Dal and Alper (2016:12), who argue that cooperative learning activities might encourage teachers to learn from one another.

It seems fair to conclude that scientific investigation workshops can enhance the affective components of teachers' attitudes, where numerous changes in their emotional states were found in the post-survey compared to the pre-survey. However, to determine if the teachers' overall attitudes improved after attending the workshop, it was necessary to also analyse the cognitive and behavioural components of their attitudes.

4.4. Discussion of the cognitive component (Section B)

According to Mzomwe (2019:210) and Vishal (2014:1-5), the cognitive component comprises an individual's thoughts and opinions (perceptions). Teachers' beliefs and thoughts regarding scientific investigations are crucial when determining their attitudes.

As indicated in **Chapter Three**, this section aligns with achieving the sub-research objective to measure and explain the effect of scientific investigation workshops on the cognitive component of the Life Science teachers' attitudes. This sub-objective was constructed from the supporting research sub-question concerning what effect the scientific investigation workshop would have on the cognitive component of the Life Science teachers' attitudes.

As mentioned in the previous chapter, the pre-experimental design implemented in this study guided the establishment of a connection between the intervention (scientific investigation workshop) and the outcome (the possible change in the cognitive component of the teachers' attitudes toward scientific investigations). **Table 4.6** presents the data obtained about the impact of this workshop on the cognitive component of the participants' attitudes.

Table 4.6. The results for the items in Section B

1. I learn scientific investigation skills when working with Life Science teachers.			
	Pre-Survey	Post-Survey	Difference
Average	4.05	4.65	0.6
StdDev.	0.826	0.489	0.681
t-test (p-value)			**0.036**
2. I know how to conduct all scientific investigations required in CAPS.			
	Pre-Survey	Post-Survey	Difference
Average	3.4	4.3	0.9
StdDev.	0.821	0.657	0.912
t-test (p-value)			**0.015**
3. I know how to use all the scientific equipment at my school.			
	Pre-Survey	Post-Survey	Difference
Average	3.3	4	0.7
StdDev.	0.801	0.725	0.979
t-test (p-value)			0.161
4. The lecture-style teaching method is suited to teaching scientific investigations.			
	Pre-survey	Post-Survey	Difference
Average	2.6	3.05	0.45
StdDev.	1.273	1.191	1.395
t-test (p-value)			1
5. I learn scientific investigation knowledge when working with Life Science teachers.			
	Pre-Survey	Post-Survey	Difference
Average	4.15	4.6	0.45
StdDev.	0.587	0.503	0.605
t-test (p-value)			0.127

6. I know all the steps of the scientific method.			
	Pre-Survey	Post-Survey	Difference
Average	3.55	4.05	0.5
StdDev.	0.945	0.686	1.192
t-test (p-value)			1
7. I know how to interpret data after a scientific investigation.			
	Pre-survey	Post-survey	Difference
Average	4.05	4.45	0.4
StdDev.	0.605	0.51	0.598
t-test (p-value)			0.233
8. I know the function of each chemical used in scientific investigations prescribed in CAPS.			
	Pre-survey	Post-survey	Difference
Average	3.4	4.25	0.85
StdDev.	0.94	0.716	0.813
t-test (p-value)			**0.009**
9. Scientific investigation is a learner-centred process.			
	Pre-survey	Post-survey	Difference
Average	3.8	4	0.2
StdDev.	1.105	1.214	0.951
t-test (p-value)			1
10. Science educators need to have both science skills and content knowledge.			
	Pre-survey	Post-survey	Difference
Average	4.684	4.85	0.158
StdDev.	0.671	4.689	0.834
t-test (p-value)			1
11. I know how to formulate a hypothesis for a scientific investigation.			
	Pre-survey	Post-survey	Difference
Average	4.15	4.6	0.45
StdDev.	0.587	0.598	0.51
t-test (p-value)			**0.036**
12. I analyse data after a scientific investigation.			
	Pre-survey	Post-survey	Difference
Average	4	4.3	0.3
StdDev.	0.649	0.571	0.657
t-test (p-value)			1
13. I can provide explanations to support my scientific conclusions.			
	Pre-survey	Post-survey	Difference
Average	4.05	4.45	0.4
StdDev.	0.605	0.605	0.681
t-test (p-value)			0.463
14. Science is a set of procedures to be memorised.			
	Pre-survey	Post-survey	Difference
Average	3.05	2.8	-0.25
StdDev.	1.05	1.361	1.41
t-test (p-value)			1
15. Scientific investigations, practical work and inquiry are synonymous.			
	Pre-survey	Post-survey	Difference

Average	3.05	3.3	0.25
StdDev.	0.999	0.979	0.91
t-test (p-value)			1
16. Every hands-on practical is a scientific investigation.			
	Pre-survey	Post-survey	Difference
Average	3.4	3.895	0.474
StdDev.	0.94	0.937	0.841
t-test (p-value)			0.662
17. Learners use the cognitive process to solve scientific investigation problems.			
	Pre-survey	Post-survey	Difference
Average	3.842	4.2	0.368
StdDev.	1.015	0.696	0.761
t-test (p-value)			1

Not all of these items' results in section B were significant, so no further discussion was required. For instance, if one analyses Item 6: *I know all the scientific method steps*, there was no statistically significant improvement in the post-survey responses compared to the pre-survey responses. The average increased by 0.5 from 3.55 to 4.05 (p-value 1 > 0.05). Therefore, the researcher concluded that the teachers knew all the scientific method steps before participating in this workshop.

The researcher made a similar conclusion for the other items with p-values < 0.05 and concluded that this scientific investigation workshop did not have a statistically significant effect on the participants' perceptions of their knowledge about how to use all the scientific equipment at their schools.

The results also indicated no statistically significant improvement in the teachers' thinking that the lecture-style teaching method is suited to teaching scientific investigations, and they learn scientific investigation knowledge when working with Life Science teachers. These results similarly indicated no statistically significant change in their perceptions regarding knowing all the steps of the scientific method and having the knowledge to interpret data after a scientific investigation. The results likewise showed no statistically significant improvement in the teachers' belief that scientific investigations are a learner-centred process and science educators need to have both science skills and content knowledge.

There was no statistically significant improvement in the following items: teachers analyse data after a scientific investigation; they can provide explanations to support their scientific conclusions; they believe that science is a set of procedures to be memorised and practical work and inquiry are synonymous.

The results showed no statistically significant change in the teachers' perceptions that every hands-on practical is a scientific investigation and learners use the cognitive process to solve scientific investigation problems.

However, in contrast, the responses to Item 8: *I know the function of each chemical used in scientific investigations prescribed in CAPS* indicated a statistically significant difference when comparing the pre-survey average, which was 3.4, to the post-survey average of 4.25; an increase of 0.85 (p-value 0.009, which is < 0.05). According to the data gathered for this item, the teachers gained more knowledge of the chemicals used in scientific investigations during this workshop.

As the p-values for Items 1, 2, 8 and 11 were < 0.05, one can assume with 95% certainty that there were statistically significant differences in the responses before and after the workshop.

Table 4.7: t-test for changes in the responses to the Likert scale item "I learn scientific investigation skills when working with life science teachers"

	Pre-Survey	Post-Survey	Difference
Average	4.05	4.65	0.6
StdDev	0.826	0.489	0.681
t-test (p-value)			0.036

The results presented in **Table 4.7** indicate an increase in the teachers' perceptions concerning learning scientific investigation skills when working with other Life Science teachers, as the average increased from 4.05 to 4.65. The t-test indicated that the observed difference between the two groups of responses was statistically significant (p = 0.036); therefore, the null hypothesis was rejected, and a conclusion was made that the workshop caused a significant improvement in the cognition of these teachers' developing skills when working with other Life Science teachers.

As seen in **Chapter Three,** this workshop implemented the inquiry-based approach to guide science teachers to investigate scientific problems, explore possible solutions, observe, ask questions, test their hypotheses and use their intuition to think creatively. During the workshop, the teachers were required to arrange themselves into groups to collaborate on the investigations and discuss their findings. According to Alozie and Mitchell (2019:501), collaboration and communication in the science classroom can be implemented by assigning different responsibilities and roles during group activities, and teachers indeed assigned different investigative roles to one another.

As mentioned in **Chapter Two**, socialising in the science classroom supports teachers in facilitating open communication, as they need to clearly explain their actions and decisions regarding the investigation, to their class (van Uum, Verhoeff & Peeters, 2016:452). Gatt and Buttigeig (2018:374) suggest that teachers become good inquirers before implementing the inquiry-based teaching method in their science classrooms. This can be achieved by socialising with their peers, as Constantinou, Rybska and Tsivitanidou (2018:2;6) argue that learning is a social activity and knowledge is constructed through interaction with others.

Implementing the inquiry approach to learning seems to be effective in enhancing the cognitive component, as indicated in the data presented in **Table 4.7**; this data also seems to correspond with Omeodu and Amadi's (2018:2) statement that workshops can serve as a bridge between teachers; a place where they can share and transfer their skills, allowing for these peer interaction opportunities within the education system to improve Life Science teachers' skills.

Table 4.8: t-test for a change in the responses to the Likert scale item "I know the function of each of the chemicals used in scientific investigations prescribed in CAPS"

	Pre-Survey	Post-Survey	Difference
Average	3.4	4.25	0.85
StdDev	0.94	0.716	0.813
t-test (p-value)			0.009

The results presented in **Table 4.8** indicate that after the workshop, there was an improvement in the teachers' cognitive thought processes; there was a statistically significant increase in their confidence to identify the chemicals used in scientific investigations, and they developed a familiarity with these chemicals' functions. The average increased by 0.85 from 3.4 to 4.25. The t-test indicated that the observed difference between the two groupings was highly significant ($p = 0.009$, p-value < 0.05), thus, rejecting the null hypothesis and concluding that the workshop led to a significant improvement in the teachers' perceptions of their knowledge about the chemicals used during scientific investigations seems reasonable.

This workshop seemingly allowed teachers to learn about the chemicals involved in scientific investigations. As mentioned in **Chapter Three**, the chemicals used during the workshops were Benedict's solution, Millon's reagent, ether, iodine solution and alcohol (ethanol). This data might have resulted from the teachers having the opportunity to develop their knowledge and skills regarding the functions of each chemical and where and when to use the chemicals in investigations. One should also consider that the teachers received a basic set of science apparatus and a small amount of each chemical they could keep, which might also have contributed to their positive thoughts regarding the chemicals used in the science classroom (see Chapter Two, Table 3.2).

The data presented in **Table 4.8** appears to support Boslisani and Bratianu's (2018:5) argument that knowledge and skills lay the foundation for performing tasks such as scientific investigations.
According to Kassema (2019:5), teachers first need to gather knowledge regarding the chemicals, such as their function and reason for use, during workshops, and thereafter, develop and practice the skills required to use the chemicals correctly.

Table 4.9: t-test for a change in the responses to the Likert scale item "I know how to conduct the scientific investigations required in CAPS"

	Pre-Survey	Post-Survey	Difference
Average	3.4	4.3	0.9
StdDev	0.821	0.657	0.912
t-test (p-value)			0.015

The results presented in **Table 4.9** indicate that after the workshop, there was more positivity in the teachers' perceived ability to conduct the scientific investigations required by the CAPS curriculum, as seen in the average increase from 3.4 to 4.3. The t-test indicated that the detected difference between the two groups was statistically significant ($p = 0.015$, $p\text{-value} < 0.05$); therefore, the null hypothesis was discarded, and a conclusion was made that the workshop caused a significant improvement in the teachers' perceived knowledge about how to conduct scientific investigations.

The teachers who participated in this scientific investigation workshop had the opportunity to work with the basic necessary science equipment to conduct scientific investigations with their learners, as mentioned in **Chapter 3, Figure 3.2**. As stated by Kibirige, Teffo and Singh (2022:9), a lack of resources might also hinder the demonstration of scientific investigations. During this workshop, the teachers received a basic set of scientific equipment that could be used during the workshop activities and in their classrooms. As was previously mentioned, the equipment included microscope slides, coverslips and test tubes, laundry pins to hold the test tubes, ice cream sticks, filter paper, toothpicks and a syringe. The teachers also had to work with microscopes and gas burners in some scientific experiments, which provided them with the opportunity to practice their use of this equipment. The teachers who might not have been able to utilise this equipment successfully before had the chance to acquire knowledge and skills in their use. The data presented in **Table 4.9** seems to support the argument that teachers believe that, after participating in the workshop, they were better able to use this equipment during scientific investigations.

Table 4.10: t-test for a change in the responses to the Likert scale item "I know how to formulate a hypothesis for a scientific investigation"

	Pre-Survey	Post-Survey	Difference
Average	4.15	4.6	0.45
StdDev	0.587	0.598	0.51
t-test (p-value)			0.036

The results presented in **Table 4.10** indicate that after the workshop, there was a statistically significant increase in the teachers' perceptions of their ability to formulate a hypothesis for a scientific investigation, as the average increased from 4.15 to 4.6. The t-test indicated that the observed difference between the two groupings was significant ($p = 0.036$, p-value < 0.05); therefore, the null hypothesis was rejected, and a conclusion was made that the workshop caused a significant improvement in the teachers' perceptions about their ability to formulate a hypothesis for a scientific investigation.

A hypothesis can be defined as a proposed explanation for a phenomenon that is based on limited evidence and serves as a starting point for further investigation (Anupama, 2018:78). As this workshop incorporated the inquiry-based teaching approach, the participants were required to apply their science process skills during the investigations, including the creation of a hypothesis. Creating a hypothesis is crucial in understanding the relationship between two variables; it guides teachers through the inquiry process, as it provides them with the plan to test their presumption by applying their newly acquired skills and knowledge (Anupama, 2018:79).

Formulating a hypothesis is one of the steps in the scientific method implemented in inquiry-based teaching (Shanmugavelu, Parasuraman, Ariffin, Kannan & Vadivelu, 2020:8). As this workshop encompassed an inquiry-based approach to teaching scientific investigation, the teachers were required to formulate hypotheses. The data presented in **Table 4.10** indicates that the skill and knowledge required to formulate a hypothesis were developed during the scientific investigation workshop.

According to Cherry (2022:3), to formulate a hypothesis, one should first observe and evaluate the scientific information at hand; after which one should gather data on possible causes of a problem and explore explanations for what might cause the problem. The next step is to develop possible hypotheses and think of ways that one can confirm or disprove these hypotheses. These are all the skills needed by a science educator to successfully implement a scientific investigation (Cherry, 2022:3).

Hypothesising contributes to developing curiosity among teachers and learners about a science topic. Teachers and learners should use their prior knowledge to question the truth of the data obtained during investigations and then make sense of what they have learned to comprehend and appreciate the wonder of science (Cherry, 2022:3). As can be deduced from the results presented in **Table 4.10**, knowing how to formulate a hypothesis can support teachers in developing science skills and knowledge to transfer to their learners in the science classroom.

4.5. Discussion of the behavioural component (Section C)

Mzomwe (2019:210) stated that the behavioural component contains an individual's decision or intention to take action. As mentioned in **Chapter 2, Figure 2.1**, the three components of the attitude theory interact and influence one another. Although the three components were discussed separately, one should remember that they do not function independently, but in an integrated manner. The affective component can influence the cognitive component, which can influence the behavioural component. Since statistically significant improvements in aspects of the participants' cognitive and affective components were observed, it seems reasonable to expect that a similar improvement in the behavioural component might have occurred.

Teachers who undergo training and development through workshops might develop positive perceptions of scientific investigations, which can subsequently change their behaviour. An individual's behaviour encompasses actions such as demonstrating, using, providing, creating and attending, amongst others – the items in Section C contained items that included these actions words.

As indicated in Chapter Three, this section aligns with achieving the sub-research objective to measure and explain the effect of scientific investigation workshops on the behavioural component of the Life Science teachers' attitudes. This sub-objective was constructed from the sub-research question concerning what effect the scientific investigation workshop had on the behavioural component of the Life Science teacher's attitudes. These results are presented in **Table 4.11**.

Although the teachers' behaviour was measured in this study, one can only truly measure the impact of this workshop on the teachers' behaviour in the classroom setting. Therefore, the researcher suggests that an in-depth follow-up study that includes these teachers' learners be conducted to assess the true success of the scientific investigation workshop.

Table 4.11. All the results from the responses to the items in Section C

1. I will demonstrate scientific investigations to my learners.			
	Pre-Survey	Post-Survey	Difference
Average	3.5	4.5	1
StdDev.	1.051	0.607	1.076
t-test (p-value)			**0.023**
2. My learners conduct scientific investigations themselves.			
	Pre-Survey	Post-Survey	
Average	2.45	2.8	0.35
StdDev.	1.234	1.105	1.348
t-test (p-value)			1
3. I will use scientific apparatus to perform experiments.			
	Pre-Survey	Post-Survey	
Average	3.4	4.45	1.05
StdDev.	1.188	0.605	1.099
t-test (p-value)			**0.019**
4. I will create opportunities for my learners to participate in scientific investigations.			
	Pre-Survey	Post-Survey	Difference
Average	3.7	4.5	0.8
StdDev.	0.733	0.607	0.834
t-test (p-value)			**0.019**
5. I have subject meetings with my colleagues to plan scientific investigations.			
	Pre-survey	Post-Survey	Difference
Average	3.05	4.35	1.3
StdDev.	1.146	0.988	0.979
t-test (p-value)			0.001
6. I attend Life Science in-service training workshops.			
	Pre-Survey	Post-Survey	Difference
Average	3.9	4.6	0.7
StdDev.	0.968	0.503	0.865
t-test (p-value)			**0.069**
7. I only use textbooks to teach scientific investigations.			
	Pre-Survey	Post-Survey	Difference
Average	2.9	2.25	-0.65
StdDev.	0.912	1.118	1.424
t-test (p-value)			1
8. I include preparation time for practical lessons in my schedule.			
	Pre-survey	Post-survey	Difference
Average	3.25	4.25	1
StdDev.	1.118	0.716	1.026
t-test (p-value)			0.017

9. I only use the Teacher Edition Textbook when planning scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.15	2.35	-0.08
StdDev.	0.933	0.988	1.473
t-test (p-value)			0.662
10. I design worksheets for my learners to complete during scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.55	4.25	0.7
StdDev.	0.945	0.639	1.129
t-test (p-value)			0.351
11. The lack of scientific investigation equipment discourages me from improvising.			
	Pre-survey	Post-survey	Difference
Average	3.3	3.4	0.1
StdDev.	1.302	1.188	1.21
t-test (p-value)			1
12. My learners conduct scientific investigations in groups.			
	Pre-survey	Post-survey	Difference
Average	3.35	4.4	1.05
StdDev.	1.387	0.503	1.317
t-test (p-value)			0.076
13. My learners are actively involved when I present scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.6	4.6	1
StdDev.	1.046	0.681	0.973
t-test (p-value)			0.01
14. I often walk around to monitor my learners as they perform scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.7	4.8	-0.05
StdDev.	1.174	0.41	1.504
t-test (p-value)			1
15. I use digital devices to teach scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.5	4.3	0.8
StdDev.	1.357	0.865	1.281
t-test (p-value)			0,349
16. My learners passively listen when I teach scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.25	3.45	0.2
StdDev.	0.967	1.191	1.005
t-test (p-value)			1
17. I perform scientific investigations in a normal classroom.			
	Pre-survey	Post-survey	Difference
Average	3.45	3.4	-0.05

StdDev.	1.05	1.188	1.276
t-test (p-value)			1
18. I will perform reflections with my learners at the end of scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.684	4.5	0.789
StdDev.	1.108	0.688	0.855
t-test (p-value)			0.033
19. The lack of resources does not stop me from conducting scientific investigations.			
	Pre-survey	Post-survey	Difference
Average	3.45	4.4	0.95
StdDev.	1.234	0.754	1.356
t-test (p-value)			0.181
20. I conduct scientific investigations in a laboratory.			
	Pre-survey	Post-survey	Difference
Average	2.65	3.86	1.2
StdDev.	1.226	1.137	1.005
t-test (p-value)			0.002

Not all of these items' results were significant, so no further discussion was required. For example, if one analyses Item 2*: My learners conduct scientific investigations themselves*, there was no statistically significant improvement in the average post-survey response compared to the average pre-survey response. The average increased by 0.35 from 2.45 to 2.8 (p-value 1 > 0.05). Therefore, the researcher concluded that the participants created opportunities for their learners to conduct scientific investigations themselves before they participated in this workshop.

The researcher came to a similar conclusion concerning the other items with p-values > 0.05. The researcher concluded that this scientific investigation workshop did not significantly affect the participants' proposed behaviour regarding providing the opportunity for their learners to conduct scientific investigations by themselves in the classroom.

The results also indicated that there was no statistically significant improvement in the teachers' intended behaviour to only use textbooks to teach their learners and to use the Teacher Edition Textbook when planning scientific investigations.

These results also indicated no statistically significant change in the teachers' intended behaviour regarding the lack of resources that does not prevent them from conducting scientific investigations, their learners from conducting scientific investigations themselves or that they will design worksheets for their learners to complete during scientific investigations.

The results indicated no statistically significant improvement in the teachers' intended behaviour to use digital devices to teach scientific investigations and their learners passively listening when they teach scientific investigations

However, the responses to Item 3: *I will use scientific apparatus to perform experiments,* indicated a statistically significant difference in the average of the pre-survey responses, (which was 3.4 and increased by 1.05) and the average of the post-survey responses which was 4.45 (p-value 0.019, which is < 0.05). The data shown in this item, teachers' behaviour, will include using scientific apparatus when performing experiments after attending this workshop.

Subsequently, the researcher entered into further discussions concerning Items 1, 3, 4 and 6. As the p-values of all 4 items were < 0.05, one can assume with 95% certainty that there was a statistically significant difference in the responses before and after the workshop.

Table 4.12: *t-test for a change in the responses to the Likert scale item "I will demonstrate scientific investigations to my learners"*

	Pre-Survey	Post-Survey	Difference
Average	3.5	4.5	1.0
StdDev	1.051	0.607	1.076
t-test (p-value)			0.023

The results presented in **Table 4.12** indicated a possible statistically significant increase in the teachers' possible behaviour regarding demonstrating scientific investigations to their learners after attending this workshop, as the average increased from 3.5 to 4.5. The t-test indicated that the observed difference between the two groupings was significant (p = 0.023, p-value < 0.05); therefore, the null hypothesis was rejected and a conclusion was reached that the workshop might have initiated a statistically significant improvement in the teachers' intended behaviours and they were more willing to perform demonstrations to their learners.

According to Zulkifli (2014:1), in-service training workshops are opportunities for teachers to learn, develop and improve the science skills and knowledge they are required to transfer to their learners in the classroom. Teachers are required to use scientific knowledge and skills in science lessons when they demonstrate investigations such as experiments and dissections.

According to Constantinou, Rybska and Tsivitanidou (2018:2), the inquiry-based teaching method emphasises the process of performing science; thus, teachers should understand that it is vital to demonstrate scientific investigations in science lessons rather than using the lecture-style teaching method.

Zulkifli (2014:2) and Atuhumuze and Nzarirwehi (2019:21) argue that teachers who participate in workshops are more likely to implement inquiry-based teaching methods in their classrooms. The data collected in this study appears to support this argument, as the findings in **Section A, Table 4.3, Table 4.4** and **Section B, Table 4.9** indicate a significant increase in the participants' perceptions that they had the necessary scientific skills and knowledge to conduct scientific investigations with their learners after attending the workshop, as indicated in **Table 4.12**.

Table 4.13: t-test for a change in the responses to the Likert scale item "I will use scientific apparatus to perform experiments"

	Pre-Survey	Post-Survey	Difference
Average	3.4	4.45	1.05
StdDev	1.188	0.605	1.099
t-test (p-value)			0.019

The results presented in **Table 4.13** indicate an improvement in the teachers' intentional behaviour toward using scientific apparatus to conduct scientific investigations – with an average increase of 1.05 from 3.4 to 4.45. The t-test indicated that the observed statistical difference between the two groupings was significant (p = 0.019, p-value, 0.05), and the null hypothesis was consequently rejected and it was assumed that these teachers were more willing to use science apparatus during scientific experiments after attending the workshop.

The data is in line with Boslisani and Bratianu's (2018:5) assertion that knowledge and skills lay the foundation for performing tasks such as scientific investigations. According to Kassema (2019:5), teachers first need to gather knowledge regarding the apparatus during workshops and develop and practice their skills in utilising the apparatus thereafter. This scientific investigation workshop included the apparatus mentioned in Section B. Throughout the workshop, the teachers learned about the different apparatuses and the experiments to which they are linked and they had the opportunity to use the items to practice their skills.

The findings presented in **Table 4.13** support the conclusion that the workshop led to a significant improvement in the teachers' intended behaviours concerning implementing scientific apparatus in the science classroom, as they had gained valuable knowledge and skills regarding the equipment.

Table 4.14: t-test for a change in the responses to the Likert scale item "I will provide the opportunity for my learners to participate in scientific investigations lessons"

	Pre-Survey	Post-Survey	Difference
Average	3.7	4.5	0.8
StdDev	0.733	0.607	0.834
t-test (p-value)			0.019

The results presented in **Table 4.14** indicate a statistically significant improvement in the teachers' intended behaviour toward providing opportunities for their learners to participate in scientific investigations, as the average increased from 3.7 to 4.5. The t-test indicated that the difference between the two sets of responses was significant ($p = 0.019$, p-value < 0.05); therefore, the null hypothesis was rejected, and a conclusion was reached that the workshop led to a potentially significant improvement in the teachers' intended behaviours. The data implies that the participants were more determined to provide opportunities in the science classroom for their learners to participate in scientific investigation lessons after attending the workshop.

Learners' participation can be facilitated by using the inquiry-based teaching approach. For learners to understand and appreciate science, they should participate in scientific investigations. The inquiry-based approach, the teaching method used to present this scientific workshop, requires that learners investigate problems and explore possible solutions themselves (Constantinou, Rybska & Tsivitanidou, 2018:2).

As indicated in **Section A, Table 4.3**, **Table 4.4** and **Section B, Table 4.9**, the teachers who perceive that they have the necessary scientific knowledge and skills to conduct scientific investigations adopt a positive attitude towards their learners participating in scientific investigations.

Table 4.15: t-test for a change in the responses to the Likert scale item "I will attend life science in-service training workshops"

	Pre-Survey	Post-Survey	Difference
Average	3.9	4.35	0.7
StdDev	0.968	0.988	0.865
t-test (p-value)			0.069

The results presented in **Table 4.15** indicated a statistically significant improvement in the teachers' intended behaviour toward attending scientific investigation workshops after participating in this workshop, as a statistically significant improvement could be seen with the average increasing by 0.7 from 3.9 to 4.35. The t-test indicated that the observed difference between the two sets of responses was significant ($p = 0.069$, p-value < 0.05); therefore, the null hypothesis was rejected and it was concluded that the workshop led to an improvement in the participants' intentions to attend in-service training workshops in the future.

As seen in **Section A, Table 4.3** and **Table 4.4**, the teachers who attended this Life Science scientific investigation workshop changed their perceptions of their knowledge and skills. The results indicated that these teachers encountered an opportunity to improve their scientific knowledge and skills and developed more positive attitudes towards scientific investigations. These results support Zulkifli (2014:1), who stated that teachers who attend workshops might improve their science skills and knowledge, which can support them in carrying out their teaching responsibilities. The results in **Section B**, **Table 4.8** and **Table 4.9** correlate with these results, as these teachers indicated, after attending this workshop, that they perceived that they had the necessary knowledge of the chemicals used in scientific investigations and that they could now conduct the scientific investigations required by CAPS.

The data presented in **Section C, Table 4.15** correlates with the abovementioned discussion and signifies that, after attending the workshop, the teachers were more willing to attend in-service training workshops where they can improve their scientific knowledge and skills. According to Zulkifli (2014:1), attending workshops is crucial for improving the quality of science education. Teane (2019:4) supports this statement and urges teachers to participate in workshops because they can enhance their skills and knowledge, which encourages positive attitudes and assists in overcoming challenges.

4.6. Value of the Study

Education research involves a researcher exploring problems and situations within the educational environment to find suitable solutions to identified problems (Okware, 2021). This study was relevant to the current situation in secondary schools, where Life Science scientific investigation work seems to be neglected because of teachers' negative attitudes and inadequate knowledge and skills to conduct scientific investigations successfully. The result is that learners are not being exposed to the scientific inquiry process and conceptualising knowledge through a student-centred exploration method (Mwangu & Sibanda, 2017:48).

This study provided insights into scientific investigation workshops' utilisation to change teachers' attitudes towards scientific investigations through developing, upgrading and improving their skills and knowledge. Given this, this study explored the problem of Life Science teachers' negative attitudes towards scientific investigations and the possible use of Life Science scientific investigation workshops to change their attitudes within an in-service training programme environment. This might result in teachers viewing scientific investigation work as being just as important as theoretical work and developing more positive attitudes.

4.7. Summary

This study's results show a connection between the teachers' attitudes and the scientific investigation workshop. Teachers' attitudes towards scientific investigations are informed by their perceptions, feelings and intended behaviour concerning their scientific investigations knowledge and skills. Positive attitudes can enhance teachers' confidence when conducting scientific investigations with their learners in the science classroom and can be developed through acquiring the necessary scientific skills and knowledge.

It seems fair to conclude that the inquiry-based teaching approach implemented during this workshop generated positive attitudes amongst the participants, as they indicated that they had also developed their science skills and knowledge through collaboration with other Life Science teachers during the workshop. The participants were also actively involved during the workshop. They had the opportunity to use scientific equipment to carry out investigations, supporting the notion that the hands-on approach accompanied by the inquiry-based teaching method successfully enhances confidence and encourages positive attitudes.

It has become necessary for Life Science teachers to attend regular Life Science scientific investigation workshops to remain current with scientific developments, develop scientific skills and have opportunities to collaborate and learn from one another. Professional development programmes such as this in-service training workshop are a strategy that can be used to support teachers in acquiring the necessary scientific skills and knowledge to successfully demonstrate scientific investigations with their learners.

The researcher documented how this scientific investigation workshop shaped the participants' attitudes and how it might impact their classroom practice. In the ensuing chapter, the findings of this study and the achieved objectives are synthesised into recommendations that might help Life Science teachers with the necessary scientific investigation knowledge and skills to overcome the challenges they encounter regarding scientific investigations.

Chapter 5

Findings, Conclusion and Recommendations

5.1. Introduction

In Chapter Four, the quantitative data obtained from the life Science teachers during the pre- and post-attitude surveys was analysed, compared and interpreted. The research aimed to understand and interpret the effect of the scientific investigation workshop on the Life Science teachers' attitudes.

This chapter draws a conclusion and advances recommendations based on the findings presented in Chapter Four and the literature that was reviewed in Chapter Two. These recommendations will assist Life Science teachers to adopt positive attitudes that might lead to the facilitation of scientific investigations when teaching Life Science to their learners. These recommendations might also assist future researchers in designing effective in-service training workshops. This chapter will also present an overview of this study and make recommendations for future research.

5.2. Overview of the study

This study was concerned with whether or not the scientific investigation workshop affected the Life Science teachers' attitudes toward scientific investigations. In Chapter One, the introduction, background, research problem, research questions and objectives were shaped.

The background information indicated that various factors and challenges contribute to Life Science teachers' fostering negative attitudes toward the practical facet of the subject. These challenges, which include a lack of scientific skills, knowledge and equipment, prompted the idea that in-service training workshops focusing on scientific investigations might help to combat such challenges. This gave rise to the following questions. What is the effect of scientific investigation workshops on Life Science teachers' attitudes toward scientific investigations? What suggestions or recommendations can be made to assist Life Science teachers to foster more positive attitudes toward scientific investigations?

Chapter Two reviewed literature regarding scientific investigations, attitudes, the Life Science curriculum, inquiry-based teaching methods and in-service training workshops. The ABC attitude model was defined and explained, as were the three components of the model.

The literature relevant to inquiry-based science teaching was reviewed, laying the foundation for how the scientific investigation workshop in this study was designed and constructed. The importance of the scientific investigation workshop and the attitude model was emphasised in Chapter Two. The evidence gleaned from the literature implied that Life Science teachers might foster negative attitudes toward scientific investigations because they lack the necessary scientific skills, knowledge and equipment. The literature also suggested that workshops are valuable tools to support teachers in developing the scientific skills and knowledge required to teach Life Science scientific investigations.

The research methodology and conceptual framework were explained and operationalised in Chapter Three. The quantitative research method that was adopted gave the researcher insight into the workshop's effect on the participants' attitudes and facilitated an understanding of the relationships between the variables to ascertain if the workshop had an effect. The researcher elaborated on the pre- and post-attitude surveys that were implemented to gather the data. The rationale for the choice of the attitude surveys was addressed, as well as the advantages and disadvantages of using these surveys.

In Chapter Three, the researcher also discussed how this scientific investigation workshop was designed and constructed. This discussion included the equipment that was used and the programme's structure.

In Chapter Four, the researcher analysed the data collected through the surveys. This proved to be insightful, as the data gave the researcher a better understanding of the phenomena under investigation.

5.3. Discussion

According to the findings and the review of literature presented in the study, relevant recommendations were assembled. These recommendations aim to help Life Science teachers to develop positive attitudes toward scientific investigations, which can lead to classroom practice that incorporates their newly developed scientific skills and knowledge and implements the social aspect of the inquiry-based teaching method.

The recommendations are derived from the literature that was reviewed and the conceptual framework used in this study. The literature first indicated that teachers encounter numerous challenges, such as a lack of scientific knowledge and skills to conduct scientific investigations. Secondly, it indicated that professional development programmes such as in-service training workshops are essential for developing new skills and knowledge. This workshop can also contribute to these teachers' emotional and social development. Thirdly, the literature indicated that it is essential that teachers implement the inquiry-based teaching approach in the science classroom. The workshop implemented the inquiry-based teaching approach.

In Chapter Three, the researcher used this literature to design the conceptual framework for this study and identified the scientific investigation workshops as the independent variable, the Life Science teachers' attitudes as the dependent variable and knowledge and skills as the mediating variable. This study aimed to determine whether or not Life Science scientific investigation workshops, where teachers can collaborate with other Life Science teachers and learn new science skills and knowledge, might affect the teachers' attitudes.

5.4. Recommendations

As mentioned in Chapter One, the researcher formulated the research problem as Life Science teachers' lack of knowledge and skills negatively influencing their attitudes toward scientific investigations. The aim was to understand what effect scientific investigation workshops might have on Life Science teachers' attitudes and to ascertain if the Life Science teachers' attitudes changed after attending the workshop. To achieve this, the researcher has to assess the effect of the scientific investigation workshop on each of the three ABC attitude model components: affective, cognitive, and behavioural.

The affective component entails teachers' emotions and feelings regarding scientific investigations. The findings presented in Chapter Four indicated that the participants perceived that after the workshop, they had the scientific skills and knowledge required to facilitate scientific investigations in their classrooms (see Table 4.3 and Table 4.4). The data also indicated that the teachers perceived to be more supported by their colleagues (see Table 4.5) and indicated an increased enjoyment in carrying out scientific investigations (see Table 4.2). Therefore, the researcher recommends that future in-service training workshops such as this scientific investigation workshop be implemented and regularly attended to focus on developing these teachers' scientific skills and knowledge.

However, the researcher recommends that this workshop be conducted over several days because most of the participants indicated that they would prefer to attend it over two or more days. This might help the teachers to feel less rushed when conducting the experiments and provide more time for reflection and discussions. The workshop should also be spaced out over time/days; this might help with the teachers' memory retention and comprehension of newly-acquired scientific knowledge and skills, as mentioned in the previous recommendation. Teachers might then have time to construct new knowledge and build on previous knowledge (see Tables 4.8 and 4.9).

The cognitive component of the attitude model refers to teachers' thoughts and beliefs regarding scientific investigations. The literature that was reviewed indicated that collaboration and socialising in the science classroom are essential for successfully implementing the inquiry-based teaching approach. The social domain refers to scientists working together on research projects to discuss theories and results – so too should Life Science teachers collaborate with other Life Science teachers and their learners to discuss experiments and science activities (van Uum et al., 2016:452). This statement is supported by the findings in Table 4.7, where the teachers indicated that they learnt more science skills when working with other Life Science teachers. Therefore, the researcher recommends that future scientific investigation workshops include group work among teachers and present opportunities for them to collaborate on investigations.

The researcher also recommends that future scientific investigation workshops focus on developing knowledge and skills regarding the scientific equipment and chemicals used during the investigations prescribed by the CAPS document, as the data indicated an increase in the teachers' perceptions that their knowledge about the scientific chemicals used in experiments improved because of the workshop.

The behavioural component contains an individual's decision or intention to take action and is influenced by the affective and cognitive components. As teachers started to feel more confident after having acquired new knowledge and skills regarding scientific investigations, they indicated that they were more willing to demonstrate scientific investigations with their learners (see Table 4.12). Experiencing these feelings and thoughts might have influenced these teachers to take action and attend future Life Science scientific investigation workshops (see Table 4.15).

Therefore, the researcher recommends that it should also be considered that the scientific investigation workshop is conducted at the beginning of the year, focusing only on the first and second terms' scientific investigations. A second workshop can be conducted towards the middle of the year, focusing on the third and fourth terms' scientific investigations. This might help the teachers to retain and recall newly acquired skills and knowledge without being distracted by too much new information. This could assist the teachers in their planning for the term's activities; removing some of the pressure and contributing to teachers fostering positive attitudes.

However, to truly measure this scientific investigation workshop's success, the researcher recommends that a future study be conducted that includes the learners. Future researchers might find it valuable to continue data collection with the learners in the classrooms of the Life Science teachers who attended the workshop. This will ascertain if the positive change in the teachers' attitudes is carried over and implemented in their science classroom with their learners. It is also recommended that a similar study be conducted with a larger sample size as it will support the findings to be generalised to the population. The researcher can then also follow the true scientific method to conduct the research since a larger number of participants will aid in having a control group and an intervention group.

The changes in the participants' attitudes toward scientific investigations might play a vital role in their conducting scientific investigations with their learners in the science classroom. To ensure a positive change in the teachers' attitudes toward scientific investigations, the teachers should be aware of the three components that make up their attitudes: the affective, cognitive and behavioural components. As indicated by the findings in this study, all three components contribute to one's attitude. Teachers should foster positive feelings and thoughts toward scientific investigations to behave positively; such as enjoying demonstrating and facilitating scientific investigations in their classrooms. The result of this study are indicative of the relationship between the three components within the ABC attitude model which contributes to the changes observed in teachers' attitudes toward scientific investigations.

5.5. Conclusion

The results of this study indicated that Life Science teachers' attitudes towards scientific investigations are influenced by challenges such as a lack of scientific knowledge, skills and equipment. These challenges might have a positive or a negative impact on their attitudes. The literature supported by this study's findings indicates that in-service training workshops that develop science skills and knowledge and facilitate social interaction with other Life Science teachers promote positive attitudes toward scientific investigations.

It was evident from the findings that a change in teachers' attitudes occurs when they feel confident in their science skills and ability and when they think positively about their scientific knowledge, skills and equipment. The importance of professional in-service training workshops, such as this one, are needed to implement inquiry-based science teaching, develop the required science skills and knowledge, facilitate an understanding of science equipment and facilitate support among colleagues. Although the research was conducted in the Motheo District of the Free State, the literature provided an understanding of the effect of a workshop on Life Science teachers' attitudes within other environments.

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Annexure A: Survey

EDUCATION
OPVOEDKUNDE
UFS·UV

Pre-Survey

Participant number	

Survey on exploring the effect of Life Science scientific investigation workshop on the Attitudes of Life Science teacher, situated in the Motheo district of the Free State.

To the educators:

You have agreed to participate in the Life Science scientific investigation study, an educational research project investigating Life Science teachers' attitudes toward scientific investigations. It is designed to measure and interpret teachers' attitudes in the Free State education systems to help improve the teaching and learning of Life Science.

This survey is addressed to Life Science teachers, who are asked to supply information about their academic and professional knowledge, skills and attitudes towards teaching scientific investigations. The items in this survey revolve around the scientific investigations that you teach.

Please be fully honest when completing this survey as your name and school's name will remain anonymous.

Your cooperation in completing this survey is greatly appreciated.

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Here are some items regarding Life Science scientific investigations (practical, laboratory work and experiments). Please indicate with an (X) in the open boxes to which extent you agree or disagree with these items.

Section A						
	Items	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
1	I am motivated to teach scientific investigations.					
2	Scientific information is gained through experimentation.					
3	Practical work is important in teaching science.					
4	I enjoy carrying out scientific investigations.					
5	Tactile modes are the best to understand science content.					
6	Professional development workshops developed my scientific investigation knowledge.					
7	I have enough science resources for scientific investigations.					
8	I have the science skills to facilitate a scientific investigation.					
9	Reflection is a valuable part of scientific investigations.					
10	My colleagues support me in scientific investigation lesson planning.					
11	Inquiry is a successful method of gaining scientific investigation skills.					
12	Professional development workshops develop my scientific investigation skills.					
13	My pre-service course prepared me to do scientific investigations at high school level.					
14	Life Science is best taught through a lecture-style teaching method.					
15	Oral questioning is enough when developing learners' inquiry.					
16	Our laboratory is used as a store room for science materials.					
17	Group work amongst learners is important when doing scientific investigations.					
18	I have enough content knowledge to conduct scientific investigations.					

Section B						
	Items	**Strongly Disagree,**	**Disagree,**	**Neither Agree nor Disagree,**	**Agree,**	**Strongly Agree**
1	I learn scientific investigation skills when working with Life Science teachers.					
2	I know how to conduct all scientific investigations required in the CAPS.					
3	I know how to use all the scientific equipment at my school.					
4	The lecture-style teaching method is suited to teach scientific investigations.					
5	I learn scientific investigation knowledge when working with Life Science teachers.					
6	I know all the steps of the scientific method.					
7	I know how to interpret data after a scientific investigation.					
8	I know the function of each chemical used in scientific investigations prescribed in the CAPS.					
9	Scientific investigations is a learner-centred process.					
10	Science educators need to have both science skills and content knowledge.					
11	I know how to formulate a hypothesis for a scientific investigation.					
12	I analyse data after a scientific investigation.					
13	I can provide explanations to support my scientific conclusions.					
14	Science is a set of procedures to be memorized.					
15	Scientific investigations, practical work and inquiry are synonyms.					
16	Every hands-on practical is a scientific investigation.					
17	Learners use the cognitive process to solve scientific investigation problems.					

Section C						
	Items	**Strongly Disagree,**	**Disagree,**	**Neither Agree nor Disagree,**	**Agree,**	**Strongly Agree**
1	I demonstrate scientific investigations to my learners.					
2	My learners conduct scientific investigations themselves.					
3	I have used scientific apparatus to do experiments.					
4	My learners participate in scientific investigations lessons.					
5	I have subject meetings with my colleagues to plan scientific investigations.					
6	I attend Life Science in-service training workshops.					
7	I only use textbooks to teach scientific investigations.					
8	I include preparation time for practical lessons into my time schedule.					
9	I only use the Teacher Edition Textbook when planning scientific investigations.					
10	I design worksheets for my learners to complete during scientific investigations.					
11	The lack of scientific investigation equipment discourages me from improvising.					
12	My learners conduct scientific investigations in groups.					
13	My learners are actively involved when I present scientific investigations.					
14	I often walk around to monitor my learners as they do scientific investigations.					
15	I use digital devices to teach scientific investigations.					
16	My learners passively listen when I teach scientific investigations.					
17	I do scientific investigations in a normal classroom.					
18	I do reflections with my learners at the end of scientific investigations.					
19	The lack of resourcess does not stop me from conducting scientific investigations.					
20	I conduct scientific investigations in a laboratory.					

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Section D: Demographical information

What is your gender?

	Male
	Female
	Other

What is your highest level of education?

	High School Diploma
	Attended university but did not finish
	Vocational/Technical degree or certificate
	B.Ed. degree with Life Science as the main subject
	Bachelor's Degree in another field with PGDE
	B.Ed. Honours Degree

Years of teaching Life Science

	1-5 years
	6-10 years
	11-15 years
	16-20 years
	21-25 years
	26-30 years
	More than 30 years

THANK YOU for the thought, time, and effort you have put into completing this survey.

Much Appreciated!

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Post-Survey

Section A						
	Items	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
1	I am motivated to teach scientific investigations.					
2	Scientific information was added through experimentation.					
3	Practical work is important in teaching science.					
4	I enjoyed carrying out scientific investigations.					
5	Tactile modes are the best to understand science content					
6	Professional development workshops developed my scientific investigation knowledge					
7	I have enough science resources for scientific investigations					
8	I have the science skills to facilitate a scientific investigation.					
9	Reflection is a valuable component of scientific investigations.					
10	I will support my colleagues in scientific investigation lesson planning.					
11	Inquiry is a successful method of acquiring scientific investigation skills.					
12	Professional development workshops developed my scientific investigation skills.					
13	My pre-service course prepared me to do scientific investigations at high school level.					
14	Life Science is best taught through a lecture-style teaching method.					
15	Oral questioning is enough when developing learners' inquiry.					
16	Our laboratory is used as a store room for science materials.					
17	Group work amongst learners is important when doing scientific investigations.					

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18	I have enough content knowledge to conduct scientific investigations.					

Section B						
	Items	**Strongly Disagree,**	**Disagree,**	**Neither Agree nor Disagree,**	**Agree,**	**Strongly Agree**
1	I learn scientific investigation skills when collaborating with Life Science teachers.					
2	I know how to conduct all scientific investigations required in the CAPS.					
3	I know how to use all the scientific equipment at my school.					
4	The lecture-style teaching method is suited to teach scientific investigations.					
5	I learn scientific investigation knowledge when working with Life Science teachers.					
6	I know all the steps of the scientific method.					
7	I know how to interpret data after a scientific investigation.					
8	I know the function of each chemical used in scientific investigations prescribed in the CAPS.					
9	Scientific investigations is a learner-centred process.					
10	Science educators need to have both science skills and content knowledge.					
11	I know how to formulate a hypothesis for a scientific investigation					
12	I analyse data after a scientific investigation.					
13	I can provide explanations to support my scientific conclusions.					
14	Science is a set of procedures to be memorized.					
15	Scientific investigations, practical work and inquiry are synonyms.					
16	Every hands-on practical is a scientific investigation.					
17	Learners use the cognitive process to solve scientific investigation problems.					

Section C						
	Items	**Strongly Disagree,**	**Disagree,**	**Neither Agree nor Disagree,**	**Agree,**	**Strongly Agree**
1	I will demonstrate scientific investigations to my learners.					
2	My learners conduct scientific investigations themselves.					
3	I will use scientific apparatus to do experiments.					
4	I will create opportunities for my learners to participate in scientific investigations.					
5	I will attend subject meetings with my colleagues to plan scientific investigations.					
6	I will attend Life Science in-service training workshops					
7	I will only use textbooks to teach scientific investigations.					
8	I will add the preparation time for practical lessons into my time schedule.					
9	I will only use the Teacher Edition Textbook when planning scientific investigations.					
10	I will design worksheets for my learners to complete during scientific investigations					
11	The lack of scientific investigation equipment discourages me from improvising.					
12	I will encourage my learners to conduct scientific investigations in groups.					
13	I will actively involve my learners when I present scientific investigations.					
14	I will walk around to monitor my learners as they do scientific investigations					
15	I will use digital devices to teach scientific investigations					
16	My learners will listen passively when I teach scientific investigations.					
17	I do scientific investigations in a normal classroom.					
18	I will do reflections with my learners at the end of scientific investigations.					
19	The lack of resourcess does not stop me from conducting scientific investigations.					

20	I will conduct scientific investigations in a laboratory.					

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Annexure B: SACE Registration of workshop (CPD Points)

26 March 2018

SACE

Tel: (012) 663 - 9517

Fax: (012) 663 – 9238

Private Bag x127

Centurion 0046

Ref: Theo Toolo

Tel : 012 663 9517 (switchboard)

Email : provider@sace.org.za

Dear Provider

This is to inform you of that your activities have been endorsed as follows:

Provider Name	Provider Number	Activity name	Points
UNIVERSITY OF THE FREE STATE	HE10964	The Art Of Teaching	10 points
		The Art of Curriculum Management	10 Points

Please inform us if the information has been captured correctly so that we can print the certificate.

Yours in the Teaching Profession

Ella Mokgalane

Chief Executive Officer

Annexure C: Scientific investigation workshop workbook

THE ART OF FACILITATING SCIENTIFIC INVESTIGATIONS

August 2019

THE UNIVERSITY OF THE FREE STATE

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Annexure D: Permission from the Free State Department of Education to conduct research in the Free State

education
Department of Education
FREE STATE PROVINCE

Enquiries: M.Z. Thango
Ref: Notification of research: S. Smit
Tel. 051 404 8808
Email: MZ.Thango@fseducation.gov.za

District Director
Motheo District
Xhariep District
Lejweleputswa District
Thabo Mofutsanyana District

Dear Mr. Moloi, Mr. Magwa, Ms. Zonke and Ms. Mabaso

NOTIFICATION OF RESEARCH: PERMISSION TO CONDUCT RESEARCH PROJECT IN MOTHEO, XHARIEP, LEJWELEPUTSWA AND THABO MOFUTSANYANA DISTRICTS

This letter serves to inform you that Ms. S. Smit has been granted permission to conduct research in the Motheo, Xhariep, Lejweleputswa and Thabo Mofutsanyana Districts under the auspices of the University of the Free State. The details in relation to the research project are as follows:

Topic: Exploring the Effects of Life Science Scientific Investigation Workshops on the Attitudes of Life Science Teachers.

1. **List of schools involved:** Kagisano C/S, Kgholoosego S/S, Kgauho S/S, Grassland S/S, Lekhulong S/S, St Bernard's S/S, Strydom, Sehunelo S/S, Sehlabeng S/S, Tweespruit, Intuthuko-Katleho S/S, Iphondle S/S, Rantsane S/S, Thiboloha Spec., Mookodi S/S, Mohaladitwe S/S, Panorama S/S, Springfontein S/S, Thabovuyo S/S, Trompsburg S/S, Albertina Sisulu S/S, Samuel Johnson S/S, Ollen S/S, Boaramelo S/S, Ipetleng S/S and Relebohile S/S.

2. **Target Population:** Forty Educators teaching Life Sciences at the selected schools.

3. **Period of research:** From the date of signature of this letter until 30 September 2022. Please note the department does not allow any research to be conducted during the fourth term (quarter) of the academic year nor during normal school hours. The researcher is expected to request permission from the school principals to conduct research at schools.

4. **Research benefits:** This study will provide insights into scientific investigation workshops' usage to change teachers' attitudes towards scientific investigations, through developing, upgrading and improving their skills, knowledge and attitudes. This might result in teachers viewing laboratory work as being just as important as theoretical work and developing more positive attitudes.

5. Strategic Planning, Policy and Research Directorate will make the necessary arrangements for the researchers to present the findings and recommendations to the relevant officials in the Department.

Yours Sincerely,

Mr. MZAMO W. JACOBS
DIRECTOR: QUALITY ASSURANCE, M&E AND STRATEGIC PLANNING

DATE: 07/03/2022

RESEARCH NOTIFICATION: S. SMIT. 07 MARCH 2022. MOTHEO, XHARIEP, LEJWELEPUTSWA & THABO MOFUTSANYANA DISTRICTS
Strategic Planning, Research & Policy Directorate Private Bag X20565, Bloemfontein, 9300 - Thabo House, Room 1E1, 1st Floor, St Andrew Street, Bloemfontein

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Annexure E: Title Registration

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UFS·UV
EDUCATION
OPVOEDKUNDE

1 September 2021

APPLICATION FOR TITLE REGISTRATION

Applicant: Smit, S
Student Number: 2015026798
Discipline: Subject Education in Natural Sciences
Study Code: Masters (EDNS8900)

Dear Ms Smit

Your registered title is: **"The influence of scientific investigation workshops on Life Science teachers' attitude towards scientific investigations"**

All of the best with your studies.

Yours sincerely,

Prof Patrick Mafora
Chair: CTR committee

Ms CS Duvenhage
Secretary: CTR committee

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Annexure F: Ethics Approval

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GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

21-Mar-2022

Dear Miss Shani Smit

Application Approved

Research Project Title:
The influence of scientific investigation workshop on Life Science teachers' attitudes toward scientific investigations.

Ethical Clearance number:
UFS-HSD2021/0680/22

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

Dr Adri du Plessis
Digitally signed by Dr Adri du Plessis
Date: 2022.03.22 12:17:38 +02'00'

205 Nelson Mandela Drive
Park West
Bloemfontein 9301
South Africa

P.O. Box 339
Bloemfontein 9300
Tel: +27 (0)51 401 9337
duplessisA@ufs.ac.za
www.ufs.ac.za

Appendix G: Language Editor Certificate

Proofreading Certificate

It is hereby certified that this proposal/dissertation/thesis/article has been proofread and edited for spelling, grammar and punctuation by a professional English language editor from www.OneStopSolution.co.za

Client

Name: Shani Smit

Title:

Submitted in fulfilment of the requirements for the degree of
Master's in Public Administration
in the Faculty of Arts at Nelson Mandela University

Editor

Michele van Niekerk ………………………………
Name

………………………………
Signature

29 January 2023 ………………………………
Date

I cannot guarantee that the changes that I have suggested have been implemented nor do I take responsibility for any other changes or additions that may have been made subsequently. The track changes of the language editing will be available for inspection upon enquiry, for a period of one year.

Contact

One Stop Solution
18 Woltemade str
Kabega Park
Port Elizabeth
6045

Redène Wynand
076 481 8341 / 060 520 1047
www.onestopsolution.co.za

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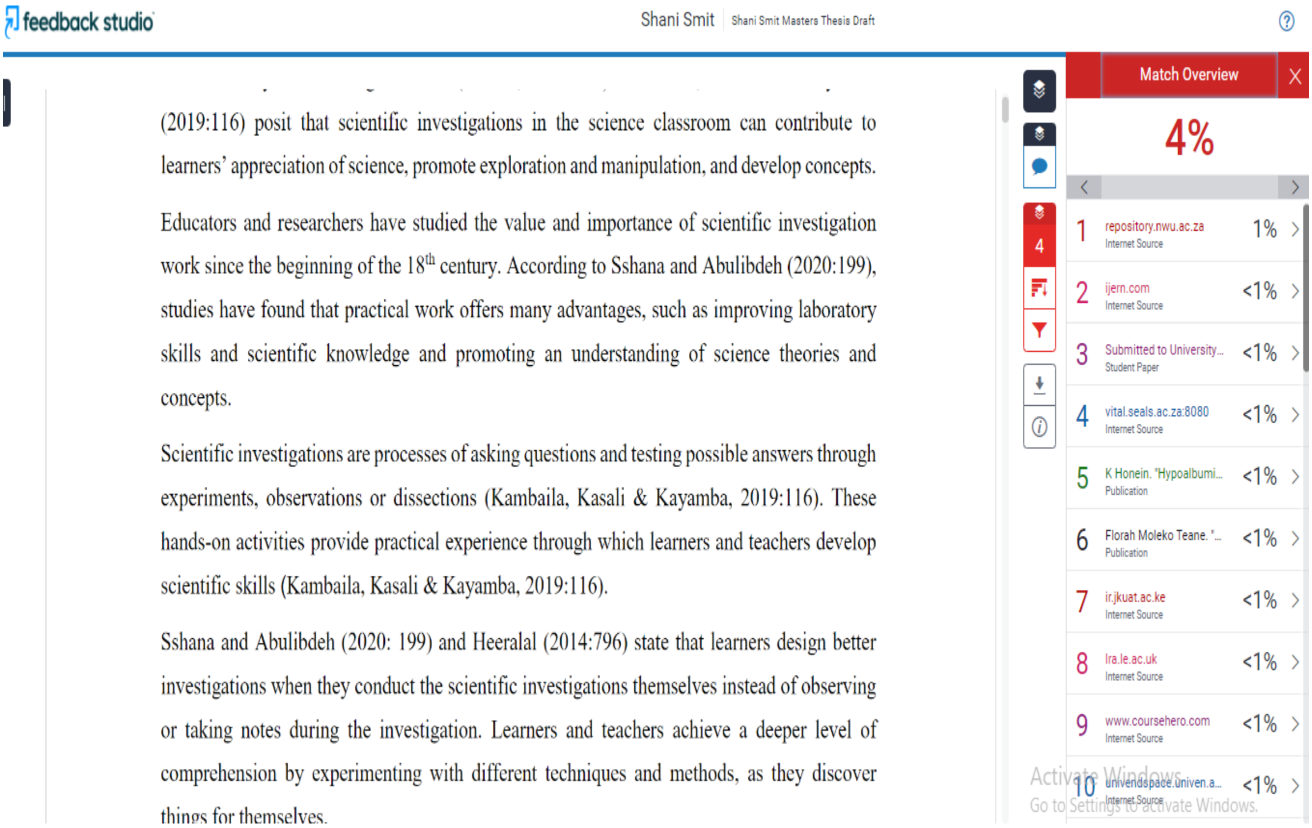
Annexure H: Turnitin Report

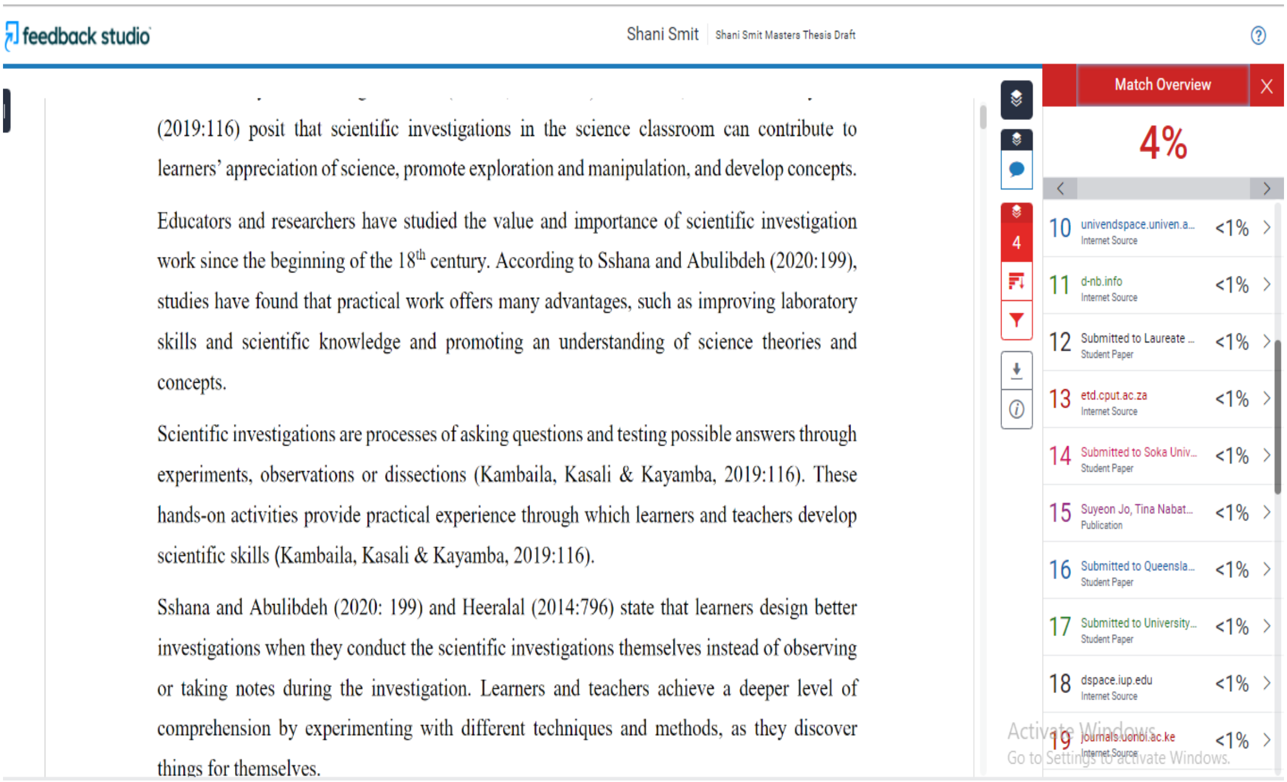

feedback studio — Shani Smit — Shani Smit Masters Thesis Draft

(2019:116) posit that scientific investigations in the science classroom can contribute to learners' appreciation of science, promote exploration and manipulation, and develop concepts.

Educators and researchers have studied the value and importance of scientific investigation work since the beginning of the 18th century. According to Sshana and Abulibdeh (2020:199), studies have found that practical work offers many advantages, such as improving laboratory skills and scientific knowledge and promoting an understanding of science theories and concepts.

Scientific investigations are processes of asking questions and testing possible answers through experiments, observations or dissections (Kambaila, Kasali & Kayamba, 2019:116). These hands-on activities provide practical experience through which learners and teachers develop scientific skills (Kambaila, Kasali & Kayamba, 2019:116).

Sshana and Abulibdeh (2020: 199) and Heeralal (2014:796) state that learners design better investigations when they conduct the scientific investigations themselves instead of observing or taking notes during the investigation. Learners and teachers achieve a deeper level of comprehension by experimenting with different techniques and methods, as they discover things for themselves.



feedback studio — Shani Smit — Shani Smit Masters Thesis Draft

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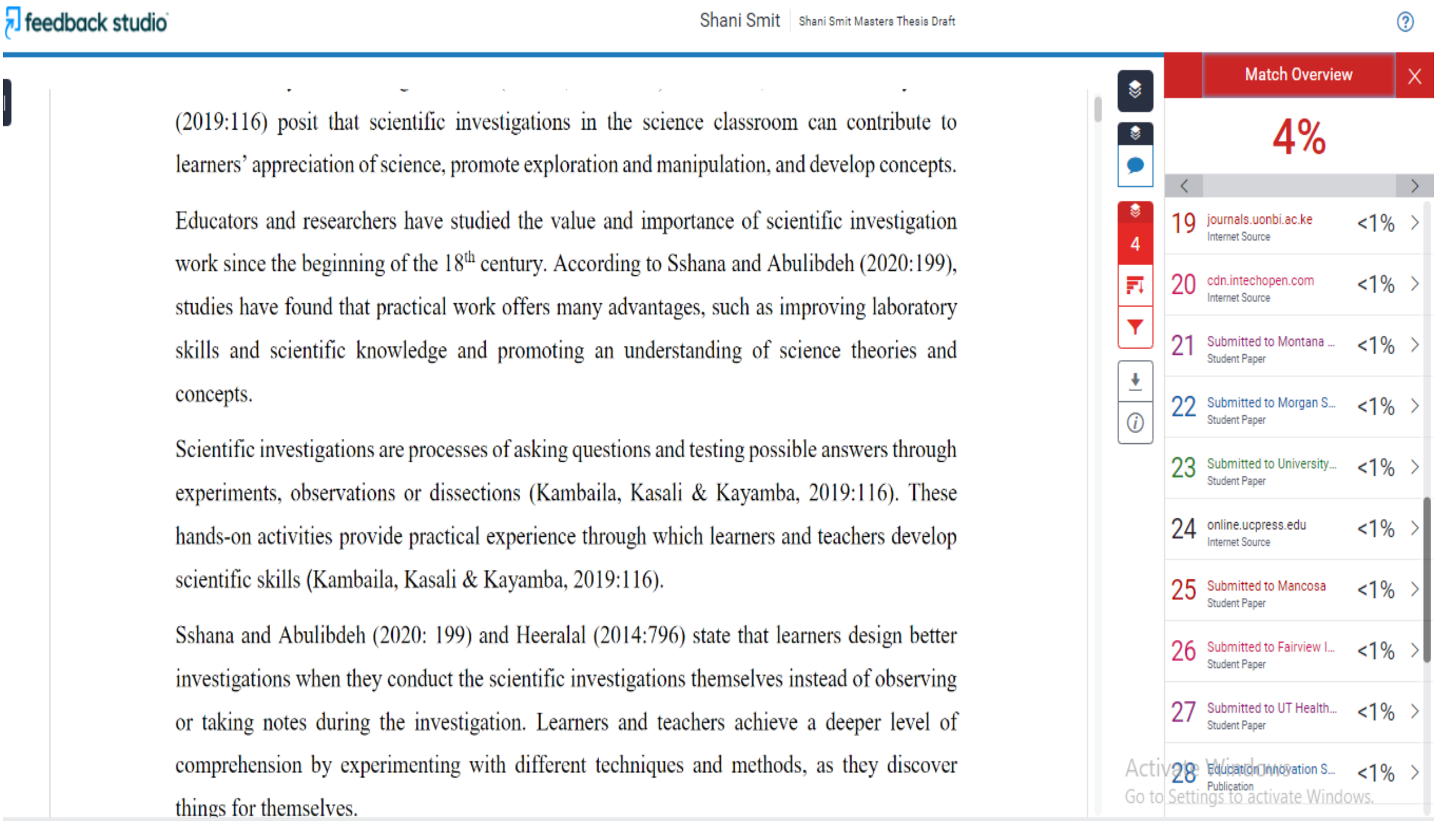

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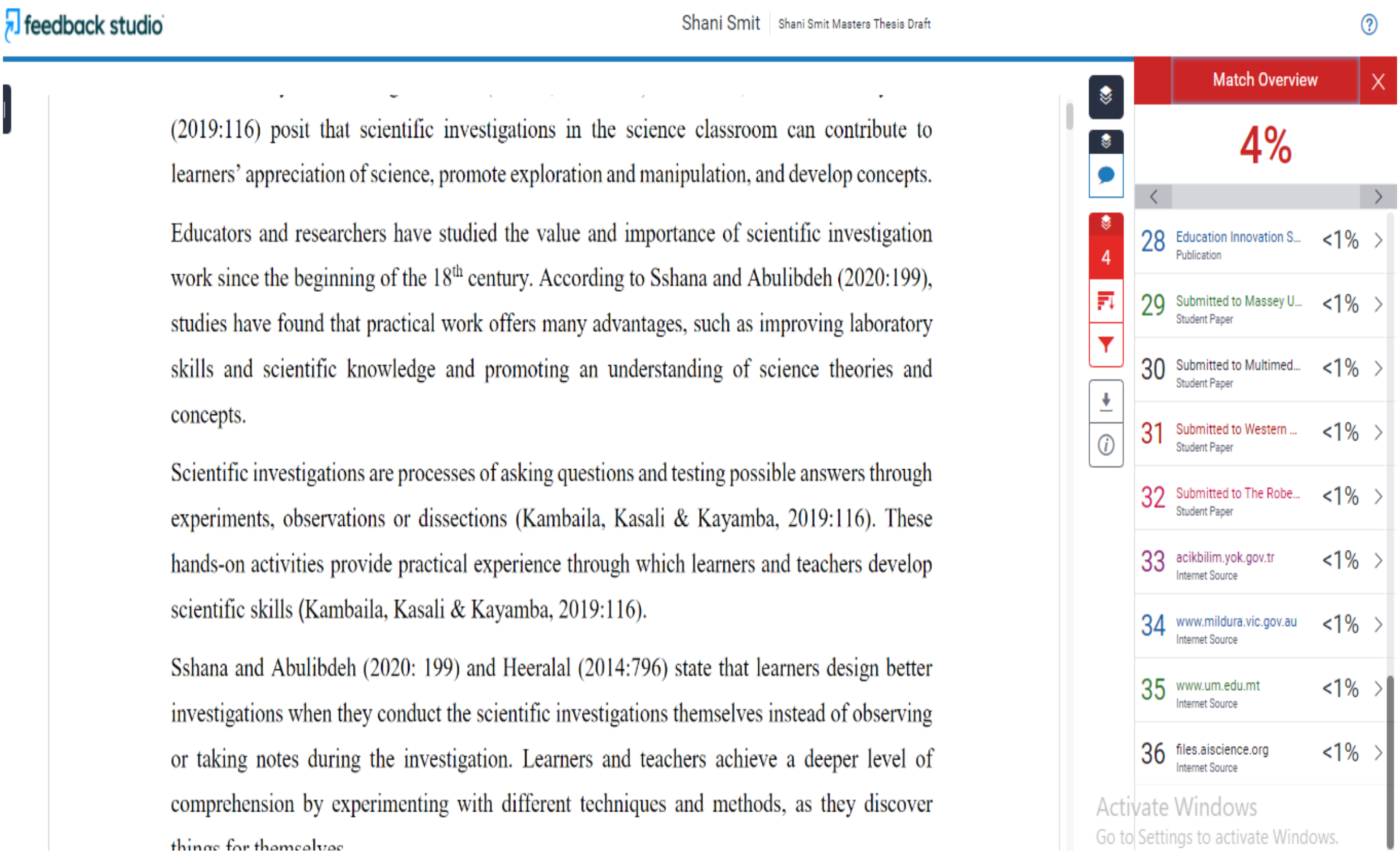

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Appendix I: Permission letter to conduct workshop at the facility.

Hoërskool Jim Fouché

h/v Wildeals & Lilaclaan
Gardeniapark
BLOEMFONTEIN
9301

051-502 1760/1
051-522 6858
Admin: admin@jf.co.za
Skoolhoof: hoof@jf.co.za

Privaatsak X40002
Fichardtpark
9317
www.jf.co.za

With this letter, I H.C. Wilken, the headmaster of Jim Fouché Hoërskool, grant permission to Shani Smit and her research supervisor, prof Jannie Pretorius to conduct their scientific investigation workshop on the school premises.

The facilities will be available for them and the research participants on the 23rd of April 2022 from 07:00-15:00.

H WILKEN

PRINCIPAL

List of Acronyms

ABC- Affective, Behaviours and Cognitive

CAPS- Curriculum Assessment Policy Statement

CPD-Continuing Professional Development

D0E- Department of Education

NOS- Nature of Science

SACE- South African Council for Educators

SEDEC-Science Education to Develop European Citizenship

B.Ed.- Bachelor's Degree of Education

PGDE- Post Graduate Diploma in Education.