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A FRAMEWORK FOR SUPPORTING FOUNDATION PHASE NOVICE TEACHERS' INSTRUCTION COMPETENCIES IN NATURAL SCIENCE

by

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7 December 2024

DECLARATION

I, Elizabeth Joy Fredericks, hereby declare that the content of this thesis represents my own work, and that the dissertation has not previously been submitted for academic examination towards any qualification. It represents my own opinions and not necessarily those of the Cape Peninsula University of Technology. I further declare that all sources cited or quoted are indicated or acknowledged by means of a comprehensive list of references.

Signed: Fredericks

Date: 1 December 2024

ABSTRACT

Globally, scientific literacy and general knowledge of the nature of science (NoS) are invaluable since they equip societies to make informed decisions about current economic, social and environmental issues. Foundational Natural Science (NS) knowledge affords learners the building blocks for understanding the natural world and is essential for nurturing their innate curiosity, fostering critical thinking and problem solving. Currently in South Africa, the Foundation Phase Life Skills Curriculum and Assessment Policy Statement (CAPS) document, which incorporates NS, lacks a distinct emphasis on scientific literacy, thereby creating a possible gap in NS foundational skills. The absence of explicit coverage of both content knowledge (CK) and subject matter knowledge (SMK) limits teachers' ability to fully integrate the subject into their teaching. Inadequate training in inquiry-based practice at Higher Education Institutions (HEIs) restricts trainee teachers' exposure to hands-on exploration, critical thinking, and the understanding of basic scientific concepts, which are crucial for early cognitive development.

This study aimed to answer the question: What framework can be developed to support novice teachers' (NTs') instruction competencies in NS in the Foundation Phase? This main research question was explored by addressing three supporting sub-questions: i) What were the novice teachers' experience and understanding of the teaching of Natural Science before the intervention programme? ii) How did the novice teachers develop cognitive and higher-order thinking abilities during the intervention programme? iii) What were the novice teachers' experience and understanding of the teaching of Natural Science after the intervention programme?

An amalgam of five theoretical frameworks underpins the research. Its components are Shulman's theory, Strampel and Oliver's levels of reflection (2007), Bloom's taxonomy (1956), the theory of andragogy (1975), and the community of inquiry (2000). Collectively, these five theories, formed a comprehensive foundation for the intervention aimed at improving the NTs' NS teaching.

Situated within the interpretivist paradigm of enquiry, this research employed a qualitative approach and a collective case study design that was fundamental to the research process. The research took place in three urban, public primary schools in the Metro Central Education District (MCED) in the Western Cape. The sample of seven purposively selected Foundation Phase NTs all had three or fewer years of experience and had qualified at different HEIs.

Qualitative research methods employed to gather data included questionnaires, semi-structured interviews, classroom observations, field notes, reflective journal entries, and one informal focus group interview. Data analysis involved both deductive and inductive strategies. Open coding was employed to identify trends and determine main themes and sub-themes. The data collected tracked the NTs' evolving pedagogical perspectives and cognitive development over time.

The comprehensive eight-week intervention programme (IP) covered a wide range of FP NS themes, concepts and exploratory practical activities. The IP addressed the NTs' identified needs and bridged the theory-practice gap, facilitating changes in their professional discourse. Addressing the gaps identified as developmental needs, this research involved the creation of a structured yet flexible framework to inform an IP aimed at addressing NTs' diverse needs in the context of the NS curriculum. The IP further provided targeted support to develop the requisite skills, pedagogical knowledge and practices for NS education.

The findings revealed that before the IP, NTs with little or no science education had limited NS teaching knowledge. Some were unaware that NS was included in the FP curriculum and therefore unsure how to teach the subject. During the IP, they acquired knowledge of NS concepts, scientific process skills and SMK. After the IP, there was clear evidence of the NTs' increased confidence and growth in professional discourse and classroom engagement. Their teaching became constructivist and learner-centred, prioritising inquiry.

The salient concepts gleaned from the findings facilitated the development of a new conceptual framework, the Collaborative, Reflective and Cognitive Development Framework (CRCD). The CRCD is based on the findings of the study as interpreted through a blend of the five theories mentioned above, each reliable and grounded in its specific principles. The framework focuses on the three main concepts that emerged from the findings during and after the IP: collaborative learning, cognitive processing and learner autonomy. Combining these essential concepts with the sub-concepts of a supportive environment, progressive skills building, critical reflection, self-guided inquiry and resolution, produced a 'road map' for teacher training and teacher professional development (TPD) programmes.

NS plays a pivotal role in a holistic education and inculcates the cognitive and inquiry skills essential for other subjects in the FP curriculum. Through NS, learners engage in critical thinking, problem-solving, and evidence-based reasoning, which are essential for scientific literacy and lifelong learning. Recommendations include affording NS the same status as the other subjects in the CAPS FP curriculum and explicitly defining concepts such as scientific literacy and the NoS. A targeted comprehensive TPD programme needs to be developed using the CRCD framework for both pre-service and in-service teacher training to address the gaps in curriculum and scientific knowledge. Future research could investigate how the CRCD framework could be employed across the curriculum subjects and phases to facilitate changes in teachers' professional discourse.

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LIST OF ABBREVIATIONS

3-D	3-Dimensional objectives
4IR	Fourth Industrial Revolution
BA	Bachelor of Arts
B Ed	Bachelor of Education
BK	Beginning knowledge
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statement
CK	Content knowledge
CoI	Community of Inquiry
CPD	Continuous professional development
CPUT	Cape Peninsula University of Technology
CRCD	Collaborative, Reflective and Cognitive Development conceptual framework
DHET	Department of Higher Education
DI	Direct instruction
DoBE	Department of Basic Education
EK	Everyday knowledge
FP	Foundation Phase
GET	General Education and Training
HEI	Higher Education Institution
HOTS	Higher-order thinking skills
IBL	Inquiry-Based Learning
IBT	Inquiry-Based Teaching
IP	Intervention programme
ISP	Intermediate and Senior Phase
KWL	Know-Want-Learn strategy: What I Know, what I Want to know, what I have Learned
LoLT	Language of Teaching and Learning
LTSM	Learning and teaching support material
MCED	Metro Central Education District
MRTEQ	The Minimum requirements for teacher education qualifications
NCS	National Curriculum Statements
NoS	Nature of science
NQF	The National Qualifications Framework
NRC	National Research Council

NS	Natural Science
NSE	Norms and standards for educators
NT	Novice teacher
OBE	Outcomes-Based Education
PCK	Pedagogical content knowledge
PD	Professional Development
PGCE	Postgraduate Certificate in Education
PIM	Practical inquiry model
PIRLS	Progress in International Reading Literacy Study
PK	Pedagogical knowledge
PSW	Personal and social wellbeing
Q & A	Question-and-answer strategy
RNCS	Revised National Curriculum Statement
RQ	Research question
SA	Subject advisor
SACE	The South African Council for Educators
SAQA	The South African Qualifications Authority
SBA	School-Based Assessments
SCP	Senior curriculum planner
SK	Scientific knowledge
SMK	Subject matter knowledge
TIMMS	Trends in International Mathematics and Science Study
TPACK	Technological pedagogical knowledge and content knowledge
TPD	Teacher professional development
TPS	Think-pair-share
WC	Western Cape
WCED	Western Cape Education Department

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CHAPTER 1

INTRODUCTION TO THE STUDY

This chapter provides the background of the study by detailing key components. The chapter commences with the rationale and context significance of the study, research questions and objectives of the study, assumptions of the study, the contribution of the study, clarification of key concepts, theoretical and conceptual frameworks, overview of the research design and methodology, limitations of the study and the organisation of the thesis.

1.1BACKGROUND

The education system in South Africa (SA) has undergone several significant transformations since the advent of democracy in 1994. Major paradigm shifts have been made by policymakers to remediate the injustices and inequalities of apartheid education. Democracy ushered in a series of revisions designed to unify the education system and make it accessible to all citizens. The previous curriculum was replaced by Curriculum 2005 (C2005) in 1997, with Outcomes-Based Education (OBE) as its constructivist basis. OBE guided the development of the Revised National Curriculum Statement (RNCS) in 2002. The RNCS reaffirmed the commitment to OBE and emphasised scientific literacy within the Foundation Phase (FP) Life Skills learning programme, particularly through scientific investigations (South Africa: Department of Education, 2002a).

The RNCS featured Natural Science (NS) as a mandatory subject and included a separate policy document for NS, with an emphasis on scientific investigative learning through process skills (Ross & Cartier, 2015). Refinement of the RNCS translated into the current curriculum in 2011, the Curriculum and Assessment Policy Statement (South Africa: Department of Basic Education, 2011. Hereinafter referenced as DoBE, 2011). The CAPS NS in FP is integrated into Life Skills, with the basic scientific process skills and concepts to be learned using scientific inquiry.

In the Western Cape, the most southerly province of South Africa, learners in the FP do not yet fully benefit from a curriculum designed to develop learners who are active problem solvers and critical thinkers (DoBE, 2011:5). While CAPS incorporates NS as a component of Life Skills, the presence of NS is not prominent or even overt. The curriculum lacks specific content depth, explanations of fundamental scientific concepts, explications of terminology and appropriate pedagogy (Beni et al., 2017; Dixon et al., 2018; James et al., 2019). These absences and deficiencies make it difficult for teachers to teach NS to its full potential.

High-quality NS education in the FP is essential for nurturing learners' innate curiosity and fostering critical thinking and problem solving. Limited depth in their knowledge of science and feelings of inadequacy among FP teachers, however, hinder effective NS teaching. This shortcoming, coupled with negative feelings toward the subject and a lack of exposure and training in NS pedagogy at Higher Education Institutions (HEIs), poses challenges to NS education.

Without a strong foundation in NS content, teachers may struggle to create inquiry-based classroom environments that encourage active learner engagement. This shortcoming hampers the development of crucial scientific process skills that learners need to investigate and understand the world around them.

Introducing science education in the early years of schooling holds potential as an innovative solution to educational challenges. Unlike passive knowledge, science education stimulates curiosity, analytical thinking and inquiry skills. Through hands-on sensory learning, young learners develop the cognitive abilities needed for problem solving and critical thinking (Goswami, 2015; Khairati et al., 2021). This observation is in line with the cognitive requirements for future academic excellence identified in assessments such as the Progress in International Reading Literacy Study (PIRLS) (Mullis & Martin, 2023) and the Trends in International Mathematics and Science Study (TIMMS) (International Association for the Evaluation of Educational Achievement [IEA], 2023).

A crucial aspect of teaching in the South African context is language. In multilingual classrooms, the way scientific concepts are introduced affects learners' understanding and engagement. This study acknowledges the role of language in science education and considers how linguistic diversity influences the proposed framework, ensuring a more inclusive and effective approach to teaching Natural Science in the Foundation Phase.

To raise the standard of teaching and learning in the FP, there is a pressing need to invest in professional development (PD), curricular development and curricular improvements (DoBE, 2011-2023). Emphasising inquiry-based teaching rooted in constructivist theory can empower learners to develop a deeper understanding of scientific concepts. The issue needs to be addressed urgently (DoBE, 2011-2023).

1.2 RATIONALE AND CONTEXT

In 2023, the DoBE's Circular S5 introduced a reduction in the time devoted to Life Skills to recover Mathematics and Languages learning hours lost during the COVID-19 pandemic, a policy now implemented nationally. While aiming to bolster Language and Mathematics through increased instructional time, this change elevated concerns about the erosion of Life Skills, which covers areas such as Physical Education, Creative Arts, Social Science, Technology and NS (DoBE, 2011:6). Reducing Life Skills by up to 3 hours per week inevitably curtails the development of NS skills in FP learners (Khosa, 2022).

The circular acknowledges the importance of integrating Life Skills with Mathematics and Language but places a burden on teachers, largely because of a lack guidance as to how to use the increased Language (Reading) and Mathematics time. A more balanced approach is needed to ensure that the integrity of all subjects is maintained. While the increased focus on Reading and Mathematics is crucial for academic success, it can inadvertently minimise the importance of other equally beneficial subjects, such as Natural Science (Fullan, 2016). Exploring ways to reinforce Language (Reading) and Mathematics through existing Life Skills content could offer a more sustainable solution, during the learning recovery period and beyond. This would support the development of critical thinking, emotional intelligence and problem-solving abilities, ensuring that learners are prepared for both academic and life challenges. However, any remedy involving interdisciplinary, integrative learning to reinforce important basic skills must continue to respect the distinct nature of NS and scientific inquiry.

CAPS outlines a comprehensive FP curriculum aimed at producing well-rounded critical thinkers and problem solvers. As a former Western Cape Education Department (WCED) Curriculum Advisor and now a curriculum planner, this researcher has discovered, however, that the focus in FP continues to rest, primarily, on Mathematics and Languages while Life Skills, which includes NS, the focus of this study, has been marginalised (Bosman, 2017; James et al., 2019). Strong language skills and the ability to read with comprehension are vital for effective communication, while a sound foundation in Mathematics enhances critical thinking and problem solving. According to the CAPS, learning NS reinforces these skills. Through hands-on inquiry, learners develop vocabulary, enhance their ability to articulate observations, reach logical conclusions and acquire scientific literacy. This, in turn, facilitates the understanding of mathematical concepts, reasoning and data analysis in real-world contexts. A holistic approach helps to realise the goal of a balanced education (DoBE, 2011; Spaull & Jansen, 2019). FP is a critical period in which young learners have limitless curiosity, and an interest in scientific inquiry and a love for learning can be ignited in them. Sparking the habit of inquiry in these early years through science education cultivates collaboration, exploration, experimentation, critical thinking and problem solving that benefit not only Science but also Languages and Mathematics.

The researcher’s experience, coupled with observations of School-Based Assessments (SBAs), and the WCED’s Systemic Assessments (conducted in the Western Cape only), have revealed a concerning trend. Learners are performing well in internal assessments for Language and Mathematics (SBAs), yet not nearly as well in assessments conducted externally. For instance, the Systemic Assessments reveal that 78% of learners cannot read for meaning. In Life Skills SBAs, which include Beginning Knowledge (Social Science, NS and Technology) with a weighting of forty per cent (40%), the high scores are even more pronounced (> 92%). Since learners must apply essentially the same skills in Language and Life Skills (recognise patterns, read data, problem solve, analyse and interpret), the discrepancy between learners' scores for Home Language and Life Skills is worrying. It raises concerns both about the accuracy of these internal assessments and about teaching practices and skills development in Life Skills, especially within the NS component.

While Home Language and Mathematics may involve critical thinking and communication skills, NS demands a deep understanding of these very same concepts. Crucial for scientific inquiry are skills such as making predictions, offering explanations, posing questions, applying process skills, recording and interpreting data, generating solutions, and designing and drawing conclusions (DoBE, 2011; McDonnough & Henschel, 2015). Although approached in a playful and fun-filled manner, these skills are taught and mastered during the FP, establishing a strong foundation to prepare learners for transition to the Intermediate and Senior Phases (ISPs). Presently, as noted above, learners consistently achieve high scores in Life Skills, which includes NS, but there appears to be a discrepancy between this achievement and their actual skills development. This discrepancy is concerning, suggesting a disconnect between assessment practices and application, particularly in the NS skills such as observation, critical thinking, inferring, evaluation and problem solving. If learners can perform well in these assessments, why are they struggling with reading for meaning?

The low scores in external assessments for Home Language, particularly in skills such as reading (predictions), comprehension and writing, and in Mathematics (problem solving, patterns and data handling, etc.) suggests that learners are not acquiring these essential skills (Spaull & Jansen, 2019). Fundamental critical thinking and problem-solving skills are taught and reinforced in science education, with an emphasis on executive functioning, highlighting the common set of competencies and skills developed in knowledge application across the range of school subjects (Dixon et al., 2018). These are the same skills purportedly assessed in Life Skills. The disparity hints at the possibility that the assessments focus on rote memorisation over scientific inquiry and the application of critical thinking skills. Teachers may not have been trained to teach NS or they might have lower expectations for science instruction compared to the core subjects (Dixon et al., 2018).

Failure to train teachers to teach scientific literacy effectively in the FP has broader consequences (Mullis et al., 2021). Strong recommendations from assessments such as Trends in Mathematics and Science (TIMMS) have gone unheeded, leading to a persistent cycle of missed opportunities (Mullis et al., 2021). If teachers are not teaching NS because of a lack of knowledge, this impacts on learners' foundational knowledge and critical thinking skills, hindering academic success. This is reflected in South Africa's continuing underperformance in the TIMMS and Progress in International Reading Literacy (PIRLS) assessments (Mullis et al., 2021). Regardless of the CAPS curriculum, the success of teaching NS ultimately depends upon lessons provided by well-trained and informed teachers (Bagherzadehla & Tejeddin, 2020). Many teachers appear to lack experience or prior training in Science and inquiry-based pedagogy. To bridge this gap, comprehensive professional development programmes are crucial. Such professional development programmes should equip teachers with the necessary NS content knowledge (CK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) for NS education (Shulman & Shulman, 2004; Evens et al., 2018; Chuene & Singh, 2024). Additionally, integrating technological pedagogical knowledge and content knowledge (TPACK) can help teachers develop more varied and effective learning experiences which include their lived, observed or perceived interactions, events and processes encountered (Petr, 2013; Durden, 2016; Kartini et al., 2022).

Research frequently deplores the gap between theory and practice when referring to teachers' inability to translate what they have learned into actual classroom practice (Mohajerzad et al., 2021; Andrews et al., 2022; Levy Morchio, 2022; Phillips & Condy, 2023). Inadequate training and out-of-field teaching have been identified as being part of FP teachers' plight, together with the stark underperformance of FP learners (Luft et al., 2020). This research project aims to explore NTs' interpretation of NS in CAPS and the strategies they employ to teach the subject in FP classrooms in the Western Cape (WC). The preparedness of NTs is investigated, to gain insight into their knowledge base regarding content and pedagogy. The study seeks to understand the nature of the NTs' execution of theory and practice. By focusing on professional development initiatives and curricula enhancements, the study aspires to promote an inquiry-based teaching approach to science education in FP classrooms. The purpose is to help learners develop into competent critical thinkers and problem solvers, thus enriching their overall educational experience (Almeida et al., 2019).

This research aims to develop an IP for NTs. What is envisaged is a flexible and comprehensive programme addressing a variety of needs to equip NTs with the requisite knowledge, skills and pedagogy to encourage reflective practice and the adoption of practical and adaptable strategies to teach NS effectively in FP classrooms. The goal is to educate our FP learners in science education by using a variety of learning media to develop critical thinking, problem-solving abilities, strong communication skills and a deeper understanding of the world (Kartini et al., 2022).

It is hoped that the research project can be a catalyst for change, informing policy decisions within the DoBE and in professional development, and leading to a more engaging FP NS curriculum that prioritises scientific exploration. This shift has the potential to empower teachers to develop the well-rounded learners envisaged by CAPS, nurturing curious, critical thinkers; learners who can read, write and calculate and are empowered to thrive in a world that requires these skills (DoBE, 2011).

1.3 SIGNIFICANCE OF THE STUDY

The research study emerged from my observations as a senior curriculum planner (SCP) for Life Skills – in particular NS – in the WCED. It seeks to address critical issues identified such as that the Life Skills curriculum is too dense, that there is a lack of explicit content and subject knowledge, and that there are few explicit NS topics accompanied by suitable pedagogy. These aspects are highlighted in the findings of Beni et al. (2017), Bosman (2017), Dixon et al. (2018), James et al. (2019), Nhase (2019), and Chuene and Singh (2024).

The study seeks to identify and remedy gaps in the specialised knowledge of generalist FP teachers required to teach NS. Little research has been conducted in South Africa in this specific field. What research has been done overseas does not fall within the ambit of a system like CAPS and is therefore of no real value in this context. The existing literature underscores the challenges that out-of-field (non-specialist) FP NTs face when trying to engage their learners in scientific inquiry. By exploring the shortcomings in FP NTs' knowledge and investigating the potential of inquiry-based pedagogy, this study aims to show how teachers can acquire the skills and competencies needed to teach NS and scientific literacy effectively in a CAPS environment in South Africa.

The goal is to capacitate NTs with specialised knowledge and practical strategies to improve their confidence and competence in teaching NS. The specific focus on inquiry-based teaching aims to develop skills such as critical thinking, problem-solving, effective teaching strategies and classroom management. These are essential for learner-centred, interactive learning environments as envisaged by constructivist theory.

The findings will inform professional development programmes and contribute to the broader field of educational research by presenting strategies to bridge the gap between generalist teaching and subject-specific pedagogy in the teaching of scientific literacy. The framework to be developed will serve as a guide for NTs who do not have strong specialised knowledge of NS to enable them to integrate NS into the curriculum. Previous research has pointed to a lack of sufficient knowledge as an impediment to teaching NS in FP (Bosman, 2017; James et al., 2019) because it tends to result in monotonous, uninspired lessons (Kartini et al., 2022). The programme will mitigate such shortcomings.

The impact of being exposed to NS at an early age improves learners' future choices and empowers them to become productive citizens, acquiring the scarce skills needed to meet the challenges of the fourth industrial revolution (4IR).

1.4 RESEARCH QUESTIONS AND OBJECTIVES OF THE STUDY

The main research question that the study seeks to answer is: "What framework can be developed to support novice teachers' instruction competencies in Natural Science (NS) in the Foundation Phase (FP)"?

In order to answer the main research question, the following three sub-questions are posed:

i) What were the novice teachers' experiences and understandings of the teaching of Natural Science **before** the intervention programme?

ii) How did the novice teachers develop cognitive and higher-order thinking abilities **during** the intervention programme?

iii) What were the novice teachers' experiences and understandings of the teaching of Natural Science **after** the intervention programme?

The central objective of the study is to develop a framework to facilitate FP NTs' professional development by adjusting their discourse on and approaches to teaching NS in FP classes. To achieve this, the following sub-objectives are pursued:

1. To examine the novice teachers' (NTs') experiences (challenges, applications and reflections) and understandings (the cognitive processing that occurs after the experience - knowledge, insights and interpretations) of teaching Natural Science – their content knowledge, pedagogical content knowledge and instruction competencies – before the intervention programme (IP).
2. To investigate how the teachers develop cognitively (including conceptual and skills development) during the IP through a process of collaboration and reflective practices and the creation of shared meaning to change their perspective and professional discourse, developing self-concept and resolution.
3. To investigate affective changes in the NTs (attitudes, values, skills and behaviours) and the effect this had on their cognitive development and professional discourse.

1.5 ASSUMPTIONS OF THE STUDY

In this research study, several reasonable assumptions have been made. First, that the NTs were teaching in FP classes Grade 1 to 3 and that they were trained to teach all FP subjects with a working knowledge of the instructional pedagogies of all the disciplines. Second, that the NTs who had recently entered the FP teaching fraternity and who were participants in this study were representative of NTs in the sense of possessing a limited content knowledge of NS. Third, that they possessed a desire to improve their instructional competencies and would be motivated to apply the acquired theory, teaching strategies, pedagogy and reflective practice, journaling their thoughts and progress during the IP.

1.6 CONTRIBUTION OF THE STUDY

This study makes an academic contribution by developing an inquiry-based intervention to boost teachers' capacity to teach NS. It presents a new framework to support DoBE policy and promote professional development, offering a guide for continuous professional development (CPD) that addresses gaps identified in the key Life Skills NS Curriculum and Assessment Policy Statement. The findings will inform CPD and contribute to the broader field of educational research by suggesting strategies to build bridges among generalist and subject-specific pedagogy, policymakers, Higher Education Institutions (HEIs), curriculum designers for professional development programmes, and educational institutions. By integrating cognitive, affective, collaborative, and reflective practices, the intervention programme offers a scalable model for fostering inquiry-driven pedagogical practices that can enrich teacher training programmes and curriculum development, ultimately promoting more effective NS education in FP.

1.7 CLARIFICATION OF KEY CONCEPTS

The following terms are explained to ensure that readers understand their use in this study:

1.7.1 Curriculum
1.7.2 Foundation Phase
1.7.3 Life Skills
1.7.4 Novice teacher
1.7.5 Natural Science
1.7.6 Scientific concepts
1.7.7 Scientific process skills
1.7.8 Scientific attitudes and values
1.7.9 Scientific literacy
1.7.10 The nature of science

1.7.11 Pedagogy
1.7.12 Inquiry-based teaching

1.7.1 Curriculum

The term “curriculum” encompasses the planned sequence of learning experiences and content offered to learners to develop understanding, skills, values and attitudes within an educational programme. The curriculum defines what learners should learn, how they will learn it and how their learning will be measured (Young, 2014). “Curriculum” can also refer to the interdisciplinary study of educational experience (Deng, 2017).

1.7.2 Foundation Phase

The FP is the first phase of formal schooling in South Africa, catering for children aged 5 to 9. The phase stretches from the Reception Year, known as Grade R (5-6 years of age) to Grade 3 (± 9 years of age).

1.7.3 Life Skills

The subject Life Skills in CAPS for FP (Grades R-3) is organised into four study areas: Beginning Knowledge (Introducing NS, Social Science and Technology), Personal and Social Wellbeing (social and emotional skills), Creative Arts (Performing Arts: music, dance, drama and visual arts) and Physical Education (Dixon et al., 2018).

1.7.4 Novice teacher

According to the Minimum Requirements for Teacher Education Qualifications (MRTEQ) (South Africa: Department of Higher Education and Training, 2015), a new or novice teacher (NT) is a graduate who has completed their professional qualifications (Relative Education Qualification Value 14 [REQV 14]) at an HEI and been appointed to teach at a South African public school for the first time. REQV is a system that standardises educational qualifications to ensure that teachers are qualified to enter the profession. Some researchers view an NT as a qualified teacher with 2 years of experience (Haynes, 2011), while for others an NT is a teacher who has taught for fewer than 5 years (Graham et al., 2020). Ulvik et al. (2017) generalise the descriptor by characterising NTs as teachers with little or no teaching experience.

1.7.5 Natural Science

Natural Science is a systematic endeavour to understand the natural world. Science is concerned with the description, prediction and understanding of natural phenomena. Such understanding is based on empirical evidence from observation and experimentation (Miah, 2020).

1.7.6 Natural Science concepts

The CAPS identifies four science concepts (within its content knowledge), known as knowledge strands in Intermediate and Senior Phase: (i) Life and Living; (ii) Matter and Materials; (iii) Energy and Change, and (iv) Planet, Earth and Beyond (DoE, 2011:8). Each of these broad concepts includes many interconnected layers of ideas. For example, Matter and Materials includes the states of matter, properties of different materials, how substances combine to make mixtures, and chemical reactions. Knowledge of all this is known as subject matter knowledge (SMK).

1.7.7 Natural Scientific process skills

The FP NS curriculum outlines six scientific process skills that ought to underlie inquiry-based learning: (i) observing, (ii) comparing, (iii) classifying, (iv) measuring, (v) experimenting and (vi) communicating (DoBE, 2011). These skills are employed in a hands-on manner in scientific investigations to develop evidence-based scientific knowledge, which refers to systematic understanding and explanations of natural phenomena which originates through observation, experimentation, and reasoning (Bell, 2009). Additionally, indigenous knowledge (IK), which is based on centuries of lived experiences, environmental interactions, and cultural practices, further contributes to scientific understanding.

1.7.8 Scientific attitudes and values

Scientific attitudes are the habits of mind or dispositions essential for carrying out scientific investigations and understanding scientific knowledge. These attitudes include: (i) curiosity, (ii) scepticism, (iii) open-mindedness, (iv) objectivity, (v) critical thinking, (vi) integrity, (vii) honesty and (viii) perseverance. Such attitudes are essential for scientific inquiry, as they enable researchers to engage in rigorous, unbiased and evidence-based investigations (Lederman & Lederman, 2021).

1.7.9 Scientific literacy

Scientific literacy is a multifaceted concept encompassing the knowledge and skills necessary to understand and engage with NS. It is not just about memorising facts and specialised vocabulary, but rather about developing a deeper understanding of the scientific process and how science is used in the world around us. Scientific knowledge is acquired and produced through systematic exploration, observation, and inquiry (scientific research), enabling learners to develop an understanding of natural phenomena based on evidence and logical reasoning. It is high-grade knowledge, that is, knowledge that satisfies demanding epistemic standards and that, as a result, is highly reliable, robust, or well-established.

1.7.10 Nature of science (NoS)

The phrase ‘nature of science’ (NoS) typically refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent in the development of scientific knowledge (Lederman, 2019). The National Science Education Standards (NRC,1996) emphasises the historical, tentative, empirical, logical, and well-substantiated nature of scientific claims. NoS is a broader understanding of science itself. NoS is not only derived from the eight science practices delineated in the *Framework for K–12 Science Education* (National Research Council, 2012), but also incorporates an understanding of how scientific knowledge is developed, proven and communicated. It includes knowledge of the characteristics of scientific inquiry and recognition of the role of creativity and imagination in science.

1.7.11 Pedagogy

Pedagogy is defined as the philosophy and theory of teaching and learning (Lang, 2021), It encompasses the overall approach to the instructional process, including methods and strategies. It involves understanding learners' needs, designing effective learning experiences, and promoting active engagement and critical thinking skills (Biesta, 2015). In this study, pedagogy refers to the influence of factors such as educational philosophies, learning theories and societal contexts, and considers the big picture of how knowledge is transmitted, skills are developed, and learners are engaged. Pedagogy is not limited to the transmission of knowledge, but also seeks to foster a learner-centred approach to develop learners' social, emotional, and cognitive abilities. Pedagogy is considered a fundamental pillar in the field of education as it provides a framework for effective teaching practices and facilitates the achievement of educational outcomes (Biesta, 2015).

1.7.12 Inquiry-based teaching

Inquiry-based teaching (IBT) is a learner-centred teaching method that encourages learners to investigate real-world problems. It is a form of active learning that starts with posing questions or problems and progresses through phases (Ødegaard et al., 2014). Learners co-create knowledge through collaboration and hands-on experiences by exploring, experiencing and discussing in a structured or guided process of investigation (Kawalkar & Vijapurkar, 2015).

1.8 THEORETICAL AND CONCEPTUAL FRAMEWORKS

Theoretical and conceptual frameworks were selected or constructed to suit the ambit and nature of the study. The frameworks include Strampel and Oliver’s (2007) levels of reflection, which incorporate social, cognitive and teaching presence; Bloom’s taxonomy (1956), with its six categories of knowledge as a continuum from simple to complex levels of critical thinking; the community of inquiry (Garrison et al., 2000) in John Dewey’s progressive understanding of education; and the theory of adult learning or andragogy, that emphasises NTs’ participation, readiness to learn, self-image, experience, willingness, orientation and motivation to learn (Kearsley, 2010).

1.9 OVERVIEW OF THE RESEARCH DESIGN AND METHODOLOGY

The research study was grounded in the interpretive paradigm and adopted a qualitative approach and collective case study design. The study’s design enabled exploration and analysis of multiple cases (Merriam & Tisdell, 2016; Frey, 2018; Creswell & Creswell, 2022), while the qualitative approach facilitated in-depth examination and critical interpretation of the NTs’ subjective experience: their perspectives, constructed meanings, challenges and changing discourse regarding teaching NS (Creswell & Poth, 2018).

The study was conducted in three urban, public primary schools within the Metro Central Education District in the Western Cape. Seven Foundation Phase participants who had been teaching for fewer than three years (novice teachers) were purposively selected. Multiple qualitative instruments were used to collect data from, and about, them. These included a questionnaire to obtain biographical details, semi-structured individual pre-interviews and classroom observations. The observations provided insights into the NTs' perceptions, lived experiences, processes and teaching practices before the study, and these informed the development of the intervention programme (IP). The IP was conducted via Microsoft TEAMS. The researcher made field notes and the NTs compiled reflective journals during the IP. They were encouraged to document their thoughts about their learning, teaching practices, successes, challenges and goals. Individual interviews were conducted after the IP to determine the NTs' teaching experiences and ascertain whether they had been able to continue with inquiry-based teaching. Collectively, these instruments provided an understanding of the NTs' knowledge, skills, practices and reflections.

The data was analysed in a multi-layered, structured way, using both deductive and inductive approaches (Saldaña, 2021). The study's trustworthiness was sustained throughout the data generation and data analysis processes, ensuring its reliability by emphasising its credibility, transferability, dependability and confirmability (Creswell & Poth, 2018).

All the necessary protocols were observed, such as obtaining ethical clearance from the Cape Peninsula University of Technology, permission to conduct research from the Western Cape Education Department and informed consent from the principal and the NTs in the study. All ethical requirements were scrupulously met, including preserving the anonymity of the participants and their schools.

1.10 LIMITATIONS OF THE STUDY

The limitations of any study stem from the factors that influence its scope (Creswell & Creswell, 2022). This study experienced several limitations. First, the data generation period (2021) coincided with the COVID pandemic, which presented unique challenges to the participating novice teachers as they grappled with the demands of adapting to an intense and unprecedented situation. Another limitation was the relatively small sample size, which was further reduced by the departure of two NTs after the preliminary interviews. One NT cited the overwhelming stress of the COVID situation, while the other was relocating to a different Metro District school. A third NT withdrew from the study due to personal bereavement. This reduction highlighted the constraints of conducting research during the COVID-19 period, but also underlined the resilience and adaptability of the research design.

The researcher encountered constraints resulting from her physical absence from the NTs' classrooms during their teaching practice and her inability to be present in the same room during focus group sessions. The sessions that would have been face-to-face were instead conducted via the Microsoft TEAMS platform. This was a limitation because of the practical nature of the programme. It was mitigated by using short videos to showcase pedagogical practices or experiments, the regular classroom practice activities and the reflections thereafter.

The circumstances described also hindered the researcher's ability directly to observe essential details such as expressions and gestures, which might have provided deeper insights into the participants' cognitive status. The researcher tried to compensate for these limitations by asking participants to keep their cameras on during the sessions or when they wanted to communicate, though this was not always possible due to connectivity problems. Despite this situation not being conducive to the capture of all the nuances of communication, valuable insights were gained.

1.11 ORGANISATION OF THE THESIS

As the introductory chapter, Chapter 1 serves as the foundation of this research report, outlining the study's background, rationale, context and significance, detailing its research questions and objectives, assumptions, limitations and overall contribution. Key concepts are clarified and an overview of the research design and methodology is provided. The chapter concludes with a chapter-by-chapter anatomy of the structure of the thesis.

Chapter 2 critically reviews the literature pertinent to the study. Topics covered include the National Curriculum (Curriculum and Assessment Policy Statement), qualifications and pedagogical practices, lesson planning, self-efficacy and the notion of the reflective practitioner. The chapter concludes with a summary synthesis of the international and national literature reviewed.

Chapter 3 discusses the five key theoretical frameworks that underpin the empirical enquiry in the study: Shulman's (1986) theory of pedagogical content knowledge (PCK), Strampel and Oliver's levels of reflection (2007), Bloom's taxonomy (1956), the theory of andragogy (Knowles, 1984), and Garrison et al.'s (2000) community of inquiry.

Chapter 4 introduces the study's research paradigm, research approach, research design and research methodology. The research sites, participant selection and piloting of the instruments are described. Details are furnished regarding the data generation instruments, including the questionnaire, pre-interviews, pre-observations, the intervention, post-observations, as well as informal discussions and journal entries. The chapter also discusses data analysis, trustworthiness, the researcher's role and ethical considerations.

Chapter 5 introduces the findings in respect of Research Question (RQ) 1, and offers detailed discussion and analysis of the novice teachers' initial professional discourse on the teaching of NS.

Chapter 6 explicates the findings regarding RQ 2, presenting a comprehensive analysis of the lived experiences and challenges faced by the NTs in teaching NS during the eight-week IP.

Chapter 7 presents the findings that respond to RQ 3, regarding the NTs' teaching experiences, processes and understandings of teaching NS after participating in the eight-week IP.

Chapter 8 provides an overview of the results pertaining to RQs 1, 2 and 3 and describes the development of the Collaborative, Reflective and Cognitive Development conceptual framework (CRCD) to support NTs.

Chapter 9 presents an overview of the study, offering a summary of its key findings, some theoretical and conceptual reflections, and several recommendations. The chapter concludes with an estimate of the contribution of the study to the existing body of knowledge.

CHAPTER 2

LITERATURE REVIEW

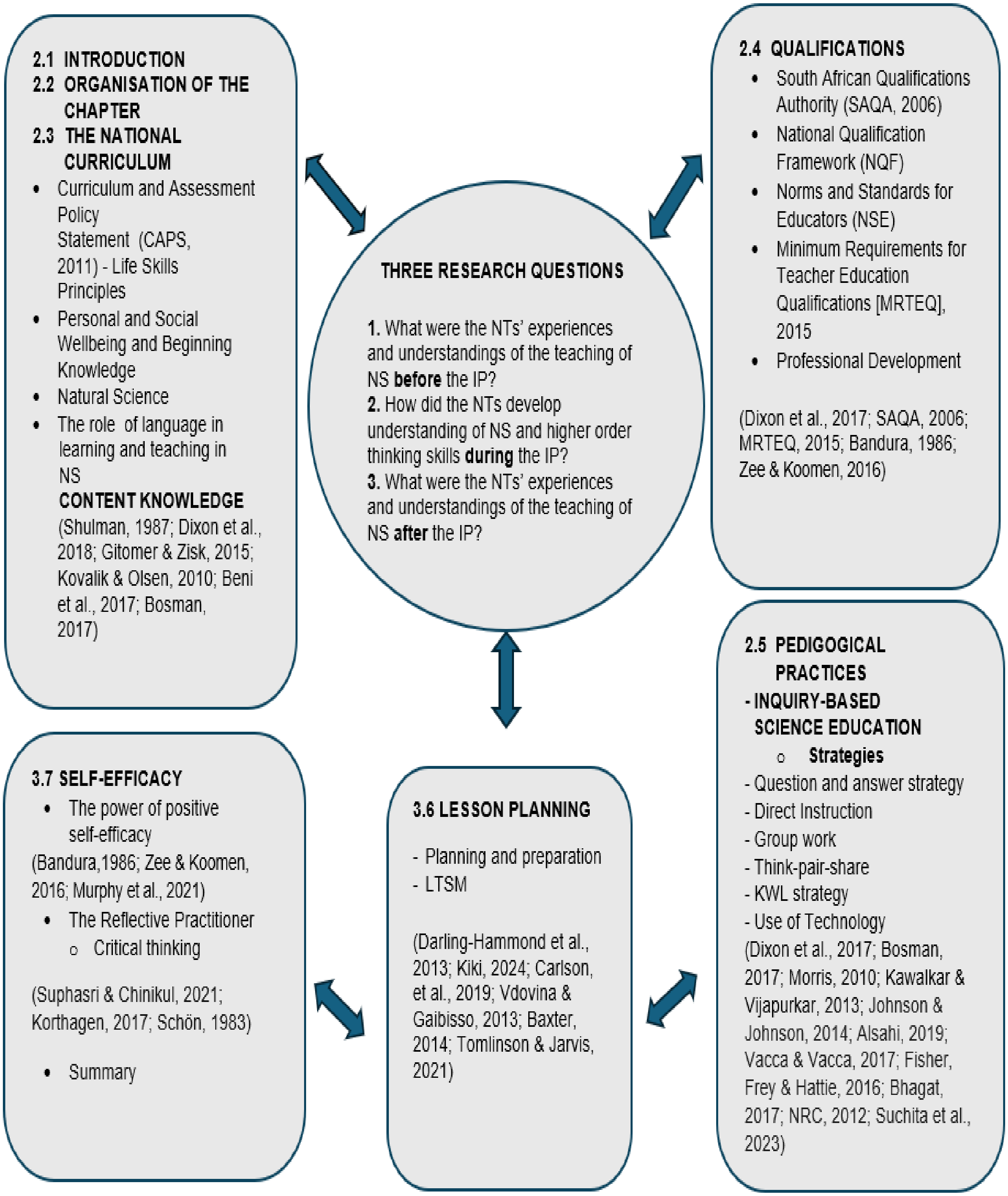
2.1 INTRODUCTION

Effective Natural Science (NS) teaching in the Foundation Phase (FP) is crucial for inculcating scientific literacy and critical thinking skills among young learners. Qualified novice teachers (NTs) often find it difficult, however, to translate theoretical knowledge into effective classroom practice. This research project investigates the preparedness of four qualified FP NTs teaching NS in the Western Cape Province of South Africa. The study focuses on how four NTs (1, 4, 5 and 7) interpreted the Curriculum and Assessment Policy Statement document (DoBE, 2011) and assesses their proficiency in CK and pedagogical CK (PCK), as well as their application of this knowledge in the classroom. The data collected informed the development of a targeted intervention program (IP) designed to address the identified needs and challenges of the NTs in delivering NS education. By bridging the theory-practice gap, the research aspired to cultivate a more confident and adept cohort of NTs, ultimately reducing barriers to effective NS teaching by improving attitudes towards the teaching of this important subject.

2.2 ORGANISATION OF THE CHAPTER

This chapter critically reviews and discusses literature relevant to the primary objective of the thesis, exploring the identified shortcomings in teacher preparedness in NS, with a specific focus on bridging the gap between theory in the curriculum and practice in the classroom by bringing to light what is “hidden” or “missing” in the Life Skills curriculum.

The literature review draws upon international and national research pertinent to aspects of the CAPS (2011) NS document for FP NTs. The objective of reviewing relevant sources is to position the study within the broader body of knowledge and to gain a comprehensive perspective on the teaching of NS in the FP. Figure 2.1, below, provides a visual representation of the theoretical and applied concepts of research explored and discussed in this chapter:



2.1 INTRODUCTION
2.2 ORGANISATION OF THE CHAPTER
2.3 THE NATIONAL CURRICULUM

- Curriculum and Assessment Policy Statement (CAPS, 2011) - Life Skills Principles
- Personal and Social Wellbeing and Beginning Knowledge
- Natural Science
- The role of language in learning and teaching in NS

CONTENT KNOWLEDGE
(Shulman, 1987; Dixon et al., 2018; Gitomer & Zisk, 2015; Kovalik & Olsen, 2010; Beni et al., 2017; Bosman, 2017)

THREE RESEARCH QUESTIONS

1. What were the NTs' experiences and understandings of the teaching of NS **before** the IP?
2. How did the NTs develop understanding of NS and higher order thinking skills **during** the IP?
3. What were the NTs' experiences and understandings of the teaching of NS **after** the IP?

2.4 QUALIFICATIONS

- South African Qualifications Authority (SAQA, 2006)
- National Qualification Framework (NQF)
- Norms and Standards for Educators (NSE)
- Minimum Requirements for Teacher Education Qualifications [MRTEQ], 2015
- Professional Development

(Dixon et al., 2017; SAQA, 2006; MRTEQ, 2015; Bandura, 1986; Zee & Koomen, 2016)

2.5 PEDIGOGICAL PRACTICES
- INQUIRY-BASED SCIENCE EDUCATION
  - **Strategies**

- Question and answer strategy
- Direct Instruction
- Group work
- Think-pair-share
- KWL strategy
- Use of Technology

(Dixon et al., 2017; Bosman, 2017; Morris, 2010; Kawalkar & Vijapurkar, 2013; Johnson & Johnson, 2014; Alsahi, 2019; Vacca & Vacca, 2017; Fisher, Frey & Hattie, 2016; Bhagat, 2017; NRC, 2012; Suchita et al., 2023)

3.6 LESSON PLANNING

- Planning and preparation
- LTSM

(Darling-Hammond et al., 2013; Kiki, 2024; Carlson, et al., 2019; Vdovina & Gaibisso, 2013; Baxter, 2014; Tomlinson & Jarvis, 2021)

3.7 SELF-EFFICACY

- The power of positive self-efficacy

(Bandura,1986; Zee & Koomen, 2016; Murphy et al., 2021)

- The Reflective Practitioner
  - Critical thinking

(Suphasri & Chinikul, 2021; Korthagen, 2017; Schön, 1983)

- Summary

Figure 2.1: An overview of the components of the investigation

2.3 THE NATIONAL CURRICULUM

The foundation for lifelong learning is laid in the early years of education. Building upon the DoBE's reform efforts (as outlined in the 2011 policy document and referenced in Chapter 1), the current curriculum implementation for Grades R to 10 commenced in 2012. This research project scrutinises the Foundation Phase (FP) Life Skills curriculum, with a particular focus on Natural Science. Specifically, it examines the following:

2. 3.1 Core principles of the CAPS (2011) document
2.3.2 Aims of the CAPS (2011) document
2.3.3 Foundation Phase (FP) Curriculum and Assessment Policy Statement (CAPS) – Life Skills
2.3.3.1 Personal and social wellbeing and beginning knowledge in Life Skills
2.3.3.2 Natural Science: The four NS concepts
2.3.3.3 Natural Science: The six scientific process skills
2.3.3.4 Natural Science (NS): topics
2.3.3.5 Challenges in the FP NS curriculum
2.3.3.6 Time constraints and challenges
2.3.3.7 The importance of language in teaching and learning Natural Science
a. Scientific vocabulary, and
b. The power of 'talk' in scientific discourse.

By exploring these elements, the subsequent sections offer an overview of early childhood education in South Africa. The CAPS curriculum (DoBE, 2011) prioritises the development of critical thinking and essential skill development in SA education. It outlines a learner-centred approach embodying several core principles intended to ensure educational quality and equity. However, the Life Skills document has presented significant challenges, including limited explicit coverage of CK, unclear curriculum guidelines, inadequate provision of subject matter knowledge (SMT), inadequate pedagogical content knowledge, and underestimated times for instruction. These shortcomings impede the achievement of the high standards envisioned by the learner-centred curriculum. The next section introduces the core principles of CAPS and discusses how they are interrelated in striving to achieving the aims envisaged.

2.3.1 Core principles of the CAPS (2011) document

South Africa's education system is guided by ambitious and well-intentioned principles aimed at improving teaching practices and addressing the shortcomings of the past curriculum. These principles include:

i) social transformation, ensuring quality educational opportunities for all
ii) active and critical learning, developing critical thinking and problem solving
iii) high knowledge and high skills, provision of demanding, yet age-appropriate standards
iv) progression, emphasising continuous learning development
v) human rights
vi) inclusivity, environmental and social justice, promoting diversity and fostering social and environmental responsibility
vii) valuing indigenous knowledge systems, aiming to integrate South Africa's rich cultural heritage and
viii) credibility, quality and efficiency, aiming for global education standards (DoBE, 2011: 4-5).

2.3.2 The aims of the CAPS (2011) document

The core principles and aims are inextricably linked and form the basis for continuous, life-long learning to prepare learners for a changing world. The CAPS document seeks to develop learners as global-minded citizens, integrating humane values and environmental responsibility. It references the National Curriculum Statement's (South Africa: Department of Education, 2002) aim to produce learners who can think critically and solve problems, with an even greater emphasis on developing critical thinking skills. The seven declared aims of CAPS (2011) are examined through the lens of inquiry-based teaching (DoBE, 2011:8) in the paragraphs that follow. What becomes clear is the crucial role that NS plays in fostering not only scientific understanding but also essential life skills for young learners.

The CAPS document aims to produce learners who are able to:

1. Identify and solve problems and make decisions using critical and creative thinking,
2. Work effectively as individuals and with others as members of a team,
3. Organise and manage themselves and their activities responsibly and effectively,
4. Collect, analyse, organise and critically evaluate information,
5. Communicate effectively using visual, symbolic and/or language skills in various modes,
6. Use science and technology effectively and critically showing responsibility towards the environment and the health of others, and
7. Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

Developing critical thinking skills during the inquiry process is fundamental (Pedaste et al., 2015; Lai & Hwang, 2016). NS education encourages questioning, exploration, idea generation, the critical analysis of objects, creative problem solving and using the imagination to represent scientific ideas (Abraham, 2023). The emphasis on critical thinking skills stimulates learners to investigate, analyse and understand the world, not merely memorise facts.

Collaboration, practised as effective group work in inquiry, is an educational approach to teaching and learning which involves learners working together to solve a problem. The result is a rich learning experience for all (Laal & Laal, 2011). Johnson and Johnson (2015) found that cooperative learning strategies, such as those used in IBT, improved learners' ability to work effectively in teams.

To perform well, learners need to develop executive functioning skills to manage time, tasks and resources effectively, a capacity that is key to achieving one's goals in all areas of life (Diamond & Lee, 2011; McGlynn & Kelly, 2020). Such skills are developed through a well-established structure, including clear rules, routine procedures, set expectations and consistent classroom practices during NS lessons (Diamond & Lee, 2011). The approach empowers learners to take responsibility for their own learning.

The habit of collecting, analysing and evaluating information lays the groundwork for thinking critically and making informed decisions (Law, 2012). In NS, learners are taught to collect data through observation (counting, measuring) and experiment, to organise the information logically, to critically analyse and evaluate the results, and to draw conclusions (Pedaste et al., 2015).

Communication in classrooms assumes various forms to ensure the effective, clear and confident mediation of knowledge generation and explanation (Rachel et al., 2016). Learners learn to present their findings in multimodal ways, using drawings, data tables and simple charts. They learn to express scientific ideas in written reports and oral presentations and demonstrations (Bosman, 2017).

Science and technology are powerful tools, and it is important to introduce FP learners to the responsible use of these tools (Saravanakumar et al., 2023). Learners are taught scientific attitudes and values to acquire a sense of environmental responsibility and an awareness of the impact of science on their health and wellbeing (Petr, 2013). Such knowledge provides the basis for responsible decision-making in the future. Learners are introduced to the interconnectedness of the world across different subjects in the classroom (DoBE, 2011). They are encouraged to see problems from multiple perspectives and identify how systems interact. Systems thinking is a crucial skill in science, as the natural world is interconnected (Drake & Reid, 2018). The Life Skills curriculum deals with the topic of interconnectedness.

2.3.3 Foundation Phase (FP) Curriculum and Assessment Policy Statement (CAPS) – Life Skills

This section describes and explains the Foundation Phase curriculum. It offers an overview of the core subjects and describes the Life Skills curriculum and what it entails, focusing on science concepts and scientific process skills, the NS curriculum, the NS topics, challenges in the NS curriculum and notional time and constraints.

The South African FP CAPS (2011) document outlines four core subjects: Home Language, First Additional Language, Mathematics and Life Skills. Life Skills comprises four Study Areas namely: Beginning Knowledge (BK), Personal and Social Wellbeing (PSW), Creative Arts, and Physical Education (PE) (DoBE, 2011:8-9). Figure 2.2 is a visual representation of the four Life Skills study areas.

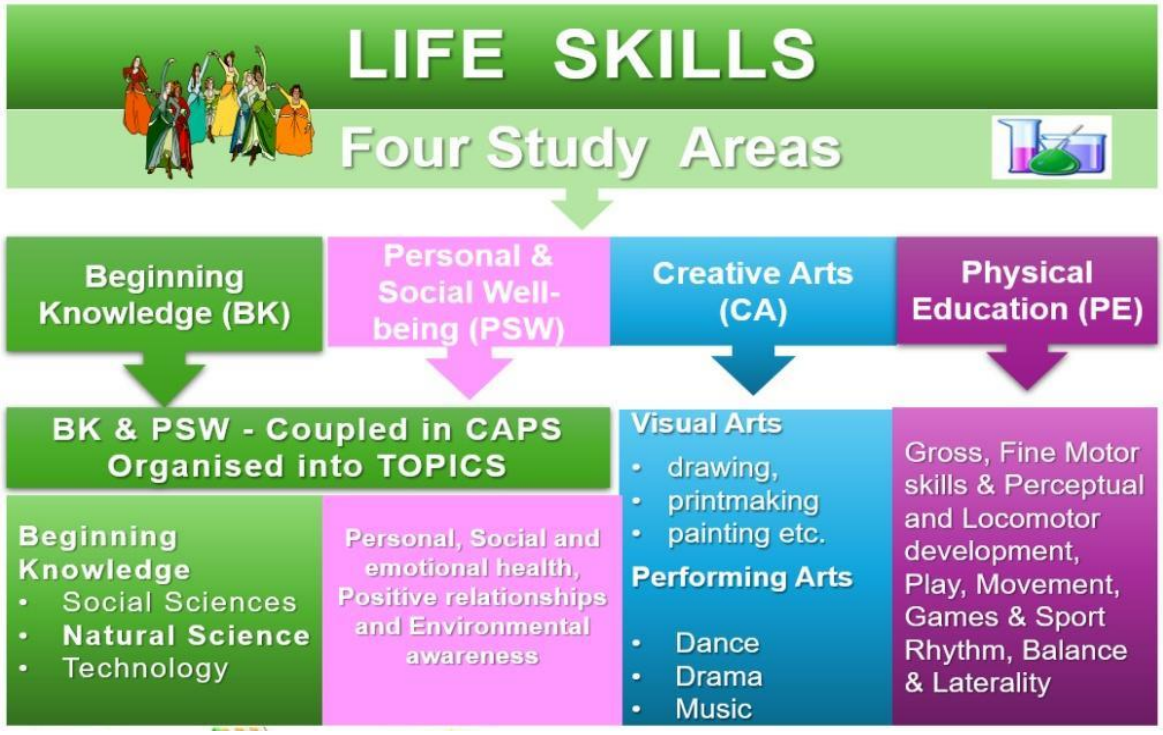


Figure 2.2: An overview of the four Study Areas listed in NS Life Skills (developed by the researcher)

Of the four Study Areas, the focus in this study rests upon BK and PSW. BK includes Social Science, NS and Technology (DoBE, 2011:6; Dixon et al., 2018).

2.3.3.1 Personal and Social Wellbeing and Beginning Knowledge in Life Skills

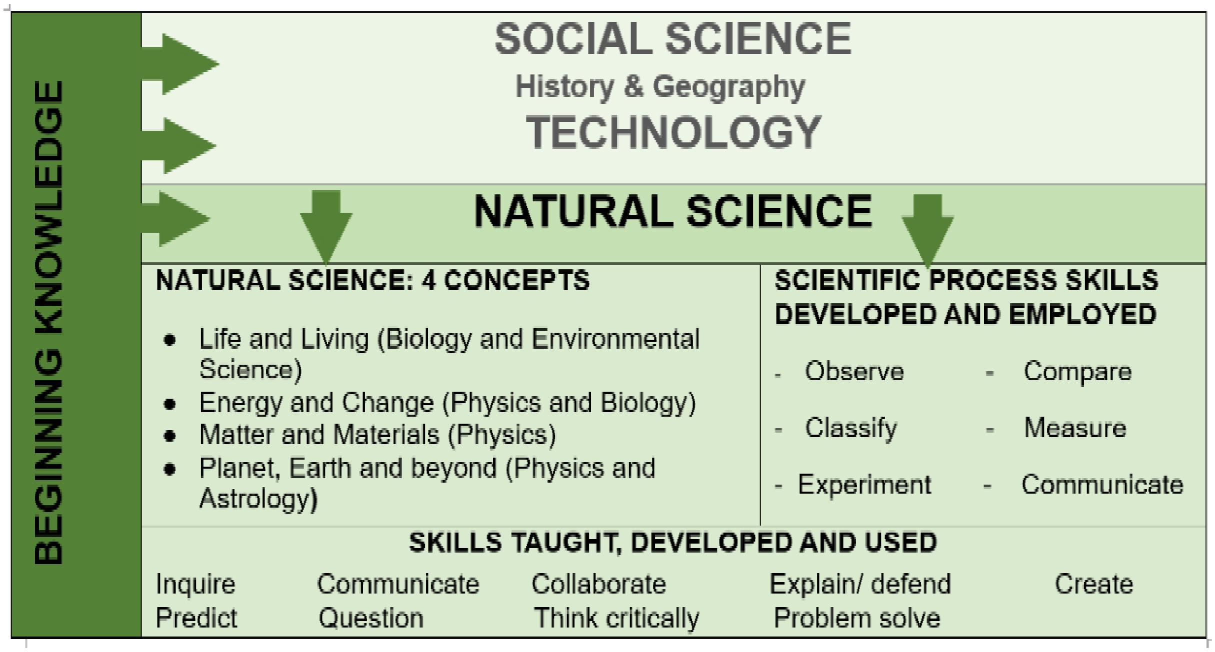
Personal and Social Wellbeing:

The study area of Personal and Social Wellbeing (PSW) in FP focuses on practical everyday knowledge to build a strong foundation for young learners (DoBE, 2011). PSW includes personal health, social and emotional health, positive relations and environmental awareness (Stroebel et al., 2017). According to Dixon et al. (2018), these aspects are appropriate at this developmental stage. However, there is little in the curriculum by way of disciplinary knowledge and pedagogy, which makes it difficult for teachers to plan and guide and teach their learners effectively.

Beginning Knowledge: This study area draws upon content and knowledge from specialised subjects: Social Sciences (History and Geography), Technology (Technological process skills) and NS (DoBE, 2011:8; Dixon et al., 2018). Each subject has its own content and skills that require conceptual understanding (Dixon et al., 2018). Table 2.1 presents an overview of Beginning Knowledge (BK), with a focus on NS.

In the Beginning Knowledge study area, there are four broad NS concepts and scientific process skills. The four concepts are: (i) Life and Living (ii) Matter and Materials (iii) Energy and Change and (iv) Planet Earth and Beyond. The scientific process skills include observing, comparing, classifying, measuring, experimenting and communicating (DoBE, 2011:8; Beni et al., 2017). In the next section, the four NS concepts are presented and discussed. This is followed by elaboration of the scientific process skills, referencing the CAPS document and current literature.

Table 2.1 An overview of Beginning Knowledge in FP with a particular focus on NS concepts



BEGINNING KNOWLEDGE

SOCIAL SCIENCE
History & Geography
TECHNOLOGY

NATURAL SCIENCE

NATURAL SCIENCE: 4 CONCEPTS

- Life and Living (Biology and Environmental Science)
- Energy and Change (Physics and Biology)
- Matter and Materials (Physics)
- Planet, Earth and beyond (Physics and Astrology)

SCIENTIFIC PROCESS SKILLS DEVELOPED AND EMPLOYED

- Observe
- Compare
- Classify
- Measure
- Experiment
- Communicate

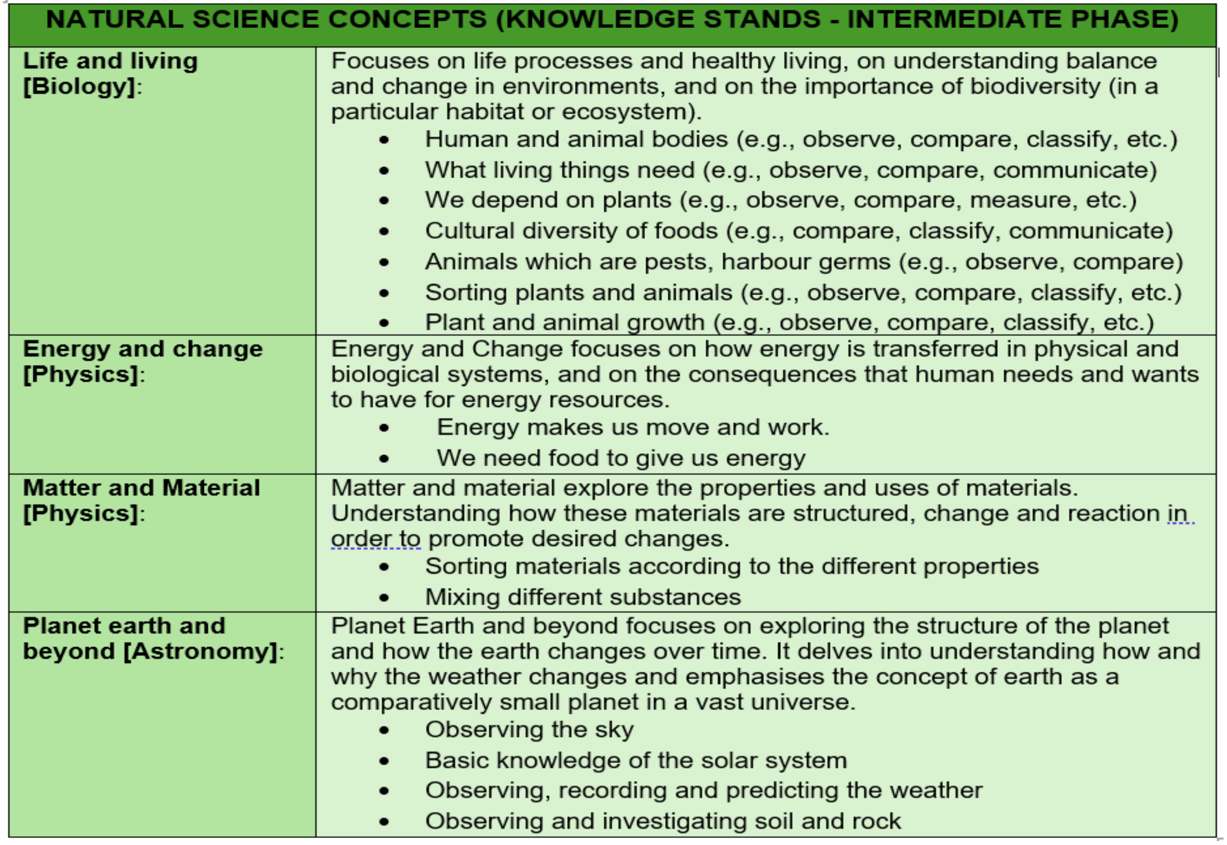
SKILLS TAUGHT, DEVELOPED AND USED

Inquire	Communicate	Collaborate	Explain/ defend	Create
Predict	Question	Think critically	Problem solve	

2.3.3.2 Natural Science: The four NS concepts

To gain a deeper understanding of the four FP NS concepts in the CAPS (2011) document, the researcher consulted the CAPS Intermediate Phase NS and Technology document. Although these concepts are included in the FP document, only limited foundational information is provided. There is more explicit information about these concepts in the Intermediate Phase NS and Technology document, as shown in Table 2.2.

Table 2.2 Explanations of the four science concepts (knowledge strands) (DoBE, 2011:14-39)



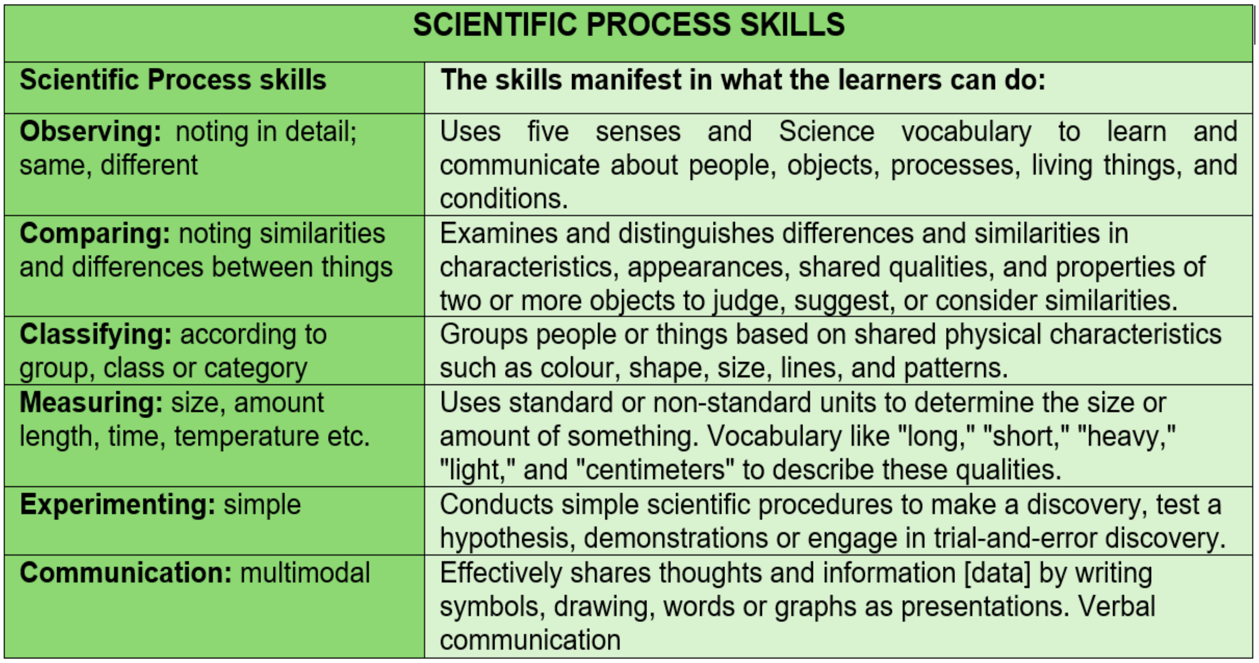
NATURAL SCIENCE CONCEPTS (KNOWLEDGE STANDS - INTERMEDIATE PHASE)	
Life and living [Biology]:	Focuses on life processes and healthy living, on understanding balance and change in environments, and on the importance of biodiversity (in a particular habitat or ecosystem). • Human and animal bodies (e.g., observe, compare, classify, etc.) • What living things need (e.g., observe, compare, communicate) • We depend on plants (e.g., observe, compare, measure, etc.) • Cultural diversity of foods (e.g., compare, classify, communicate) • Animals which are pests, harbour germs (e.g., observe, compare) • Sorting plants and animals (e.g., observe, compare, classify, etc.) • Plant and animal growth (e.g., observe, compare, classify, etc.)
Energy and change [Physics]:	Energy and Change focuses on how energy is transferred in physical and biological systems, and on the consequences that human needs and wants to have for energy resources. • Energy makes us move and work. • We need food to give us energy
Matter and Material [Physics]:	Matter and material explore the properties and uses of materials. Understanding how these materials are structured, change and reaction in order to promote desired changes. • Sorting materials according to the different properties • Mixing different substances
Planet earth and beyond [Astronomy]:	Planet Earth and beyond focuses on exploring the structure of the planet and how the earth changes over time. It delves into understanding how and why the weather changes and emphasises the concept of earth as a comparatively small planet in a vast universe. • Observing the sky • Basic knowledge of the solar system • Observing, recording and predicting the weather • Observing and investigating soil and rock

The FP curriculum provides few definitions and limited guidance on what the four NS concepts entail and how they connect to FP NS topics (Beni et al., 2017). The lack of detail makes it difficult for FP teachers to conceptualise or translate the concepts into subject matter for NS lesson planning.

2.3.3.3 Natural Science: Six scientific process skills

The CAPS (DoBE, 2011) document emphasises and lists six scientific process skills. According to Beni et al. (2017), FP CAPS does not explicitly discuss these skills, which are detailed in Table 2.3.

Table 2.3 Exposition of the scientific process skills to be taught in FP



SCIENTIFIC PROCESS SKILLS	
Scientific Process skills	**The skills manifest in what the learners can do:**
Observing: noting in detail; same, different	Uses five senses and Science vocabulary to learn and communicate about people, objects, processes, living things, and conditions.
Comparing: noting similarities and differences between things	Examines and distinguishes differences and similarities in characteristics, appearances, shared qualities, and properties of two or more objects to judge, suggest, or consider similarities.
Classifying: according to group, class or category	Groups people or things based on shared physical characteristics such as colour, shape, size, lines, and patterns.
Measuring: size, amount length, time, temperature etc.	Uses standard or non-standard units to determine the size or amount of something. Vocabulary like "long," "short," "heavy," "light," and "centimeters" to describe these qualities.
Experimenting: simple	Conducts simple scientific procedures to make a discovery, test a hypothesis, demonstrations or engage in trial-and-error discovery.
Communication: multimodal	Effectively shares thoughts and information [data] by writing symbols, drawing, words or graphs as presentations. Verbal communication

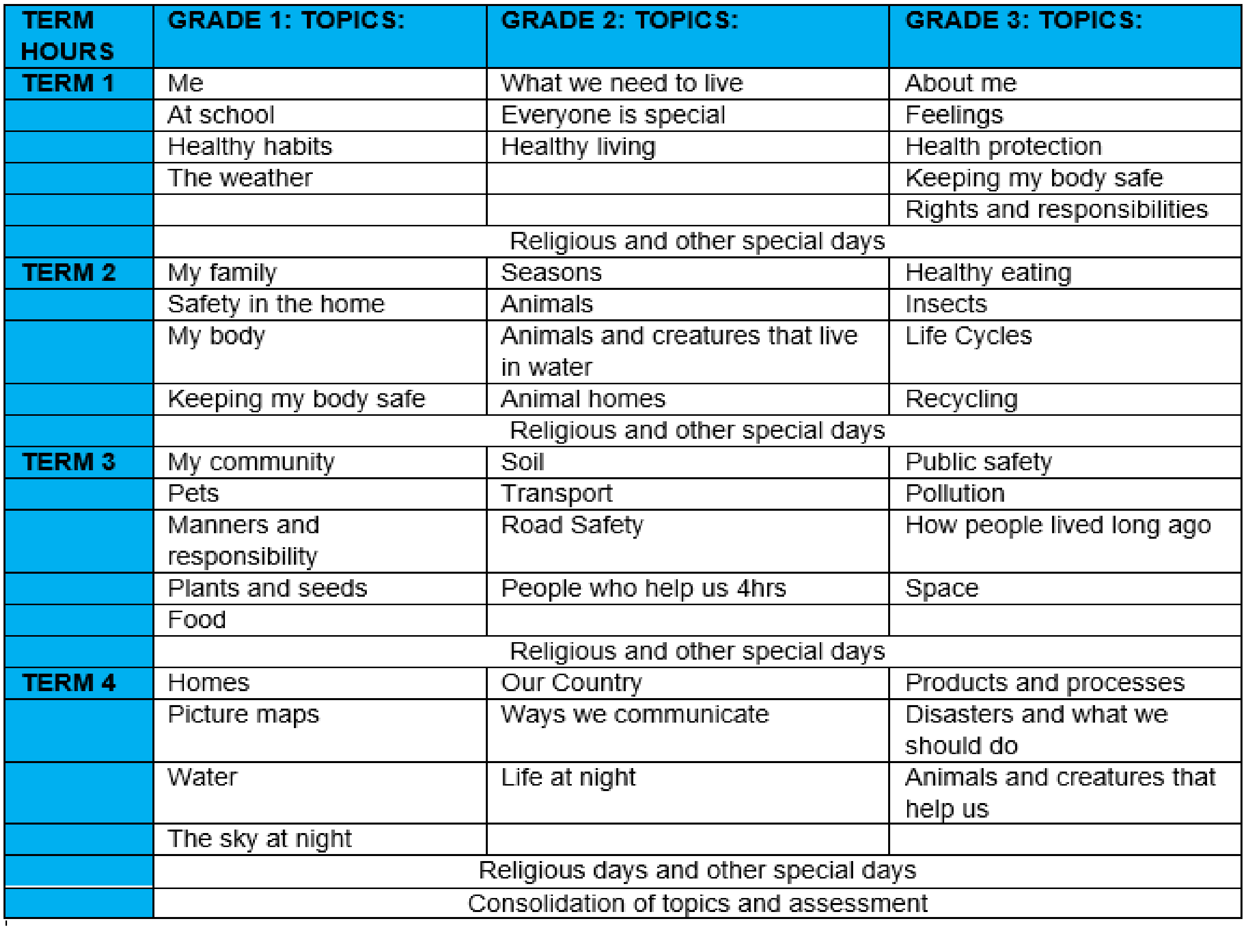
Table 2.3 was compiled by referencing the Intermediate Phase Natural Science and Technology CAPS document (DoBE, 2011:11). The explanatory notes on scientific process skills are absent from the FP NS CAPS document. Yet these skills are key to conducting scientific investigations (DoBE, 2011:8) and should be taught. The National Research Council (NRC, 2012), however, perceives the explicit teaching of process skills as a supposed misconception. NRC (2012) advocates that learners naturally think scientifically, and that it is the teacher's responsibility to nurture this inherent ability. This is in line with the belief that thinking processes generally are innate (Kovalik & Olsen, 2010). On the other hand, Demirçalı and Selvi (2022) argue that scientific process skills are gradually and experientially developed through the growth of conceptual understanding and therefore should be taught. For example, in order to be able to observe and compare, learners need to understand specific concepts and their connection (e.g.,

colour, shape, size, texture). Beni et al. (2017) and Bosman (2017) concur that explicit explanations in the curriculum are essential to guide teachers in their planning for teaching NS topics.

2.3.3.4 Natural Science (NS): Topics

The FP CAPS Life Skills document includes predetermined topics for Grades 1-3, across the four terms in an academic year. These NS topics are integrated across BK and PSW. While integration promotes interdisciplinary learning, it presents challenges because of a lack of detail in two key areas: the specific content of each study area (which topic belongs in which area), and the pedagogy for teaching these topics (Beni et al., 2017). Table 2.4 displays the topics for Grades 1 to 3 across the four terms.

Table 2.4 Topics in the CAPS (2011) document for Grades 1-3, by term



TERM HOURS	**GRADE 1: TOPICS:**	**GRADE 2: TOPICS:**	**GRADE 3: TOPICS:**
TERM 1	Me	What we need to live	About me
	At school	Everyone is special	Feelings
	Healthy habits	Healthy living	Health protection
	The weather		Keeping my body safe
			Rights and responsibilities
	Religious and other special days		
TERM 2	My family	Seasons	Healthy eating
	Safety in the home	Animals	Insects
	My body	Animals and creatures that live in water	Life Cycles
	Keeping my body safe	Animal homes	Recycling
	Religious and other special days		
TERM 3	My community	Soil	Public safety
	Pets	Transport	Pollution
	Manners and responsibility	Road Safety	How people lived long ago
	Plants and seeds	People who help us 4hrs	Space
	Food		
	Religious and other special days		
TERM 4	Homes	Our Country	Products and processes
	Picture maps	Ways we communicate	Disasters and what we should do
	Water	Life at night	Animals and creatures that help us
	The sky at night		
	Religious days and other special days		
	Consolidation of topics and assessment		

Within the BK and PSW, the topics are not aligned with specific subjects (SS, NS, Technology and PSW) and, as already mentioned, minimal content is provided to guide teachers. Research by James et al. (2017) highlights the lack of explicit CK for each subject and the absence of clear explanations of the terminology used (Dixon et al., 2018; DoBE, 2011:8-9). According to Dixon et al. (2018), the topics draw upon multiple disciplines and teachers have to rely on their own CK to discern which topics fall within the NS spectrum.

For each topic presented across the four terms, teachers are expected to distinguish: i) the subject (PSW, NS, Social Science, Technology), ii) the CK and iii) the subject matter knowledge (SMK). For example, Schudel's (2014) analysis of a Grade 3 topic "Recycling: What happens to our waste?" (DoBE, 2011:55), demonstrates the complexity of this requirement. The topic intersects with various subjects, including SS (land pollution, informal dumping, air pollution), NS (matter and materials, re-use, reduce, recycle), Technology (construct, make using recyclable materials), Life Orientation (citizenship, waste reduction) and PSW (health hazards) (Kok & Van Schoor, 2014). Once teachers identify the subject within the integrated BK and PSW topics, they must meticulously select the appropriate concept, process skills, and pedagogical content knowledge (PCK) needed to inform and design appropriate lesson plans.

An additional challenge lies in seamlessly linking the topic with other subjects, as exemplified by the "recycling" example (Schudel, 2014). The process necessitates a sound CK in the various subjects and careful consideration of learning objectives. In sum, the diverse and specialised nature of the curriculum content presents significant challenges for generalist teachers who may lack subject-specific knowledge and pedagogy (Beni et al., 2017; Dixon et al., 2018).

2.3.3.5 Challenges in the FP NS Curriculum

Dixon et al. (2018) argue that merging specific subjects (NS, Social Science and Technology) into a single focus area may cloud distinctions between specialised kinds of knowledge. It can be difficult to tell what knowledge belongs to which discipline. Any lack of clarity, especially for Science, makes it difficult for teachers to plan effective lessons.

Dixon et al. (2018) maintain that since Science is not clearly classified and defined within the Life Skills curriculum, teachers need a strong understanding of the content, that is, they need to know what to teach and how to teach it to be successful.

The challenge lies in the disconnect between the four science concepts identified, the six scientific process skills and the actual topics that teachers are supposed to teach. Although there is no doubt about the importance of these concepts and skills (Hugo, 2013), the curriculum provides insufficient guidance on their application to specific topics. Teachers must consequently rely on their own content knowledge and subject matter expertise to select appropriate concepts and scientific process skills for each topic. Hugo (2013) proposes that a detailed and progressive approach to NS content development is necessary to alleviate these challenges.

2.3.3.6 Notional time constraints and challenges

The CAPS (2011) document for FP (Grades 1 to 3) emphasises the teaching time to be allocated to BK, which includes NS (DoBE, 2011:14). Because of the loss of learning time during the COVID-19 pandemic, to bolster Language and Mathematics through increased instructional time, the notional time devoted to Life Skills was reduced by half (Circular S5, DoBE, 2023). Table 2.5, below, shows the time allocated to BK pre-COVID-19, and the diminished time post-COVID-19.

Table 2.5 Instructional time in Grades R to 3 for Life Skills in FP (DoBE, 2011:6)

SUBJECTLIFE SKILLS	**Grades 1 to 2**	**Reduced time**	**Grade 3**	**Reduced time**
TOTAL HOURS	**6 hours**	**3 hours**	**7 hours**	**3 hours**
• Beginning knowledge (Social Science, Natural Science and Technology)	**1 hour**	**30 minutes**	**2 hours**	**30 minutes**
• Personal and Social Wellbeing	**1 hour**	**30 minutes**	**1 hour**	**30 minutes**
• Creative Arts (Performing and Visual Arts)	**2 hours**	**1 hour**	**2 hours**	**1 hour**
• Physical Education	**2 hours**	**1 hour**	**2 hours**	**1 hour**

Prior to the COVID-19 pandemic, the notional time for BK (NS, Social Science and Technology) was 1 hour for Grades 1 and 2 and 2 hours for Grade 3 per week. For NS, particularly, this time was insufficient for the implementation of effective NS pedagogies (DoBE, 2011:8). Currently, post-COVID, the time earmarked for BK has been reduced to 30 minutes per week across all the grades in FP (DoBE, 2011:6). The reduced period simply does not afford the teachers enough time to teach scientific process skills. IBT requires exploration, experimentation and comprehensive planning to cover the NS curriculum. The hands-on nature of scientific investigation needs more time if a strong foundation in NS is to be established for young learners (Bosman, 2017; James et al., 2019). The time constraint is especially hard on teachers lacking specific training in NS (Dixon et al., 2018), and on learners receiving instruction in their second language.

2.3.3.7 The importance of language in teaching and learning Natural Science

Well-organised Science education in the FP hinges on a strong foundation in language, particularly for teachers (Bosman, 2017). Language transcends mere information transmission: it is the cornerstone of effective instruction and learning. Effective Science teachers in FP must possess a deep understanding of science concepts and the ability to translate these into clear, age-appropriate scientific vocabulary, using explanations acceptable to the scientific community (Bosman, 2017). Such proficiency empowers teachers to create engaging learning experiences, facilitating scientific inquiry and ensuring that learners co-construct the knowledge that will enable them to comprehend complex scientific phenomena. Teachers who lack strong language skills to back up a thorough knowledge of science will struggle to explain concepts, answer learners' questions, address misconceptions and foster a love for NS during these crucial years (Wellington & Osborne, 2014). Inquiry-based learning (IBL), the cornerstone of effective NS instruction, necessitates the effective communication of observations, explanations, hypotheses and predictions (Lee et al., 2013). Language thus plays a central role in facilitating scientific exploration, fostering critical thinking and creating a firm basis for scientific literacy (Moje, 2015).

a. The importance of scientific vocabulary

Science education presents a unique linguistic challenge because of its specialised vocabulary and idiom (Fang, 2012). Encountering terms such as “photosynthesis” and “observation” for the first time can be daunting for FP learners (Moje, 2015). Effective instruction, however, can transform these terms into tools to unlock the wonders of the natural world and scientific understanding (Moje, 2015). Teachers play a crucial role in this process by modelling scientific language through well-crafted questions and explanations while creating opportunities for learners to practise the vocabulary in real-world contexts (Nagy & Townsend, 2012). For example, the concept of “observation” in everyday language simply means paying attention to something. The term “scientific observation”, however, requires focused attention, specific tools for data generation and recording, as well as precise communication of what has been observed (Wellington & Osborne, 2014). By explicitly teaching scientific vocabulary and its application, teachers empower learners with the language to grasp complex concepts and articulate their understanding clearly and coherently (Nagy & Townsend, 2012). Learners who can record their observations of plant growth using scientific terms like “stem” and “leaves” demonstrate their conceptual understanding of scientific phenomena.

While effective vocabulary acquisition requires repeated practice within relevant contexts, the value of scientific vocabulary extends far beyond memorisation, empowering learners to engage in critical thinking and scientific inquiry (Lee et al., 2013). Terms such as “predict” and “experiment” introduce the scientific method, enabling learners to formulate relevant questions, design investigations and communicate their findings using the comprehensible and exact language of science (Tang & Rappa, 2020).

b. The power of ‘talk’ in scientific discourse

Science education should not only produce scientifically literate learners, it should also foster a collaborative learning environment where communication, particularly spoken language, is further developed (Lee et al., 2013). Discussions, group work and presentations allow learners to engage in scientific discourse, where they can explain their ideas and collaboratively process information gleaned from experiments, observations and experiences (Vartiainen & Kumpulainen, 2019; Alsahi, 2020). Open-ended questioning by teachers is most effective in activating learner talk (Oliveira, 2010). Questions of this kind prompt longer responses. Participation in these talk-based activities helps learners to refine their communication skills, develop critical thinking abilities and collaborate effectively within the scientific community (Alsahi, 2020).

A firm grasp of content knowledge is a prerequisite for applying such communication, critical thinking and collaborative skills in scientific concepts and inquiry.

2.3.3.8 Content knowledge

A strong foundation in content knowledge is essential for effective science teaching. The following sections explore the various dimensions of content knowledge and its significance in the science classroom.

a. Overview of content knowledge (CK)
b. The purpose and value of CK in Natural Science (NS)
c. Everyday knowledge (EK) and scientific knowledge (SK) in NS education
d. Subject matter knowledge (SMK)
e. Out-of-field teaching and challenges

a. Overview of content knowledge

Content knowledge (CK), as defined by Shulman (1986), involves a deep understanding of the underlying principles, theories and processes that govern a specific academic domain. CK enables teachers to provide clear explanations, break down complex ideas into manageable parts, address common misconceptions and use relatable examples to enhance understanding (Shulman, 1987). It empowers them to foster critical thinking skills in their learners and inspire a passion for learning (Arends & Kilcher, 2010; Gitomer & Zisk, 2015).

b. The purpose and value of content knowledge (CK) in (NS)

Content knowledge (CK) serves a multifaceted purpose in effective teaching. A solid grasp of CK enables teachers to deliver clear and accurate explanations and guide learners to analyse, evaluate and question information, promoting critical thinking skills

(Arends & Kilcher, 2010). Multiple studies delve into the significance of CK in strengthening the teaching of NS and improving learning outcomes (Gess-Newsome et al., 2017; Pitjeng-Mosabala & Rollnick, 2018). These studies emphasise the foundational role of a strong grasp of factual knowledge, core concepts and skills within a subject area for effective teaching (Gess-Newsome et al., 2017; Pitjeng-Mosabala & Rollnick, 2018). Deep knowledge and understanding enable teachers to cultivate critical thinking skills in learners by encouraging them to question, generate ideas, analyse and evaluate scientific information (Shulman, 1987; Arends & Kilcher, 2010).

c. Everyday knowledge (EK) and scientific knowledge (SK) in NS education

Effective Science education depends on the interaction between EK and SK (Bernstein, 1996). EK, although informal and context-specific, forms the foundation for building scientific concepts and serves as a crucial bridge for connecting new concepts to existing understanding (Moll & González, 2014; Morris, 2014).

SK, on the other hand, emerges from rigorous inquiry and is characterised by precise language and a focus on objectivity (Morris, 2014). Some argue that there is an overreliance on EK in the curriculum, but effective teaching recognises the value of both forms of knowledge (Morris, 2014). The transition from EK to SK is a transformative experience fostered by inquiry-based learning that allows learners to refine initial observations, engaging with the natural world through questioning, testing, and refining their initial understanding (Hugo, 2013). The teachers' journey of deep curriculum development builds a profound understanding of scientific concepts through interaction between familiar (EK) and unfamiliar (SK) knowledges. To help learners acquire an understanding of the subject matter, teachers must scaffold them through their existing knowledge to new learning (Singh & Kwok, 2023).

d. Subject matter knowledge (SMK)

The traditional view of SMK focused solely on the possession of scientific facts, but ongoing research has produced a more multifaceted picture. Pedagogical content knowledge (PCK) is a crucial element of SMK, involving not only knowing the Science content but also understanding how to teach it effectively (Ntuli et al., 2020). Teachers with strong PCK can anticipate learner difficulties, select appropriate pedagogical strategies and utilise questioning techniques that promote deeper understanding (Ntuli et al., 2020). SMK thus includes an awareness of common learner misconceptions about scientific concepts. This enables teachers to design lesson plans to address these and connect ideas to real-world applications (Nkanyani & Mudau, 2021).

e. Out-of-field teaching and challenges

A strong foundation in NS is imperative for a well-rounded education. Scientific literacy, the ultimate aim of Science education, encompasses foundational scientific knowledge, the development of critical thinking skills and their application to real-world decision-making (Crowell & Schunn, 2016).

However, achieving this goal in FP education can be hampered by “out-of-field” teaching, where generalist teachers who lack extensive CK struggle to teach NS effectively. Having no scientific background hinders their ability to understand scientific concepts, detracts from their pedagogical flexibility, and undermines their ability to engage learners effectively (Luft et al., 2020). The lack of a strong Science foundation is a major reason for Science CK deficiencies in South Africa (Luft et al., 2020).

2.4 QUALIFICATIONS

To ensure that all South African teachers meet internationally comparable standards of competency, several key frameworks and standards for teacher qualifications have been established. A brief discussion of these structures and standards follows:

2.4.1 The South African Qualifications Authority (SAQA)
2.4.2 The National Qualifications Framework (NQF)
2.4.3 Norms and Standards for Educators (NSE)
2.4.4 The Minimum Requirements for Teacher Education Qualifications (MRTEQ)
2.4.5 Professional Development (PD)
2.4.5.1 Continuous Professional Development (CPD).

Examining these components will promote an understanding of the landscape of qualifications and professional development within the South African education system.

2.4.1 The South African Qualifications Authority (SAQA)

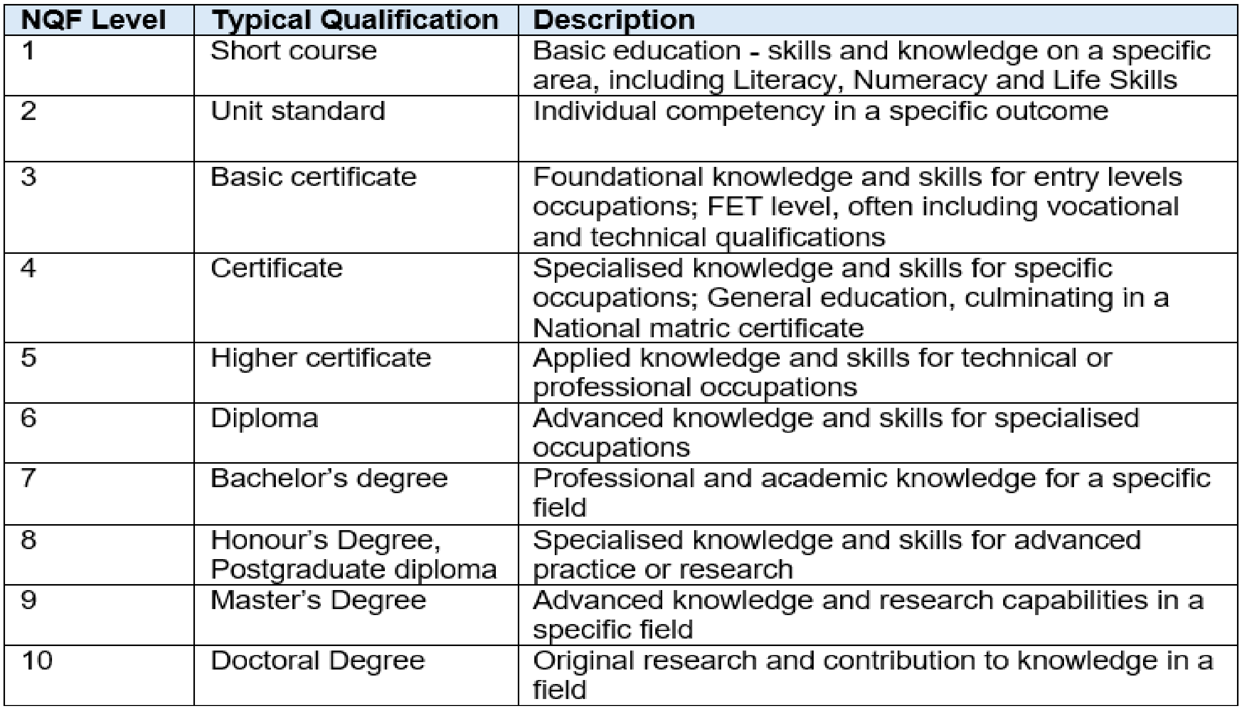
According to SAQA, a qualification is a structured set of learning outcomes designed to achieve specific objectives, equipping learners with practical skills and a foundation for further education. SAQA (South African Qualifications Authority [SAQA], 2006) is the official body mandated to coordinate the National Qualifications Framework (NQF) in South Africa. According to SAQA's (2020) strategic plan, the primary vision is to promote and ensure the development and implementation of a high-quality, internationally comparable education and training system throughout South Africa, ensuring that qualifications are standardised (SAQA, 2020).

2.4.2 The National Qualifications Framework (NQF)

The NQF's (2000) objectives include integrating the education system, ensuring equitable access, promoting mobility and progress within the framework, maintaining high standards, creating training and career paths, redressing past inequalities, and supporting societal transformation through education and training (SAQA, 2020). The overarching objective is to create a unified, quality-assured education system that promotes continuous learning and socio-economic development. By setting clear standards and focusing on lifelong learning, the NQF seeks to improve the education system and contribute to societal progress (Department of Higher Education and Training [DHET], 2019).

The NQF has constructed a system that determines the qualifications required for teachers. In ensuring that these qualifications, from certificates to degrees, are aligned with NQF standards, SAQA plays a crucial role in guaranteeing teachers' readiness to teach subjects effectively (SAQA, 2006). All education in South Africa fits within this framework. NQF Levels 7 to 10, which focus on teacher education, are linked to teacher degrees, with NQF Level 7 being the prescribed qualification for novice teachers (see Table 2.6, below).

Table 2.6 A general overview of the ten SAQA levels (2006), which may vary in different fields of study and institutions



NQF Level	Typical Qualification	Description
1	Short course	Basic education - skills and knowledge on a specific area, including Literacy, Numeracy and Life Skills
2	Unit standard	Individual competency in a specific outcome
3	Basic certificate	Foundational knowledge and skills for entry levels occupations; FET level, often including vocational and technical qualifications
4	Certificate	Specialised knowledge and skills for specific occupations; General education, culminating in a National matric certificate
5	Higher certificate	Applied knowledge and skills for technical or professional occupations
6	Diploma	Advanced knowledge and skills for specialised occupations
7	Bachelor's degree	Professional and academic knowledge for a specific field
8	Honour's Degree, Postgraduate diploma	Specialised knowledge and skills for advanced practice or research
9	Master's Degree	Advanced knowledge and research capabilities in a specific field
10	Doctoral Degree	Original research and contribution to knowledge in a field

2.4.3 Norms and Standards for Educators (NSE) policy document

The cornerstone of the NSE policy document (Department of Education [DoE], 2000) is the notion of applied competence. This involves three key abilities: i) practical competence, the ability to make informed decisions and take action in real-life scenarios; ii) foundational competence, understanding the thinking that informs the decisions; and iii) reflexive competence, the ability to learn from experience, adapt to change and justify decisions taken (DoE, 2000). The foregrounding of applied or practical competence seeks to ensure that teachers can create effective learning experiences by integrating theory and practice. Applied competence involves integrating the three key competencies across the seven teacher roles. Table 2.7 outlines the seven roles of Foundation Phase teachers (SAQA, 2006). A more extensive explication can be found in Appendices 8 to 11.

Table 2.7 The 7 roles and related competencies outlined in the Norms and Standards for Educators.

THE SEVEN ROLES OF A TEACHER	
Role	**Description, Competencies and skills**
Learning mediator	The educator facilitates and creates learning environment and mediates learning, helping learners understand and engage with the material. Subject knowledge, instructional skills, learner engagement, adaptability
Interpreter and designer of learning programmes and materials	The educator interprets the curriculum and designs effective learning programmes, experiences and materials. Curriculum design, resource document, instructional design, creativity
Leader, administrator and manager	The educator will make decisions appropriate to the level, manage learning in the classroom, carry out classroom administrative duties efficiently and participate in school decision making structures. These competences will be performed in ways which are democratic, which support learners and colleagues, and which demonstrate responsiveness to changing circumstances and needs.
Scholar, researcher and lifelong learner	The educator will engage in ongoing professional development, research and lifelong learning Remember skills, critical thinking, commitment to continuous learning, professional growth to improve teaching practices.
Community, citizenship and pastoral role	Promotes social values, positive school climate, community engagement and provides pastoral care to learners. Ethical behaviours, community involvement, pastoral care, social responsibility
Assessor	Assesses learner progress and provides feedback to support learning and development. Assessment strategies, feedback techniques, data analysis, evaluative skills
Learning area/ subject/ discipline/ discipline/phase specialist	Specialises in a specific learning area, subject, or phase, ensuring expertise and effective instruction. Subject matter expertise, specialised teaching methods, continuous subject-specific development.

By fulfilling these seven roles, teachers assure the quality of education, guaranteeing a balanced and supportive environment for learners. The roles inform the Minimum Requirements for Teacher Education Qualifications (MRTEQ), guiding the development and assessment of teacher qualifications and professional development (DoE, 2000; SAQA, 2023).

2.4.4 Minimum Requirements for Teacher Education Qualifications (MRTEQ)

The MRTEQ (DHET, 2015) document provides a framework for constructing core curricula for initial teacher education and Continued Professional Development (CPD). It outlines various types of learning and associated knowledge necessary for effective teaching. Table 2.8 presents a brief outline of these types of learning:

Table 2.8 The types of learning and a description of each as set out in the MRTEQ (2015) document

Types of learning	Description
Disciplinary learning	Acquiring in-depth subject knowledge of a specific subject matter or content area
Pedagogical learning	Focuses on understanding the teaching and learning processes, including pedagogical practices
Practical learning	Hands-on experience in teaching, including classroom management, lesson planning and learner interaction
Fundamental learning	The development of core knowledge and skills essential for teaching, such as communication, critical thinking and problem-solving (Literacy and Mathematics)
Situational learning	The ability to apply knowledge and skills in real-world teaching contexts, adapting learning to different learner needs and classroom challenges.

Pedagogical learning (foundational knowledge and teaching methods) and situational learning, (pedagogical knowledge) form the core theoretical foundation of education qualifications, while practical learning is crucial in initial teacher education and the application of knowledge in the classroom (DHET, 2015). PCK, the bridge between pedagogical and situational learning, is a key construct, combining a solid foundation in NS scientific concepts with effective pedagogical practices (teaching methods). There are concerns, however, that generic FP qualifications may not fully prepare teachers for the specific subject demands of teaching NS (Beni et al., 2019).

Critics argue that the MRTEQ’s document’s focus on subject matter knowledge (SMK) within disciplinary learning might be insufficient (Bosman, 2017; Beni et al., 2019). They believe that emphasis should be placed on the curriculum CK, the importance of other pedagogical skills and classroom management alongside SMK. One objection is that there is an overemphasis on theoretical knowledge, that is, on conceptual understanding of the principles underlying a subject, which may be too abstract and disconnected from the realities of teaching NS (Rusznyak, 2015). On the other hand, Winch (2012) and Hugo

(2013) argue that pre-service training provides a valuable foundation for teachers to develop their own pedagogical reasoning and judgment. The debate in which these authors engage highlights the importance of striking a balance between theoretical knowledge and practical skills development, especially for subjects like NS, where deep subject-specific knowledge is crucial for effective teaching.

2.4.5 Professional development (PD)

The South African Council for Educators (SACE) promotes professional development as necessary for teachers to improve and broaden their knowledge and skills, sustain high-quality teaching and remain effective in their careers (SACE, 2020; Gomba, 2019). PD is essential since education is constantly evolving, with new pedagogical practices, technologies and assessment practices constantly emerging (*Schooling 2025,* South Africa: DoBE, 2018).

2.4.5.1 Continuous professional development (CPD)

SACE's continuous professional development (CPD) policy aims to promote lifelong learning among teachers, ensuring that they remain competent and up-to-date with current educational trends. Ongoing development is crucial for maintaining teaching standards and improving learner outcomes (SACE, 2020).

CPD for teachers varies globally, with some countries linking it to licence renewal or career advancement, while others view it as a professional duty with flexible participation (Gulbenkian & Oosthuizen, 2015). Regardless of the specific mode of implementation, CPD is critical for seeing to it that teachers remain effective, relevant and cognisant of the latest pedagogical strategies and content knowledge. In South Africa, well-designed CPD programmes can help fill gaps in teachers' CK and PCK by combining strong NS content knowledge with the modelling of pedagogical practices such as inquiry-based teaching and hands-on activities.

Professional learning communities (PLCs) have emerged as an effective long-term development strategy, fostering collaborative reflection, dialogue, and critical analysis of teaching practices to improve learner outcomes (Croft et al., 2010). Teachers' receptiveness to CPD benefits not only their individual, self-directed professional growth but also contributes to attaining the systemic educational goals of improved instructional practices and enhanced learning outcomes.

2.5 PEDAGOGICAL PRACTICES

Effective pedagogical practices, grounded in a strong foundation of pedagogical content knowledge (PCK), encompass a wide range of teaching and learning strategies employed to facilitate knowledge acquisition and skills development (Shulman, 1986). The subsequent discussion deals with inquiry-based teaching, its core components and effective implementation strategies. Specific focus areas include the nature of science as a cornerstone for inquiry, the teacher's role in fostering scientific attitudes, and a range of pedagogical approaches to support inquiry-based learning:

2.5.1 Inquiry-based teaching
2.5.1.1 Nature of science (NOS) as the cornerstone for inquiry-based teaching
2.5.1.2 The critical role of teachers in fostering scientific attitudes
2.5.1.3 Strategies employed in inquiry-based teaching
a. Question-and-answer strategy
b. Direct instruction
c. Group work
d. Think-pair-share (TPS)
e. The K-W-L strategy
f. The use of technology

The right blend of pedagogical and content knowledge enables teachers effectively to translate scientific concepts into engaging and age-appropriate learning experiences for young learners (Durden, 2016). PCK empowers teachers to bridge the gap between theoretical scientific knowledge and its practical application in the classroom. Petr (2013) points out that employing appropriate pedagogical practices can cultivate a constructive connection between learners' curiosity and their natural environment. By harnessing this connection with strong PCK, teachers can ignite learners' inherent sense of wonder, engendering a passion for Science.

2.5.1 Inquiry-based teaching

Inquiry-based science education (IBSE), also known as inquiry-based teaching, is a hands-on and minds-on pedagogical approach (Bosman, 2017) that empowers learners to actively construct knowledge by using the six scientific process skills (observe, compare, classify, measure, experiment and communicate) (DoBE, 2011:8). Engaging in scientific investigations and doing as scientists do encourages questions, predictions, recording and analysis, as learners begin to understand their natural world at a higher level of cognition (Bosman, 2017; Jerrim et al., 2022).

In inquiry-based teaching, learners are provided with the necessary skills, knowledge and understanding of inquiry through a scaffolded approach. This kind of approach gradually awards learners agency over learning in the classroom, moving from dependence to independence. According to MacKenzie (2016), inquiry can be *structured*, *controlled, guided*, or *free*. *Structured inquiry* is a stepping stone toward the next level of inquiry, directing the learners' journey through the process of doing or building something together (MacKenzie, 2016; Beni et al., 2017). *Controlled inquiry* involves giving the outline, providing the goals, context, tools and starting ideas, with learners following the process steps creatively to execution *Guided inquiry* includes teacher choice of topic or questions, with learners collaboratively developing their own methods of inquiry and establishing concepts. *Free Inquiry* supports self-directed learning, involving choosing and exploring a topic, posing questions, choosing methods, and setting goals creatively. Mackenzie notes that teachers have to be discerning throughout the scaffolding process, to be aware when learners are ready to engage at which level, especially, free inquiry (MacKenzie, 2016). More generally, successful IBT implementation necessitates careful planning, teacher support and scaffolded instruction to address diverse learning needs (NRC, 2012; Bhagat, 2017).

FP can play a vital role in nurturing natural curiosity and critical thinking skills among young learners, particularly through IBT's promotion of active scientific discourse over passive knowledge transmission (Ødegaard et al., 2014; Bosman 2017; Beni et al., 2017). This learner-centred approach prioritises exploration, critical thinking and problem-solving (Khairati, et al., 2021), building a dynamic learning environment aligned with 21st-century skills (DoBE, 2011). Through inquiry activities, such as planting a bean seed, making a tippy-tap, building a car or mini-ecosystem, learners engage in planning, experimentation, analysis and result-sharing (Sutiani et al., 2021). Aligned with the CAPS document's "active" learning principle (DoBE, 2011), IBT cultivates higher-order thinking skills (NRC, 2012; Aditomo & Klieme, 2020).

2.5.1.1 Nature of science (NoS) as the cornerstone of inquiry-based teaching

IBT relies upon a strong understanding of the nature of science (NoS) (Abd-El-Khalick, 2012). NoS extends beyond the simple memorisation of facts to encompass the iterative processes of scientific inquiry, including experimentation, observation, data generation, analysis and critical thinking (Lederman & Lederman, 2014; Bosman, 2017). NoS recognises both the strengths and limitations of scientific knowledge, acknowledging the role of creativity, social influence and the tentative nature of scientific theories (Lederman et al., 2013; McComas, 2016). A sound understanding of NoS is crucial for teachers to promote scientific literacy in their learners. Although not explicitly mentioned in all curricula, it acts as a golden thread running through NS that enriches the learning experience (Croswell & Schunn, 2016).

The principles of NoS emphasise the importance of understanding and mirroring authentic scientific practices in the classroom (Abd-El-Khalick, 2012). These principles include the empirical NoS, the role of observation, experimentation and inference, the tentative NoS, the theory-laden nature of scientific knowledge, the social and cultural embeddedness of scientific knowledge and the creativity involved in scientific research (Hanuscin et al., 2010; Villamill & Garci-Martinez, 2021). Teachers play a vital role in seeing to it that learners not only understand the scientific facts but also learn how Science works, including experimentation, evidence evaluation and the role of science consensus. Understanding NoS empowers learners effectively to utilise scientific process skills.

2.5.1.2 The critical role of teachers in fostering scientific attitudes

While knowledge is important, fostering a love for Science requires more than the mere transfer of knowledge. By grasping the core principles of NoS, teachers can cultivate positive scientific attitudes such as curiosity, honesty, open-mindedness, scepticism, flexibility, perseverance and creativity (Yager, 2013; Prachegool & Arsaiboon, 2022). Curiosity provides intrinsic motivation, driving exploration and meaningful engagement, while open-mindedness means a willingness to consider different ideas, an aspect of critical thinking and information synthesis. Teaching scepticism encourages learners to question and seek evidence; flexibility promotes adapting to new information; perseverance encourages persistence in problem-solving, and creativity is necessary for generating new ideas and solutions (Yager, 2013; Prachegool & Arsaiboon, 2022). Nurturing these attitudes instils an inquiry-oriented mindset for lifelong learning in both teachers and learners.

2.5.1.3 Strategies employed in inquiry-based teaching

Inquiry-based Science education thrives on a variety of pedagogical practices that assist teachers to scaffold learners in their learning and cultivate autonomy. These practices empower learners to actively engage in scientific processes, think critically and relish discovery and learning.

a. Question-and-answer strategy

The question-and-answer strategy centres on asking relevant questions, which is fundamental in Science education (Almeida, 2012). According to Menninga (2017), the teacher's role in this strategy is essential yet difficult, since the aim is to employ different questioning techniques to cultivate a learning environment that actively challenges learners while helping them to think beyond their current capabilities.

Questioning strategies aligned with Bloom's taxonomy (Anderson & Krathwohl, 2001) help teachers to increase cognitive complexity, from foundational knowledge acquisition to advanced skills such as synthesis and evaluation. At the FP level, closed-ended questions are crucial for assessing learners' factual knowledge in NS and reinforcing fundamentals such as scientific terminology and basic principles (Almeida, 2012; Salmon & Barrera, 2020). The balanced application of different types of questioning, however, is essential to avoid restrictiveness (Kawalkar & Vijapurkar, 2013).

Probing questions asked by teachers at the application and analysis level stimulate higher-order thinking skills essential for scientific inquiry. When teachers encourage learners to synthesise information and critically evaluate concepts using probing questions, they foster autonomy and a deep engagement with scientific principles (Kawalkar & Vijapurkar, 2013).

Incorporating open-ended questions is instrumental in creating a dynamic environment, encouraging exploration, creativity and critical thinking in NS education (Rumohr, 2013; Menninga, 2017). Learners are thereby encouraged to formulate independent responses, explore multiple perspectives and develop analytical the skills necessary for scientific inquiry (Salmon & Barrera, 2020). Clarifying questions also play a vital role in ensuring clear communication and comprehension among learners.

Teachers need to integrate ‘wait time’ into their questioning practices to optimise learner participation and encourage deeper reflection in NS education (Rumohr, 2013). Wait time improves the quality of learner responses, allowing them to formulate thoughtful answers and contribute meaningfully to classroom discussions (Rumohr, 2013).

b. Direct instruction

Direct instruction (DI), characterised by the kind of explicit instruction characteristic of teacher-centred approaches, plays a crucial role in Science education, particularly for FP learners. DI is a method whereby teachers convey information, demonstrate skills and guide learners' practice. It has been proven to be effective when new scientific concepts are being introduced (Rosenshine, 2012). In FP classrooms, learners often need clear instruction and extensive scaffolding to grasp new scientific ideas.

Stockard et al. (2018) suggest that DI enhances learner engagement by providing lucid guidance that is critical for young learners who are still developing cognitive and conceptual frameworks. Moreover, DI ensures that essential content is covered comprehensively within limited instructional time, addressing concerns about curriculum coverage in early Science education (Rosenshine, 2012).

On the other hand, critics caution against over-reliance on DI, suggesting it may inhibit creativity and independent thinking, potentially limiting opportunities for exploration and inquiry-based learning (Hattie, 2012; Hoban & Nielsen, 2012). Despite these reservations, DI remains a foundational strategy in Science education, laying the groundwork for scientific understanding among FP learners. It offers structured learning experiences that build foundational knowledge, clears misconceptions when needed and serves as a stepping-stone to scientific inquiry and exploration (Clark et al., 2012; Hattie, 2012).

c. Group work

Johnson and Johnson (2018) describe group work as a collaborative learning approach in which learners work together in small groups to achieve common learning goals, actively engaging in discussions, problem solving, and constructing knowledge. Group work is particularly recommended in the teaching of NS because of its ability to promote peer interaction, communication skills and cooperative learning, essential competencies in scientific inquiry (Johnson & Johnson, 2014; Slavin, 2015). Research indicates that group work conduces to a deeper understanding of scientific concepts through peer-to-peer interaction and discussion. Learners benefit from sharing diverse perspectives, negotiating meaning and enhancing their critical thinking and scientific problem-solving abilities (Gillies, 2016). Mukhametshin et al. (2020) emphasise the importance of teaching learners to be patient and respectful with each other, so as to establish through social interaction the sort of learner-centred environment envisaged in Vygotsky's (1978) sociocultural theory.

Difficulties encountered in attempting to implement effective group work strategies include managing group dynamics, ensuring equitable participation, and balancing individual accountability with collaborative goals (Cohen & Lotan, 2014; Johnson & Johnson, 2018; Kalaian et al., 2018). Group work is widely endorsed in the teaching of NS, offering rich opportunities for active learning, peer support, and the development of essential 21st-century skills among learners.

d. Think-pair-share (TPS)

Think-pair-share (TPS) is a dynamic instructional strategy in Science education facilitating active engagement among learners, while providing formative assessment and saving valuable instructional time. The process begins with the ‘think’ phase, for independent reflection on a specific Science concept, problem or question. The ‘think’ phase, as noted by Kaddoura (2013) prolongs the wait time which encourages the individual processing of information so that learners can formulate their thoughts without feeling threatened before sharing them with their peers (Mundelsee & Jurkowski, 2021). Solitary reflection prepares learners to articulate their ideas effectively and engage meaningfully in subsequent discussions. In the ‘pair’ phase, the teacher prepares the learners for collaboration with a partner to discuss thoughts and findings. The ‘pair’ phase promotes peer-to-peer learning as learners share perspectives, explain their reasoning and listen actively to their partner’s contributions (Johnson & Johnson, 2018; Mundelsee & Jurkowski, 2021). Through the ‘pair’ stage learners develop self-regulation and ownership of learning, while clarifying their own understanding and encountering different viewpoints and problem-solving strategies.

Multiple social skills – cooperation, respect, teamwork and active listening – come into play when learners engage in these strategies. In the final ‘share’ phase the teacher creates opportunities for learners to present their conclusions to the class. The ‘share’ phase encourages the effective communication of ideas, enhancing learners’ confidence in expressing scientific concepts Mundelsee & Jurkowski, 2021). Additionally, the ‘share’ phase enables whole-class discussion and feedback, where learners can compare and contrast different approaches and solutions, further solidifying their understanding of the topic at hand (Ghadirian et al., 2014).

e. The K-W-L strategy

The K-W-L strategy, known for its three-stage approach of ‘K’ What I Know, ‘W’ What I Want to know, and ‘L’ What I have Learned, has gained popularity as a metacognitive instructional technique in education. The K-W-L approach encourages learners to activate prior knowledge (K), generate questions, identify areas of curiosity (W), and reflect on their learning outcomes (L) (Blachowicz & Ogle, 2008; Alsahi, 2019).

Advocates argue that the K-W-L strategy effectively bridges prior knowledge with new information, facilitating deeper comprehension and meaningful learning experiences (Fisher et al., 2016; Vacca & Vacca, 2017; Alsahi, 2019). By asking learners to articulate what they know and what they want to know, the strategy promotes metacognition and self-directed learning. According to Etuk et al. (2013), one of the most salient benefits of the K-W-L is that learners' voicing of their thinking and perceptions can tell the teacher how best to adjust her teaching strategies to enhance their understanding.

The effectiveness of the K-W-L strategy may vary, however, depending on the manner of its implementation and various contextual factors. For instance, Pratams (2022) views the "W' stage as essential for learner motivation, affording an opportunity for them to write their own questions, while Ogle (1986) notes that learners' interest grows when they understand the learning goals. Etuk et al. (2013) aver that teachers can glean what the learners are thinking during this stage and can adjust their strategy for better understanding. In short, although the emphasis and applicability of the K-W-L strategy across different subjects may vary in different educational settings, Alsahi (2019) maintains that the strategy can be adapted to suit diverse learning contexts in order to maximise its benefits.

f. Use of technology

Effective teaching in 21st-century classrooms necessitates technology integration to address modern literacy demands (Suchita et al., 2023). But the technology employed must be such that it actively supports inquiry, enriches problem contexts and facilitates cognitive and metacognitive processes (Wang et al., 2021). Effective integration thus depends on teachers' technological pedagogical knowledge (TPACK). Studies confirm that teachers with strong TPACK are likely to integrate technology successfully into their teaching practices (Suchita et al., 2023).

Teachers can use technology effectively to engage learners in interactive inquiry-based learning experiences, like the segmentation principle for discussion, questions and learners' opinions (Clark & Mayer, 2011). Real-life simulations and multi-media resources, such as time-lapse photography, allow learners to observe complex processes quickly, for example, the life cycles of plants, insects and mammals, enhancing their understanding of natural phenomena.

Research by Spiteri and Rundgren (2020) stresses the importance of training programmes that equip teachers with PCK to use technology (TPACK) in play-based learning and inquiry. As artificial intelligence tools emerge, teachers must be trained to use them responsibly. Available technological resources include the WCED ePortal and other websites that can furnish valuable tools and a wealth of resources to empower teachers to personalise learning experiences to suit the needs of learners (Suchita et al., 2023).

2.6 LESSON PLANNING

Effective lesson planning is crucial for optimising learners’ learning. The following discussion explores some key components of comprehensive lesson planning, under the headings:

2.6.1 Multifaceted lesson planning
2.6.2 Planning and preparation

2.6.1 Multifaceted lesson planning

Despite the ever-evolving educational landscape, marked by technology integration and innovative pedagogical practices, lesson planning remains a core element of professional competence (Carlson et al., 2019; Kizi, 2024). The relations between lesson plans, pedagogical practices and learning objectives can be extremely intricate, which means that lesson planning needs to be meticulous and multifaceted.

Research by Darling-Hammond et al. (2017) suggests a strong correlation between carefully planned, well-constructed lessons and learner achievement, while König et al. (2021) report a connection between well-designed lesson plans and positive learner evaluations of Science lessons. The emphasis on lesson planning extends beyond the classroom, forming a critical part of teacher education programmes worldwide.

2.6.2 Planning and preparation

Shulman (1986) identifies three key knowledge areas for effective planning: content knowledge (CK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK). PCK empowers teachers to translate CK into engaging lessons tailored to learners’ needs (Gess-Newsome, 2015). Effective teaching is a dynamic process that starts with planning and culminates in reflection, building on the knowledge base of CK, PK, PCK and familiarity with the curriculum and assessment practices.

In essence, lesson plans serve as a roadmap for teachers, outlining objectives, instructional strategies and assessment methods (Vdovina & Gaibisso, 2013). By carefully crafting lesson plans, teachers ensure a coherent flow of activities that guide learners towards achieving specific learning goals (Baxter, 2013). Lesson plans bridge the gap between curriculum requirements and classroom practice. Teachers utilise their PCK to translate abstract curriculum content into interesting and accessible learning experiences for their learners.

Tomlinson and Jarvis (2023) identify the key components of a well-structured lesson plan. Teachers should include clear and measurable learning objectives to define what learners are expected to achieve. Carefully selected resources and engaging activities facilitate the learning process, incorporating various pedagogical practices and catering for diverse learning styles (Tomlinson, 2017). The thoughtful application of assessment strategies can provide valuable feedback and inform future teaching. An understanding of the cyclical process of teaching and learning develops teachers’ confidence in their teaching ability.

2.7 SELF-EFFICACY

A teacher's belief in their ability to execute teaching tasks successfully, known as self-efficacy, significantly influences their ability to create engaging and effective learning environments leading to useful outcomes. The critical role of self-efficacy in shaping teaching practices is explained in the next sections:

2.7.1 The centrality of positive self-efficacy in teaching
2.7.2 Self-efficacy and critical thinking.
2.7.3 The reflective practitioner

2.7.1 The centrality of positive self-efficacy in teaching

Self-efficacy, a person's belief in their own capabilities (Bandura, 1997), is crucial for effective teaching. Albert Bandura (1997) identifies four elements that contribute to a teacher's self-efficacy, the most powerful of which he describes as "mastery experience", achieved when one successfully overcomes new challenges and gains confidence in one's abilities. Witnessing others succeed, or vicarious experiences, can also boost self-belief. Positive feedback from a role model, through social persuasion further strengthens this confidence. Finally, positive emotions like joy or excitement during an activity can contribute to a stronger sense of self-efficacy, teacher quality and sustainability (Suphasri & Chinokul, 2021). Research conducted by Murphy et al. (2021) show that strong teacher training programmes are associated with teacher efficacy.

Recent research by Kelly et al. (2017) emphasises that teacher confidence is important for effective NS teaching. Teachers with high self-efficacy exhibit a range of behaviours that contribute to a positive and successful learning environment. These behaviours include the implementation of innovative teaching practices, including better classroom management procedures and learner-centred strategies (Zhou et al., 2022). In the context of teaching NS, high self-efficacy among teachers correlates positively with teachers' enthusiasm for teaching, pedagogical effectiveness and learner achievement (Tschannen-Moren & Woolfolk Hoy, 2007).

2.7.2 Self-efficacy and critical thinking

In the evolving landscape of education, teachers are increasingly called upon to be critical thinkers rather than people who simply deliver a pre-packaged curriculum. Critical thinking empowers teachers to become active knowledge constructors who analyse educational materials, consider diverse learning styles and design teaching opportunities that nurture high-level thinkers. The analysis involves questioning the underlying assumptions of CK and PK, seeking high-impact practices that promote active learning (Zeichner, 2012).

By critically examining their practice, teachers can identify areas for improvement, experiment with new strategies and adapt their teaching to meet the unique needs of their learners (Brookfield, 2017). Furthermore, critical thinking skills enable teachers to effectively assess learning and make data-driven decisions about future instruction. The capacity to analyse data and adapt teaching allows teachers to create a dynamic learning environment that fosters learner growth and achievement, ultimately equipping them with the knowledge and skills they need to thrive in the 21st century.

2.7.3 The reflective practitioner

Teacher reflection is a cornerstone of effective teaching and a key component of teacher self-efficacy (Bandura, 1986; Zee & Koomen, 2016). At its core, teacher reflection is a process of deep analysis and metacognition, where teachers critically examine their entire teaching practice (Killion, 2013). By delving into the intricacies of their teaching, teachers can identify strengths, weaknesses, areas for improvement and alternative strategies. The metacognitive process empowers teachers to develop a deeper understanding of their capabilities, fostering a strong belief in their ability to implement pedagogical practices effectively. As Schön (1983) emphasises, the cyclical nature of reflection – planning, acting, observing and reflecting – contributes to a sense of agency and control over one’s teaching practice. Consequently, reflective practitioners are more likely to experiment with new approaches, adapt to challenges, and ultimately achieve desired learner outcomes (Hattie, 2012; Schrittesser, 2014).

2.8 CHAPTER SUMMARY

This chapter has reviewed relevant literature in order to position the research study within an existing body of knowledge and lay a sure foundation for the research, underscoring its relevance. The chapter has pointed both to the essential role of NS in the Foundation Phase to respond to young learners’ curiosity and promote scientific literacy and critical thinking, and to the challenges faced by FP teachers of Science. The literature canvassed has revealed that these challenges often stem from being out-of-field and lacking adequate training during their higher education studies. This gap in training significantly influences their attitudes towards teaching the subject, often leading to a lack of confidence and uncertainty in their ability to teach effectively. Criticisms of the CAPS for NS in South Africa point to gaps that hinder effective teaching, including a lack of guidance on the NoS and scientific literacy, and inadequate support for developing CK and PCK. These factors contribute to a sense among NTs of isolation and frustration in the classroom, making it hard for them to integrate NS content confidently.

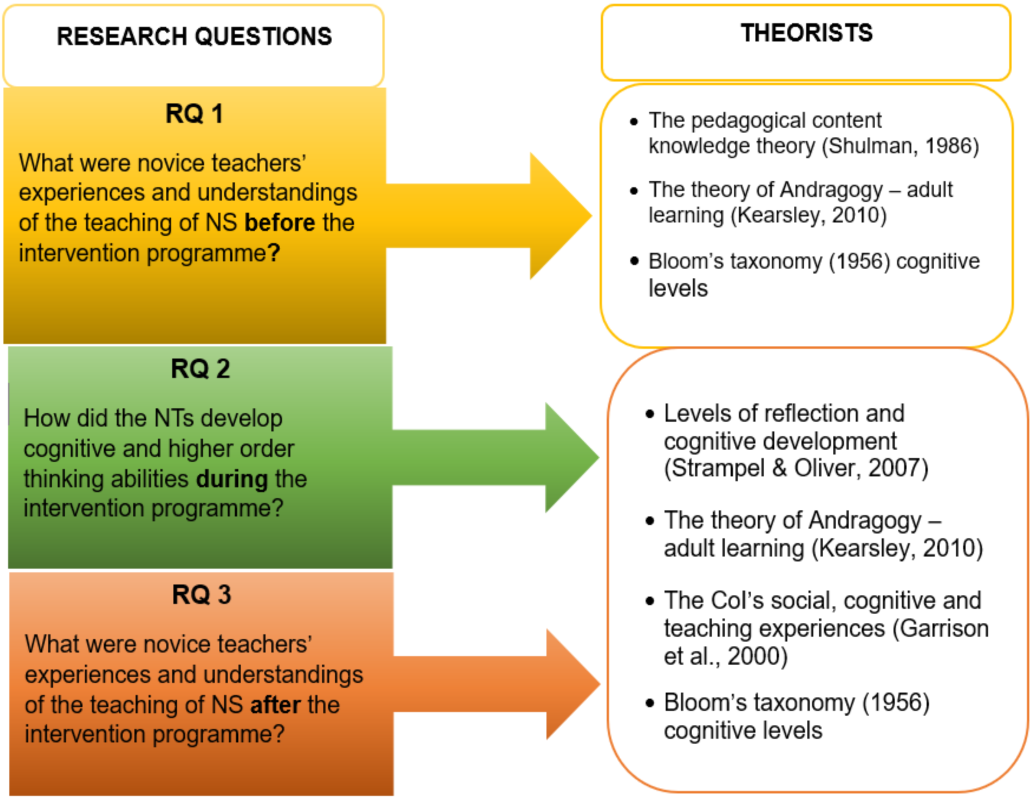
Dixon et al. (2018) have conducted a historical survey of Life Skills curricula from 1977 to the present CAPS, applying content analysis (Bernstein 1971, 1996) to illustrate the persistently weak classification and lack of disciplinary coherence. Examining the theoretical basis of the presentation of knowledge in all the subjects in Life Skills, including Natural Science, they note the difficulty of applying epistemological orientations that are often blurred or invisible. Bosman (2017) investigated the extent to which the French *La main à la pâte* (LAMAP) inquiry-based science education (IBSE) programme might be implementable in the South African context. An interpretative, qualitative multiple-case study design was employed to ascertain how attributes such as inquiry-based teaching, critical thinking and the effectiveness of integration, reflected the experiences and perceptions of teachers enrolled in postgraduate teaching programmes. Bosman (2017) focused on inquiry and the development of 21st-century skills but did not explicitly address the alignment of NS with the CAPS curriculum in Foundation Phase teaching. James et al. (2019) examined the impact of the RNCS and CAPS curriculum, noting that they highlight scientific inquiry but fail to define clearly how NS is to be taught. While some teachers used interactive methods, they lacked the content knowledge and pedagogical strategies to engage in scientific investigations. James et al. (2019) therefore propose professional development for Foundation Phase teachers to bridge this gap, though they do not specify just how the gap and the 'missing' curriculum are to be dealt with. This is precisely the area on which this thesis focuses: how to bridge the theory-practice gap and make good what is missing from the curriculum. Chapter 3 explores the fundamental theoretical frameworks that underpin this research study.

CHAPTER 3

THEORETICAL FRAMEWORK

3.1 INTRODUCTION

Five key theories informed the research process and data analysis: Shulman's (1986) theory of pedagogical content knowledge (PCK), Strampel and Oliver's levels of reflection (2007), Bloom's taxonomy (1956), Knowles's theory of andragogy or adult learning (1975) and Garrison et al.'s (2000) notion of a community of inquiry. The theories were synthesised because each provided a distinct lens for examining the NTs' experiences, their cognition and development of higher-order thinking skills, their understanding of the NS curriculum and pedagogical practices, and their transition towards self-directed learning. The following sections delve deeper into the theoretical frameworks, explaining how they assisted in answering the research questions. Figure 3.1, below, offers a visualisation of how the frameworks were employed in relation to each research question.



RQ 1

What were novice teachers' experiences and understandings of the teaching of NS **before** the intervention programme**?**

- The pedagogical content knowledge theory (Shulman, 1986)
- The theory of Andragogy – adult learning (Kearsley, 2010)
- Bloom's taxonomy (1956) cognitive levels

RQ 2

How did the NTs develop cognitive and higher order thinking abilities **during** the intervention programme?

RQ 3

What were novice teachers' experiences and understandings of the teaching of NS **after** the intervention programme?

- Levels of reflection and cognitive development (Strampel & Oliver, 2007)
- The theory of Andragogy – adult learning (Kearsley, 2010)
- The CoI's social, cognitive and teaching experiences (Garrison et al., 2000)
- Bloom's taxonomy (1956) cognitive levels

Figure 3.1: The three research questions and the theories informing data generation and results analysis

3.2 SHULMAN’S (1986) PEDAGOGICAL CONTENT KNOWLEDGE THEORETICAL FRAMEWORK

Shulman (1986) proposed a framework with three theoretical categories to describe the knowledge that a teacher of Science should possess (Almeida et al., 2019). The categories are content knowledge, pedagogical knowledge and pedagogical content knowledge (Shulman, 1986).

In 1987 Shulman reviewed and refined these aspects, identifying no fewer than seven categories: (i) knowledge of the content to be taught; (ii) broad principles and strategies of classroom management and organisation; (iii) curriculum knowledge (teaching specific subjects and topics, LTSM available); (iv) pedagogical knowledge of content relating to the specific integration of content and pedagogy, which is the exclusive domain of teachers; (v) knowledge of the age and stage of development of learners and their characteristics; (vi) knowledge of educational contexts, from group or classroom functioning, through the management and funding of educational systems, to the characteristics of communities and their cultures; and (vii) knowledge of the learning intentions, purposes and values of education, together with its historical and philosophical background (Krepf et al., 2017). Shulman’s original tripartite categorisation nevertheless remains useful for most purposes.

Teachers draw on their knowledge base in various ways when teaching including their experiences, content knowledge and adapting strategies to meet learner needs (Verloop et al., 2001; Hill & Chin, 2018; Lehmann, 2021). In this study, Shulman’s (1986) theorisation provided a useful lens to interpret whether or not or how NTs integrate NS knowledge with their teaching and reflective practice in FP. Figure 3.2 depicts Shulman’s (1986) three basic categories together with their constituent elements. The key integrative category is that of PCK.

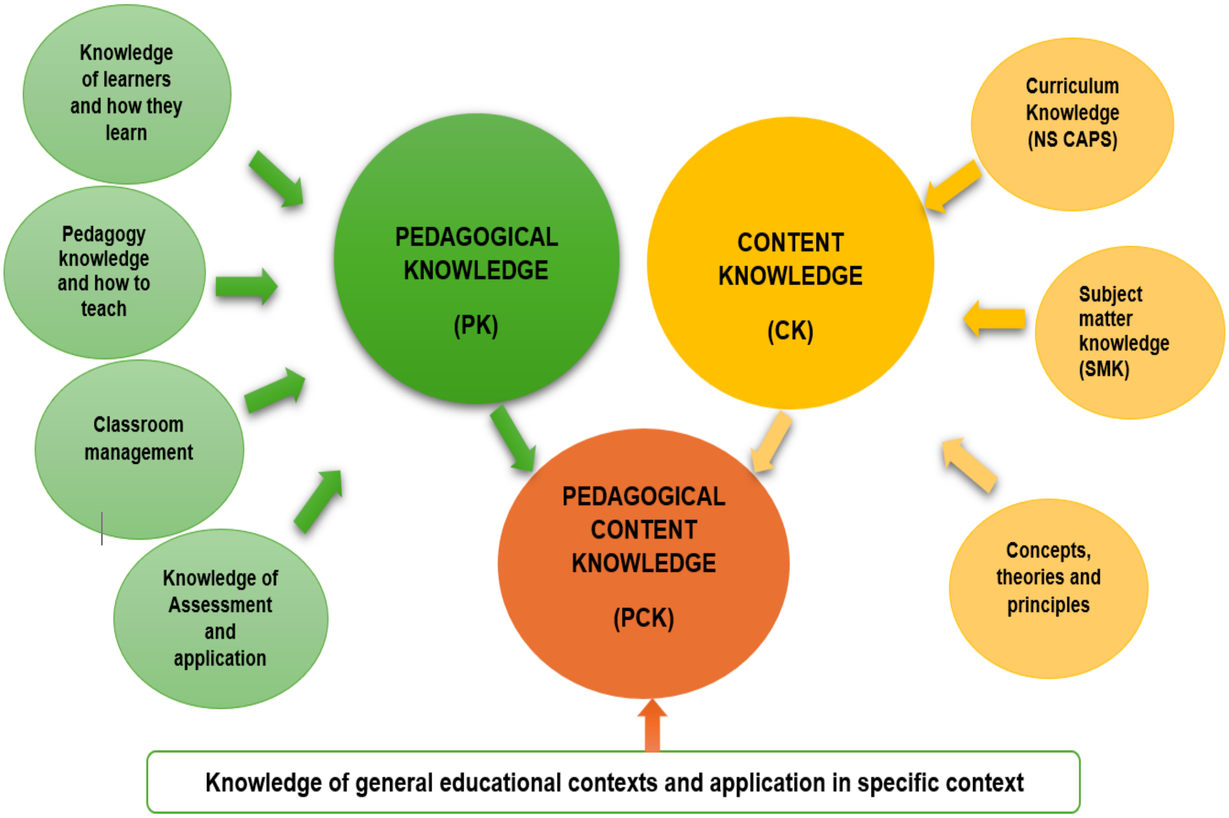


Figure 3.2: Adapted from Shulman's (1987) categories of knowledge

Content knowledge (CK) in the NS curriculum covers particular NS topics, scientific process skills and science concepts. Teachers need to need to be thoroughly acquainted with the relevant CK as well as an understanding of the intentions, purposes and values of the subject within the curriculum. Ball et al. (2008) and Stronge (2018) argue that a teacher's CK has significant implications for successful teaching. Subject matter knowledge (SMK) should enable the teacher to explain concepts clearly and dispel misconceptions. Teachers with sound CK are able to construct, plan, prepare and organise lessons, drawing at the same time on their understanding of how learners learn and construct knowledge (PK).

Pedagogical knowledge (PK) is defined as a teacher's understanding of the knowledge and academic abilities of their learners, and of how best to facilitate their learning and manage the classroom (Kartini et al., 2022). Knowledge of the learners, their learning needs and prior knowledge are important for deciding on teaching strategies. For optimal learning experiences, the learning environment should be replete with various and innovative strategies, making appropriate use of technology (Kartini et al., 2022). Knowledge of the NS curriculum is also crucial for determining the methods and processes of teaching (Almeida et al., 2019).

PCK is an amalgamation of CK and PK and a crucial component in the knowledge base of effective teachers (Shulman, 1986), especially teachers of Sciences and Mathematics (Almeida et al., 2019). According to Shulman, “Among [the categories identified], pedagogical content knowledge is of special interest because it identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented and adapted to the diverse interests and abilities of learners, and presented for instruction” (Shulman, 1987:8).

PCK is essential to a NS teacher’s ability to create effective learning experiences around NS topics, shaping the blending of CK and SMK into comprehensible, teachable content to enhance lesson outcomes (Grossman, 1990; Gess-Newsome, 2015). A comprehensive understanding of concepts in all their complexity is also necessary to scaffold effective teaching.

3.3 STRAMPEL AND OLIVER’S (2007) LEVELS OF REFLECTION

Strampel and Oliver’s (2007) framework provided a means of examining the development in critical reflection among the NTs, important for navigating new curriculum learning. Strampel and Oliver identify four levels of reflection, each linked to increasing cognitive processing skills. The levels range from stimulated reflection (recalling experiences) to critical reflection (analysing experiences, considering alternative perspectives and applying learnings). Through these different levels of reflection, the evolution of the NTs’ capacity for self-analysis and critical reflection was observed, with the ultimate aim of empowering them to become self-directed teachers who continuously refined their teaching practice. Figure 3.3 depicts the different levels of reflection and cognitive processing. Each level is discussed in more detail below.

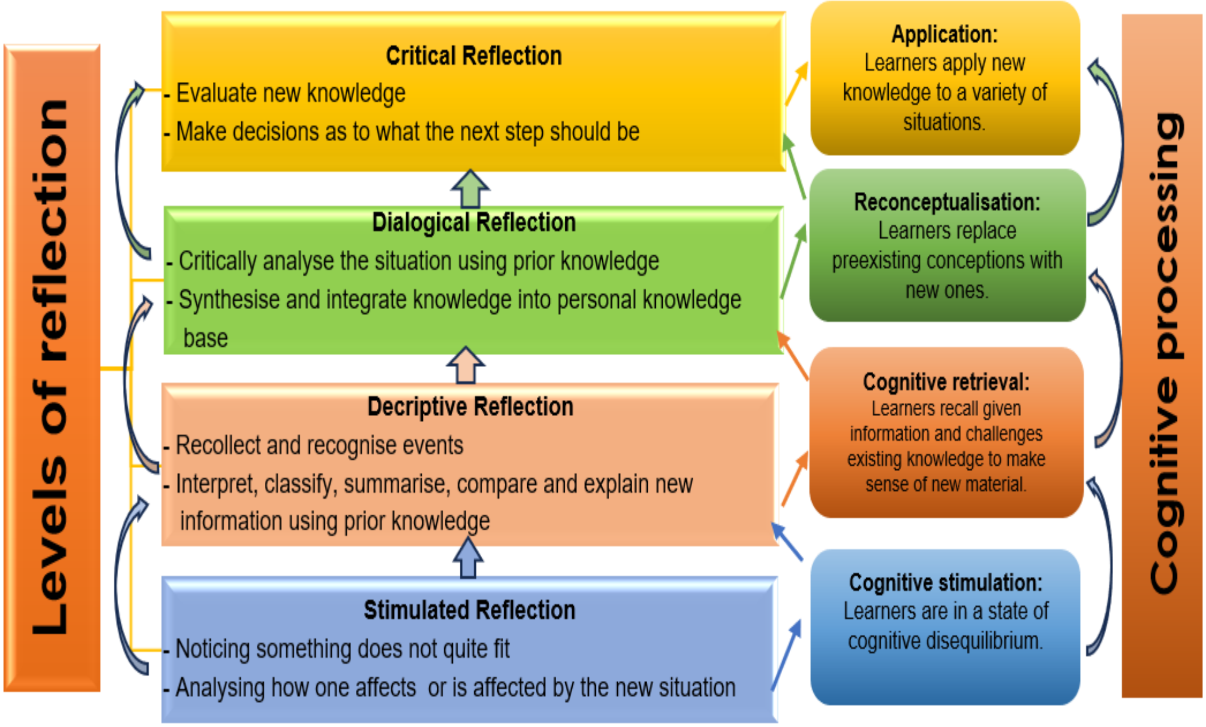


Figure 3.3: Levels of reflection and stages of cognitive processing (adapted from Strampel & Oliver, 2007)

3.3.1 Stimulated reflection and cognitive stimulation

According to Strampel and Oliver (2007), stimulated reflection acts as the initial trigger (‘noticing something does not fit’) when one is confronted with new material, creating a stage of awareness and cognitive activation.

During the IP, through engaging in activities such as discussion, journaling, and other activities, facilitated the NTs discovered unfamiliar aspects of the NS curriculum CK and scientific process skills, throughout their exploration (Luft & Roehrig, 2012). In the process of the stimulated reflection phase, recognition of their initial assumptions, reactions, and beliefs about the teaching of NS and the engagement in stimulated reflection would trigger cognitive stimulation. This state of disequilibrium, a natural part of the learning process, prompts sense making of the new information and how it could fit into their existing discourse. Through this stimulation, by being asked questions and engaging in activities, co-construction of knowledge, enabled cognitive processing and internalisation of new NS CK.

3.3.2 Descriptive reflection and cognitive retrieval

Descriptive reflection delves deeper by prompting the retrieval of prior knowledge. During this descriptive reflection stage, NTs would be expected to recognise, explain, interpret and analyse new information, but may possibly not have had the ability to apply the information in NS teaching practice (Anderson & Krathwohl, 2001). Activation and retrieval of their previous knowledge relating to their understanding of teaching NS, including both CK and pedagogical skills would support the interpretation and internalisation the new NS scientific process skills and concepts and how they would be able to apply them. Cognitive processing enables the integration of new knowledge with existing understanding (**assimilation** and **accommodation)** empowering meaning-making of the new NS CK when connecting the skills and concepts to specific NS topics. Ultimately, this process would strengthen the overall knowledge base for teaching NS (Meltzer, 2019).

3.3.3 Dialogical reflection and reconceptualisation

Dialogical reflection played a crucial role in the synthesis, integration and infusion of the new academic information and insights in this study, the new CK and PCK, the 'hands-on and minds-on' inquiry-based teaching, into their teaching philosophy. New knowledge would be used to enrich discussions, collaborations, guiding the co-creation of new ideas, activities, or a lesson plan to demonstrate understanding and application. This collaborative process of analysis and synthesis encouraged **reconceptualisation,** reshaping the NTs' teaching philosophies **and potentially leading** to more effective teaching approaches. By engaging in higher-order thinking skills, the NTs could move beyond simply memorising information and progress towards analysis, synthesis and, ultimately, the adoption and implementation of new ideas in their teaching practice.

3.3.4 Critical reflection and application

Critical reflection, the highest level of reflection, involves teachers **critically appraising their** newly acquired knowledge. This appraisal engages weighing the strengths and challenges of teaching CK (scientific process skills) and using the appropriate new pedagogical strategies embedded NS. As Strampel and Oliver (2007) suggest, **critical**

reflection requires the application of higher-order thinking skills (HOTS) like analysis, evaluation, and synthesis to form well-reasoned judgments that inform future activity in the classroom.

By progressing through the four levels of reflection – stimulated (initial thoughts), descriptive (describing teaching experiences), dialogic (discussing experiences), and critical (analysing the effectiveness of change) – the NTs engagement would increase in being able to critically analyse their teaching practices and thereby gain a deeper understanding of crucial elements for successful NS teaching.

3.4 BLOOM'S TAXONOMY (1956) OF COGNITIVE LEVELS

Bloom's taxonomy (1956), a well-established hierarchical framework for classifying learning objectives, played a crucial role in promoting HOTS within effective professional development programmes. By building on foundational knowledge, it guided participants towards progressively more complex cognitive skills. The framework, originally proposed by Bloom in 1956, has been revised by Anderson and Krathwohl (2001) and consists of six cognitive-level processes: remembering, understanding, applying, analysing, evaluating and creating (Nurmatova & Altun, 2023). Bloom's structure ensures progression, while Anderson and Krathwohl's model refines the process clarifying how the different types of knowledge interacts with cognitive processes. These processes are depicted in Figure 3.4, below, and subsequently described in some detail. They can briefly be summarised as follows:

3.4.1 Remembering: Recalling facts and basic concepts (e.g., define, identify, list)
3.4.2 Understanding: Grasping the meaning of information (e.g., explain, summarise, interpret)
3.4.3 Applying: Using knowledge and skills in new situations (e.g., demonstrate, apply, illustrate)
3.4.4 Analysing: Breaking down information into parts and examining relationships (e.g., compare, classify, analyse)
3.4.5 Evaluating: Making judgments based on criteria (e.g., evaluate, assess, critique)
3.4.6 Creating: Generating new ideas or products (e.g., design, develop, create)

This hierarchical framework categorises learning objectives in terms of increasing cognitive complexity. In this study, applying the hierarchy ensured that the NTs progressively developed their ability not just to acquire knowledge but also to analyse, evaluate and apply it meaningfully and creatively (Nurmatova & Altun, 2023).

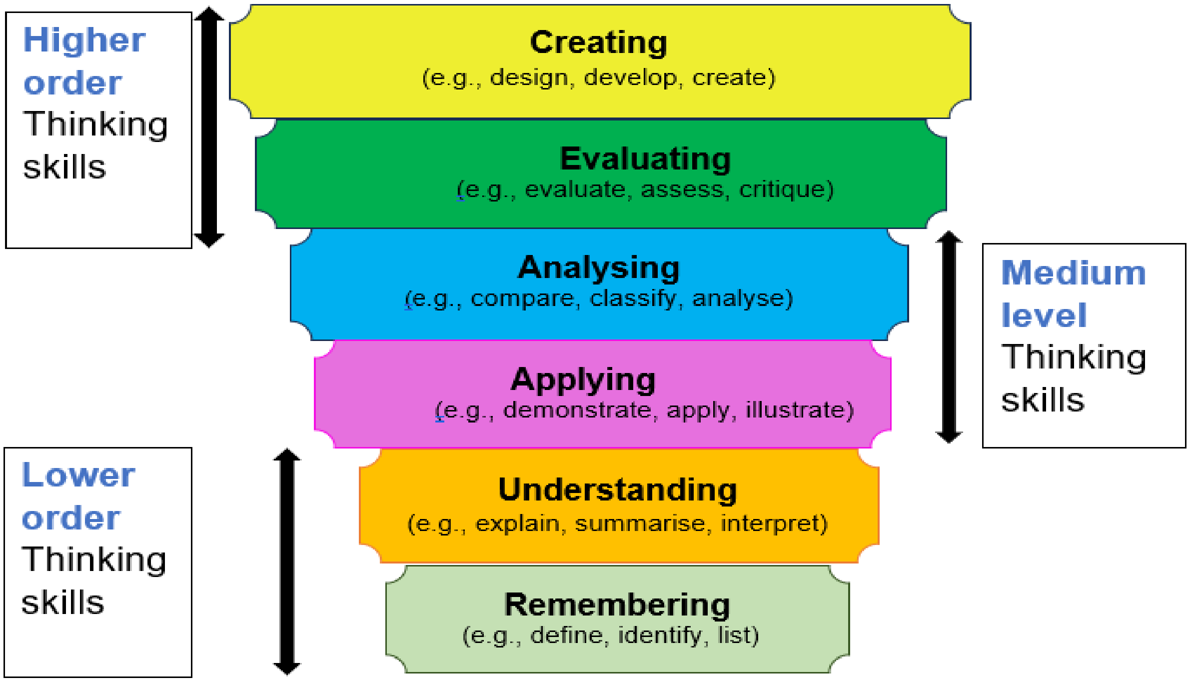


Figure 3.4: Revised Bloom's Taxonomy of cognitive levels (adapted from Nurmatova & Altun, 2023)

3.4.1 Remembering (lower-order cognitive level)

Educational research emphasises the importance of establishing a strong foundation of knowledge retrieval skills before moving on to more complex tasks (Morris, 2014). This aligns with Bloom's Taxonomy's level of 'remembering', which focuses on the ability to recall and identify factual information (Nurmatova & Altun, 2023).

3.4.2 Understanding (lower-order cognitive level)

Bainbridge and Bainbridge (2016) highlights the significance of progressing beyond simple memorisation to a deeper understanding of information. 'Understanding', the next level of Bloom's Taxonomy, challenges learners to grasp the meaning of information and explain it in their own words (Nurmatova & Altun, 2023).

3.4.3 Applying (medium-order cognitive level)

This level of application in Bloom's taxonomy (1956) involves building upon the foundation of the level of remembering and understanding to be able to demonstrate acquired knowledge and skills in new contexts (Nurmatova & Altun, 2023). The notion of moving beyond simple understanding to the application of knowledge, NS concepts and skills is the basis the researcher used for the project of designing an individual, comprehensive NS lesson plan (Bloom, 1956; Anderson et al., 2001). Understanding and application would be demonstrated by the ability to explain concepts in detail and apply the new knowledge in practice.

3.4.4 Analysing (medium-order cognitive level)

The level of analysis requires breaking down complex information, identifying its components, understanding the relationships between them and applying the knowledge (Nurmatova & Altun, 2023). During the analysis phase, the NTs compared and contrasted different scenarios, concepts and teaching strategies. Their discussion focused on identifying the best learner-centred experience for specific NS lessons. For example, the NTs discussed the potential strengths and weaknesses of various teaching strategies as applied to different NS lessons (e.g. plants and seeds: KWL, practical activity, observation), assessing their effectiveness and suitability for attaining the appropriate learning objectives. The insights gained were important for them to make informed decisions, solve problems and develop new ideas, thereby evidencing their cognitive development in this phase.

3.4.5 Evaluating (higher-order cognitive level)

Bloom’s level of evaluation entails making judgements about information and supporting the judgements with evidence based on specific sets of criteria. This may involve applying a personal perspective, but the emphasis is on logically justifiable evaluations (Nurmatova & Altun, 2023).

The NTs evaluated their individual lesson plan development and content. This included evaluating the effectiveness and suitability of different teaching strategies, assessing learning outcomes and critiquing curriculum materials (sources) chosen to teach the lesson. They also critiqued the appropriateness of educational e-resources and could provide justifications for these.

The level of evaluation entails making judgements about information and supporting the judgements with evidence based on specific sets of criteria.

3.4.6 Creating (higher-order cognitive level)

The level of creation, Bloom's highest cognitive level, includes the generation of new ideas; that is, prior knowledge and concepts are combined with new ones to generate something original (Nurmatova & Altun, 2023). The NTs commenced with lower-order cognitive activities, progressing through the different levels to the creation of comprehensive lesson plans (Bloom, 1956; Strampel & Oliver, 2007). This scaffolded approach, incorporating the gradual release model, ensured that the NTs built a strong understanding of the CK, teaching strategies and the lesson plan process, thereby gaining the knowledge to design further lesson plans independently.

3.5 KNOWLES'S (1980) ANDRAGOGY OF ADULT LEARNING

The theory of andragogy (Knowles, 1980) was employed in this study as a lens to examine the preparedness of NTs with three or fewer years of teaching experience to teach NS, in order to develop a framework for professional development. Andragogy's core principles (Knowles, 1980) provided a platform for a case study that actively engaged the NTs in the learning process, using higher-order cognitive skills and collaboration to find solutions to problems and achieve the co-creation of knowledge. The unique characteristics of adult learners determine what is considered an adequate learning environment as they prefer a measure of control over their learning experience, context and professional needs, including physical or virtual spaces, the format and pace. The environment should be aimed at leveraging their previous knowledge and experiences to provide contexts and activities appropriate to their professional needs and (in this case) teaching practice. The core assumptions underpinning andragogy are presented in Figure 3.5, below.

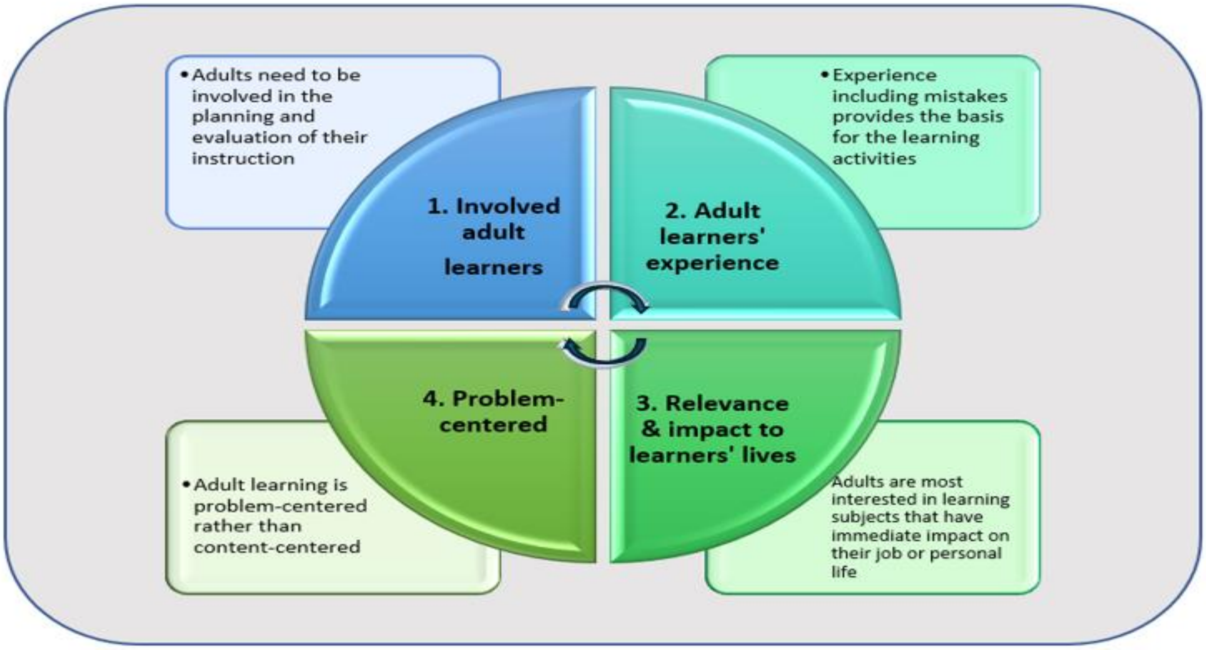


Figure 3.5: Core assumptions of andragogy (adapted from Knowles, 1984)

3.5.1 Application of the core assumptions or principles of andragogy

The principles of adult learning shaped the practical application of andragogy in this study. Explicit attention was paid to the detailed implementation of these specific principles: learner involvement and prior experiences were harnessed and translated into effective actions, yielding appropriate outcomes.

3.5.1.1 Learner involvement

Learners’ involvement through active participation in the planning and evaluation of their educational experiences is a prerequisite for adult learning (Knowles et al., 2020). Adult learners who take ownership of their learning trajectories exhibit more willingness and openness and experience more success (Kapur, 2015). Learner involvement acts as a catalyst for intrinsic motivation, through a self-directed process to self-actualisation.

An active role in planning and evaluating learning opportunities during the study empowered a sense of ownership, decision-making and partnership in the NTs learning trajectory (Knowles et al., 2020). In line with theorisations of andragogy, higher levels of motivation, participation and self-directed learning were manifested, yielding positive advantages and outcomes.

3.5.1.2 Experience-based activities

Knowles et al. (2020) advocate experiential learning, the engagement of adult learners in experience-based activities through iterative processes. Such practical activities facilitate learners' progress through providing them with opportunities to learn from making mistakes. Hands-on experience in real-world contexts aligns with the principles of andragogy, enabling a more effective acquisition of insights and knowledge through deep and significant learning encounters (Kapur, 2015).

3.5.1.3 Focus on relevance and application

Intrinsic motivation is activated when adult learners perceive the content of their learning to be personally relevant, valuable and directly beneficial to their current professional needs (Knowles et al., 2020). Engaging the NTs in real-life experiences was intended to augment the relevance and applicability of the knowledge being acquired, promoting deeper connections through personal significance and practical value. Problem-centred learning was given prominence in the IP. By infusing practical classroom strategies and skills into the activities, the NTs were able, through multiple iterations, to practise them in their classrooms. The priority accorded to immediate relevance and applicability had the potential to heighten the NTs' motivation (Knowles et al., 2020) and effectively bridge the theory-practice gap, facilitating their professional growth.

3.5.1.4 Flexible and supportive environment

A flexible and supportive learning environment should include multiple styles of teaching and learning, including lectures, collaborative activities, exploration, discussions and practical experiences (Knowles et al., 2020). Creating thriving, supportive learning environments for adult learners promoted a non-judgemental space for the free exploration of new ideas (Kapur, 2015). Attention was directed towards maintaining a supportive environment with provision for open discussion, adult autonomy and a flexible programme (Knowles, 1980).

3.6 COMMUNITY OF INQUIRY (CoI) FRAMEWORK (GARRISON ET AL., 2000)

In the research on the professional development of NTs in NS education, the CoI theory (Garrison & Arbaugh, 2007) provided a valuable framework for creating a collaborative, online learning environment that promoted the development of critical thinking (Garrison et al., 2000; Armellini & De Stefani, 2016). With its emphasis on online inquiry, this framework was particularly suitable considering the obstacles to face-to-face interactions during the COVID pandemic. The CoI framework emphasises three key elements: social presence, cognitive presence and teaching presence, as represented in Figure 3.6, below. In an educational setting, these three presences interact with each other in a variety of ways, creating opportunities for learners to develop their higher-order thinking skills (Garrison et al., 2000; Armellini & De Stefani, 2016; Cleveland-Innes, 2019).

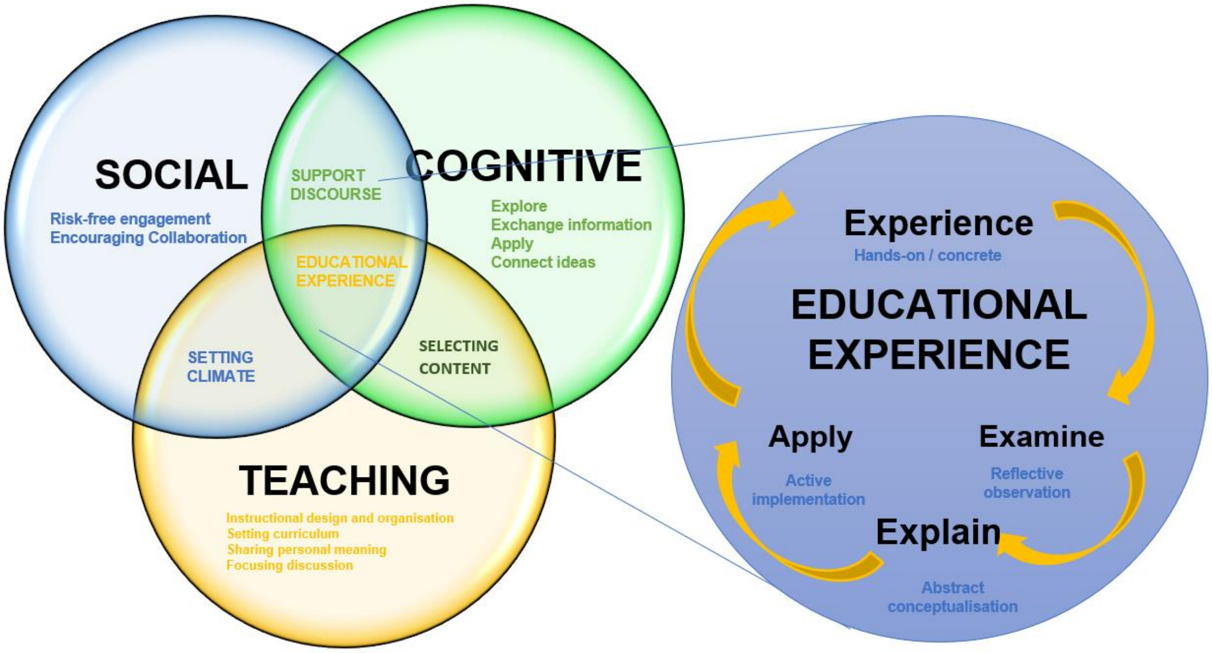


Figure 3.6: The CoI Framework (adapted from Garrison et al., 2000; Armellini & De Stefani, 2016)

3.6.1 The CoI framework in the research study

Garrison et al.'s (2000) CoI, which promotes critical thinking and collaboration in a community, was deemed to be a suitable framework for creating a meaningful learning environment in this study. The framework proposes effective online interaction through the integration of social presence, cognitive presence, and teaching presence. The online learning environment thus created enables active engagement to attain learning outcomes and the development of higher-order thinking skills (Cleveland-Innes, 2019).

Social presence is described by Garrison et al. (2000:94), as “the ability of participants in a community of inquiry to project themselves socially and emotionally, as ‘real’ people, through the medium of communication being used”. Social presence contributes to improving and sustaining cognitive presence for deeper learning and critical development (Garrison et al., 2000; Shea & Bidjerano, 2010).

Garrison et al. (2000:89) define cognitive presence as “the extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication”. Accordingly, in the study scaffolded learning opportunities were created to lead the participants through the four phases of cognitive presence: triggering event, exploration, integration and resolution. Garrison et al. (2000) claim that cognitive presence is an indicator of learners’ finding pathways towards higher-order thinking.

Teaching presence is essential for developing and sustaining a community of inquiry (Garrison & Arbaugh, 2007). The effectiveness of teaching presence pivots on the extent to which the curriculum facilitates cognitive and social processes to achieve personally meaningful learning goals (Anderson & Krathwohl, 2001). Teaching presence is “a significant determinant of student satisfaction, perceived learning, and sense of community”. It involves “planning, guiding, and managing cognitive and social processes to achieve outcomes that are both personally meaningful and educationally valuable" (Garrison & Arbaugh, 2007:163).

3.7 CONCLUSION

Five distinct strands of theory were selected to frame the study’s exploration of the challenges faced by novice teachers in their attempts to implement CAPS in Natural Science education in the Foundation Phase in South Africa. Together these theories created a synergy capable of addressing the multifaceted nature of the problem and forming the basis for a flexible grounded programme to address the needs of these novice teachers.

The theoretical strands comprised Shulman's PCK (1986), which focused on the combination of knowledges and how the teachers could bridge the theory-practice gap; Strampel & Oliver's (2007) levels of reflection, which by gradations enabled in-depth reflection by the NTs; Knowles's (1980) theory of andragogy, crucial for understanding how adults learn best to reach resolution; Garrison et al.'s (2000) community of inquiry (CoI), which emphasised the collaborative nature of learning and helped to establish a rich learning environment where knowledge sharing and construction added to professional development; and Bloom's (1956) cognitive levels, which made possible the investigation and analysis of the teachers' cognitive progress. The result was the creation of an inclusive and supportive online environment where cognitive processing, collaborative engagement and productive discourse prevailed, with regular reflective practice and continuous peer feedback (Shea & Bidjerano, 2009; Garrison & Akyol, 2013; Armellini & De Stefani, 2016). Building on these theoretical foundations, Chapter 4 describes the research paradigm, design and methodology employed to ensure a rigorous and trustworthy investigation.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

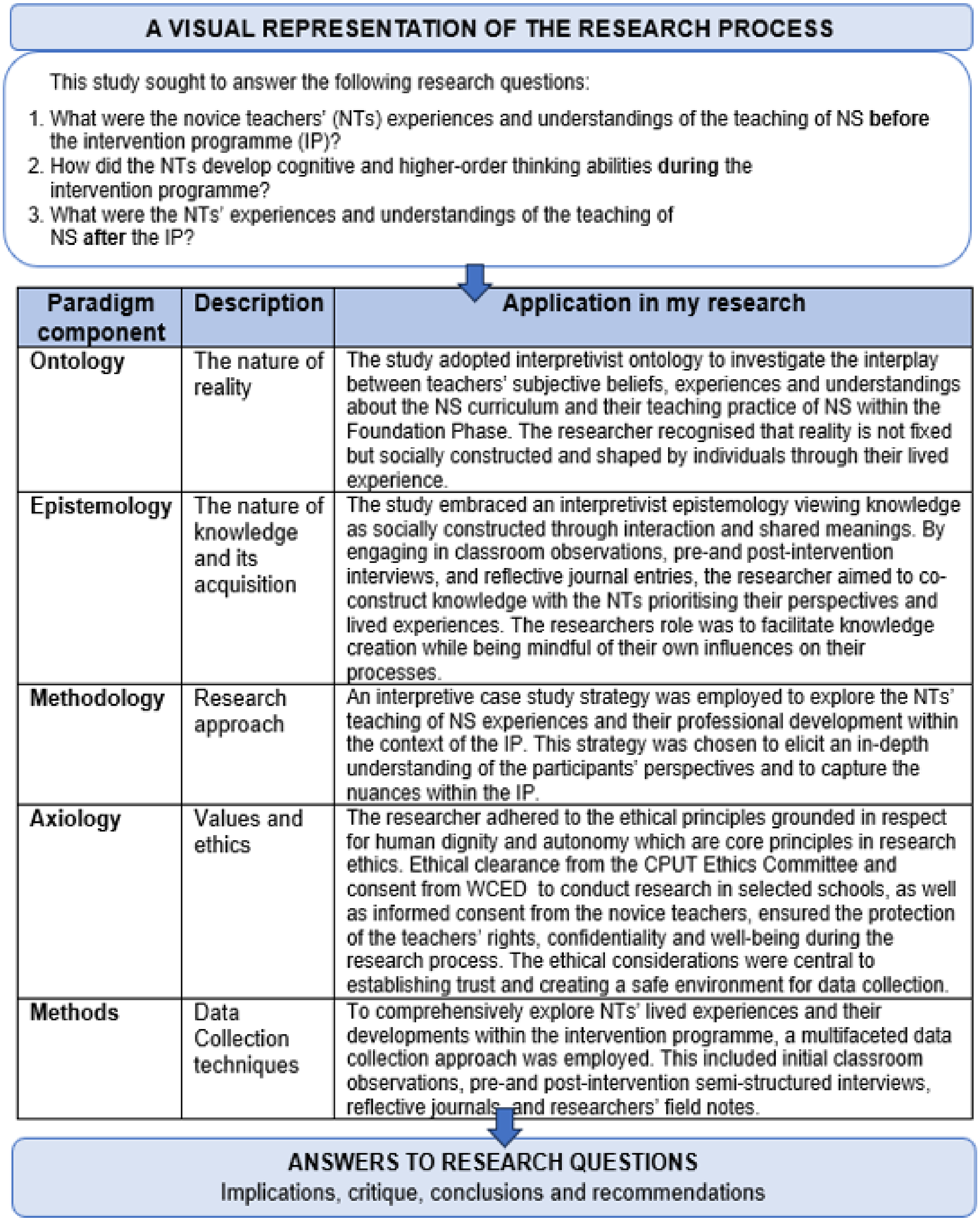
4.1 INTRODUCTION

This chapter outlines the methodological foundations of the study. It commences by discussing the interpretive research paradigm, qualitative research approach and the case study design. It then explores the specific research methodology employed, including research sites, participant selection, data generation instruments, data analysis procedures, considerations for ensuring trustworthiness, the role of the researcher and salient ethical considerations, concluding with a chapter summary.

4.2 RESEARCH PARADIGM

A paradigm serves as a foundational framework that underpins research inquiry. Paradigms are interconnected sets of assumptions encompassing five main components: ontology (the nature of the reality of the research), epistemology (the nature of knowledge and how we can acquire and critically interpret that knowledge), methodology (the overall research approach), axiology (the procedures, values and ethics guiding the inquiry) and methods of research used.

The theoretical frameworks (discussed in Chapter 2), grounded in the interpretivist paradigm, shaped every aspect of the research process, from the research questions to the methods employed and, ultimately, to how sense was made of the data generated (Creswell & Creswell, 2022). The selection and application of these components are detailed in Figure 4.1, which depicts the research objectives, research paradigm, and approach employed to answer the three research questions informing the study.



A VISUAL REPRESENTATION OF THE RESEARCH PROCESS

This study sought to answer the following research questions:

1. What were the novice teachers' (NTs) experiences and understandings of the teaching of NS **before** the intervention programme (IP)?
2. How did the NTs develop cognitive and higher-order thinking abilities **during** the intervention programme?
3. What were the NTs' experiences and understandings of the teaching of NS **after** the IP?

Paradigm component	Description	Application in my research
Ontology	The nature of reality	The study adopted interpretivist ontology to investigate the interplay between teachers' subjective beliefs, experiences and understandings about the NS curriculum and their teaching practice of NS within the Foundation Phase. The researcher recognised that reality is not fixed but socially constructed and shaped by individuals through their lived experience.
Epistemology	The nature of knowledge and its acquisition	The study embraced an interpretivist epistemology viewing knowledge as socially constructed through interaction and shared meanings. By engaging in classroom observations, pre-and post-intervention interviews, and reflective journal entries, the researcher aimed to co-construct knowledge with the NTs prioritising their perspectives and lived experiences. The researchers role was to facilitate knowledge creation while being mindful of their own influences on their processes.
Methodology	Research approach	An interpretive case study strategy was employed to explore the NTs' teaching of NS experiences and their professional development within the context of the IP. This strategy was chosen to elicit an in-depth understanding of the participants' perspectives and to capture the nuances within the IP.
Axiology	Values and ethics	The researcher adhered to the ethical principles grounded in respect for human dignity and autonomy which are core principles in research ethics. Ethical clearance from the CPUT Ethics Committee and consent from WCED to conduct research in selected schools, as well as informed consent from the novice teachers, ensured the protection of the teachers' rights, confidentiality and well-being during the research process. The ethical considerations were central to establishing trust and creating a safe environment for data collection.
Methods	Data Collection techniques	To comprehensively explore NTs' lived experiences and their developments within the intervention programme, a multifaceted data collection approach was employed. This included initial classroom observations, pre-and post-intervention semi-structured interviews, reflective journals, and researchers' field notes.

ANSWERS TO RESEARCH QUESTIONS

Implications, critique, conclusions and recommendations

Figure 4.1: Research paradigm, approach and methodology used for this study (adapted from De Jager, 2018)

Interpretivist paradigm

Because this research is grounded in the interpretivist paradigm, a qualitative case study design was chosen to examine and critically interpret the NTs’ perspectives on the teaching of NS in the FP (Bhattacherjee, 2012). According to Bhattacherjee (2012) and Rehman and Alharthi (2016), the interpretive paradigm generates knowledge gained through observation and individual subjects’ accounts of their intentions, beliefs, values, reasons, meaning making and understanding. Observation, interviews and journal entries allowed for a deep exploration of the NTs’ subjective experience relating to their training and encompassing NS CK, PK and the implementation of NS pedagogical practices (Rehman & Alharthi, 2016; Creswell & Poth, 2018). This exploration revealed the NTs’ prejudices, perspectives, attitudes, emotions and limitations in regard to teaching NS.

Using the five amalgamated theoretical frameworks, the researcher engaged in two levels of interpretation. First, she sought to observe and experience the phenomenon from the NTs’ subjective point of view. Secondly, she examined these subjective perspectives to provide a detailed and reasonably objective narrative attempting to interpret and explain the phenomenon that they manifest (Bhattacherjee, 2012).

By focusing on the NTs’ perspectives and constructed meanings, the study aimed to illuminate the complexities of their professional evolution and how they came to make sense of NS, including developing and applying pedagogical practices in their NS teaching (Creswell & Poth, 2018). This interpretive research was not committed to finding definite answers so much as to comprehending the intricacies of the progress that unfolded during the IP, as the result of an iterative and immersive process (Bhattacherjee, 2012). Both national and international literature was consulted to analyse and provide an explication of the trajectory of this progress. The interpretivist paradigm allowed the research to focus on the phenomenon holistically rather than in fragmented parts (Alharahsheh & Pius, 2020).

4.3 RESEARCH APPROACH

This study focused primarily on the NTs’ authentic voices and the meanings they attached to their experience of NS teaching during the IP (Cohen et al., 2018). A qualitative approach was chosen, in part because the research was conducted in the NTs' natural setting (Creswell & Creswell, 2022). Considerable interaction with the NTs was essential during the IP, to determine their changing professional discourse in the teaching of NS (Creswell & Creswell, 2022). The researcher engaged in 'mask-to-mask' direct interaction with the NTs during pre-interviews and two IP sessions at the schools. The first mask-to-mask session included introductions, signing consent forms and conducting the first two intervention sessions. The researcher was grateful for the opportunity to establish rapport and trust with the NTs in the two mask-to-mask sessions. The informal focus group interview conducted ten months after the completion of the IP was similarly a mask-to-mask session.

The exploratory nature of the qualitative approach allowed for an in-depth assessment of the NTs' interpretation of CAPS for FP NS, CK, pedagogy, scientific literacy, and classroom discourse (Creswell & Creswell, 2022). Prioritising their lived experience generated rich textual data, which enabled the researcher to penetrate to the heart of how their new knowledge of CK and PCK informed their instructional practices and their changed professional discourse (Yin, 2015; Cohen et al., 2018).

Because of its fluid, evolving and dynamic nature (with endless possibilities for learning more about the human response [Patton, 2015]), qualitative research allowed for changes in the interview questions or additions to the IP to be made during the research process. This attribute also facilitated monitoring the NTs' transition and the meaningful changes or limitations they experienced (Creswell & Creswell, 2022).

4.4 RESEARCH DESIGN

A collective case study design was employed. This permitted simultaneous in-depth exploration and analysis of multiple cases, providing a rich and comprehensive understanding of the phenomenon (Creswell & Creswell, 2022). In addition to scrutiny of the processes, growth and outcomes of the NTs' NS knowledge in three primary schools in the Metro Central Education District (MCED), the design made possible analysis of differences and similarities within the sample.

Among the strengths of the collective case study was the purposive sampling, which ensured that relevant participants – NTs with three or fewer years of experience, teaching NS in FP classes – were secured for the sample (Frey, 2018). Design flexibility allowed the researcher to employ different data generation methods – questionnaires, interviews and observation – permitting exploration from multiple angles. This made possible a more textured and comprehensive understanding of the phenomenon (Creswell & Poth, 2018), while promoting the generalisability of the findings (Creswell & Creswell, 2022).

It is reasonable to regard the findings of a collective case study as generalisable or transferable since they are detailed and contextually rich (Creswell & Poth, 2018; Schoepf & Klimow, 2022). The research hence has value beyond the specific cases studied. Because the findings from one case corroborated or conflicted with the findings from another, data triangulation was built into the research design. This enhanced the credibility and reliability of the study.

The disadvantages of a collective case study stemmed from its complexity, which made it time-consuming and resource-intensive (Yin, 2016; Creswell & Creswell, 2022; Schoepf & Klimow, 2022). Analysis and synthesis of the results were challenging since they were done manually. The main limitation of the collective case study proved to be the size of the sample, since three of the participant NTs withdrew for personal reasons.

4.5 RESEARCH METHODOLOGY

This section features discussion of the research site, participant selection, data generation tools, data analysis, trustworthiness and ethical considerations.

4.5.1 Research site

Initially, convenience sampling was employed to select three urban, public primary schools within the Metro Central Education District in the Western Cape. Convenience sampling is a non-probability sampling method used by qualitative researchers. According to Neuman (2014), it typically takes into account factors such as distance, easy accessibility, and time or budget constraints. In this study, the schools were within a 20-kilometre radius of the researcher's location, ensuring a high degree of convenience, accessibility and cost-effectiveness (Creswell & Creswell, 2022). By choosing schools in close proximity to each other, the researcher could plan more frequent interviews and classroom observations. The three schools where the IP sessions were held in rotation were about 5 km apart and hence easily accessible for both the NTs and the researcher.

Additionally, purposive sampling was employed. Creswell and Poth (2018) observe that purposive sampling is a deliberate process of selection mandated by the purpose of the study, with the overall aim of gathering in-depth information to secure a deeper understanding of the phenomenon being researched. The key criterion for the purposive sampling in this instance was that each school have at least two novice Foundation Phase (FP) teachers on their staff and that the language of teaching and learning (LoLT) be English. The schools had to be willing to participate in the study. The researcher visited the three schools and supplied interested NTs with the link to complete the questionnaire (see Appendix 1). Owing to safety protocols associated with the COVID-19 pandemic, only five of the seven interviews and two of the eight IP sessions were conducted face-to-face. The remaining interviews and IP sessions were conducted virtually on a Microsoft TEAMS online platform. More details about the number of teachers in FP, the learning and teaching support material (LTSM) for NS and the technology available at each of the selected sites are presented in Table 4.1, below.

Table 4.1 Details of the selected sites

Site	**NS learning and teaching support material**	**Technology availability – provided both by WCED and their own personal laptops**	**Distance to schools (km)**
School A	none	• Interactive white boards in each classroom • Khanya computer lab (partially dysfunctional)	14.7
School B	none	• Personal laptop • Khanya computer lab (partially dysfunctional)	13.5
School C	none	• Personal laptop • Khanya computer lab (partially dysfunctional)	13

The three primary schools selected for this study had NTs on their staff establishment who were willing to be involved and learn more about the teaching of NS via this research project. At School A each classroom had an interactive board installed, but Schools B and C did not. Each school had a Khanya computer laboratory which was partially functional, yet the FP teachers rarely used this facility due to technical issues such as non-functioning or outdated equipment with little technical back-up. The NTs opted to use their own personal laptops since they were more modern and up-to-date, suitable for organising their resources and installing software to suit their teaching needs. Their laptops were used for activities such as lesson planning, accessing resources and playing short videos for discussion, or for introduction to or consolidation of their lessons, employing questioning strategies. At the commencement of the research, the FP classes did not have a NS kit. WCED provided a Science kit to School A a few weeks before the conclusion of the IP, while Schools B and C received their Science kits after the completion of the IP. The FP NS kit included a teacher-friendly guide to conducting simple experiments. Basic tools for exploration were provided to enable learners to explore their natural environment and so learn about fundamental scientific concepts in a collaborative, hands-on, interactive manner. The tools included items such as bio-display boxes to be used as a wormery or for the germination of seeds, plastic nets, tweezers, droppers, a rain gauge, magnifying glasses, plastic beakers, garden forks and spades, a thermometer, a simple balancing scale and gloves. A few months after the conclusion of the IP, School C installed interactive Whiteboards in its classrooms.

4.5.2 Participant selection

Further purposive sampling was employed to select seven NTs to participate in the study. Purposive sampling is, in this context, a method characterised by the intentional targeting of individuals who are particularly knowledgeable about the subject of the study and can provide in-depth, relevant information (Cohen et al., 2018; Creswell & Creswell, 2022).

The selection criteria were that teachers: had three or fewer years of experience, were qualified at different Higher Education Institutions (HEIs) and had taught Life Skills in the Foundation Phase with English as the language of learning and teaching (LoLT). After completion of the questionnaire, NTs meeting the criteria were selected. Hence seven participants were chosen for their potential to provide detailed and meaningful information about their experiences, training and teaching practices, rendering them probable contributors of the kind of information needed to meet the aims of the study.

Table 4.2, below, presents the demographic particulars of the sample, including their pseudonyms, years of teaching experience, the school they taught at, which institution they attended, qualifications and the grade they were teaching at the time of data generation.

Table 4.2 Demographics of the seven NTs

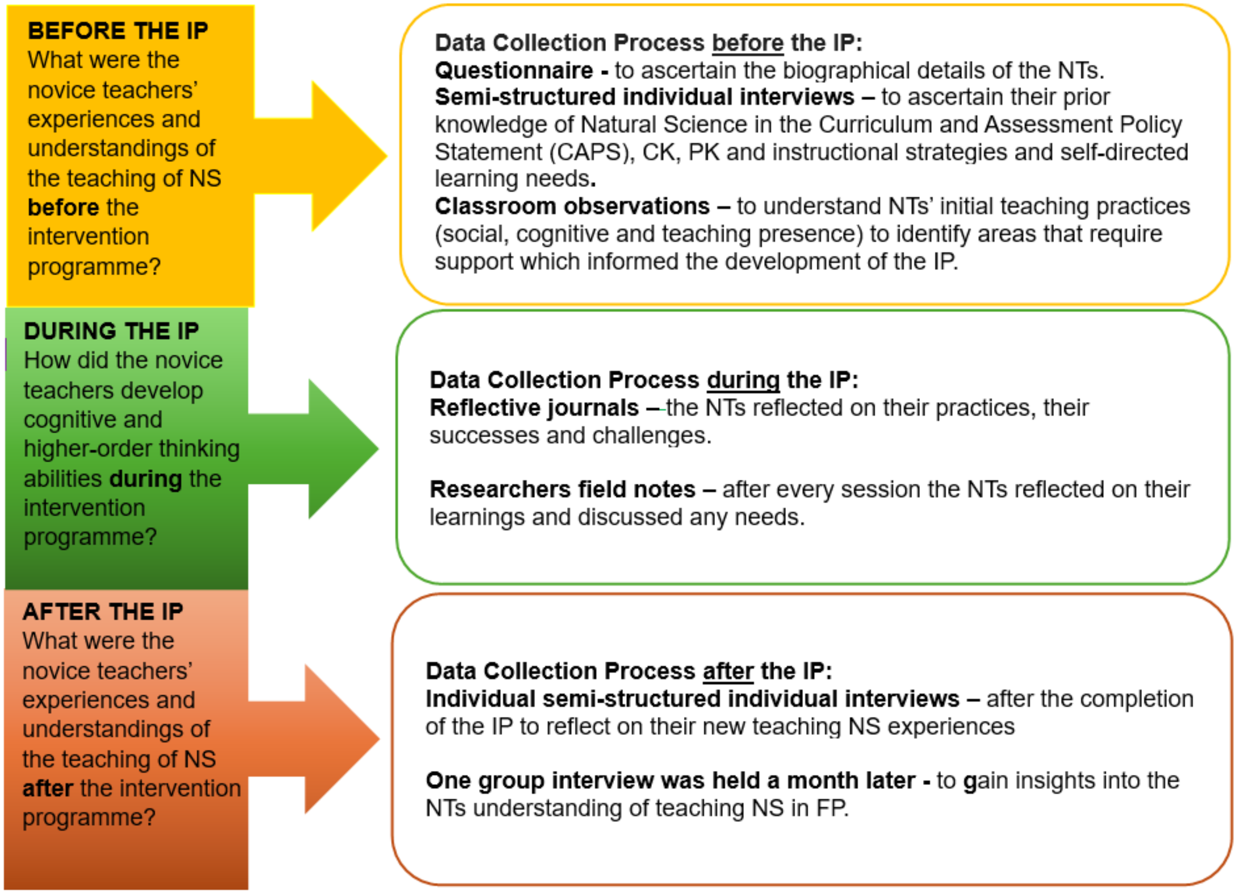
Name	Years of teaching experience	School	Higher Education Institutions (HEIs)	Qualification and Phase	Grade being taught at the time of data generation
NT 1	6 months	A	HEI A	PGCE FP	2
NT 2	6 months	A	HEI A	PGCE FP	3
NT 3	1 year 6 months	A	HEI B	B Ed FP	2
NT 4	1 year 6 months	B	HEI C	B Ed FP	2
NT 5	2 years 6 months	B	HEI C	B Ed FP	1
NT 6	1 year 6 months	C	HEI D	B Ed FP	1
NT 7	6 months	C	HEI D	B Ed Intermediate and Senior phase (IP/SP)	3

While the sample size was not pre-defined, seven participants were chosen, deemed a sufficient number for extensive and intensive exploration of the phenomenon (Kumar, 2014). Dworkin (2012) emphasises that smaller sample sizes in qualitative research, particularly if data is being collected through in-depth interviews, are often sufficient to achieve meaningful results and can offer valuable, representative insights into the study's area of focus. All seven NTs signed the consent forms (Appendix 2).

During the data generation process, NTs 2 and 3 withdrew from the research project after the initial interview before the start of the class observation. They cited wedding preparations and the stresses of the COVID-19 pandemic, and the acceptance of a teaching position in another district, respectively. NT 6 withdrew after Session 5 of the IP, due to a bereavement.

4.5.3 Data generation instruments

Multiple data generation methods were employed to collect data and gain a comprehensive understanding of the NTs' experiences. Figure 4.2, below, illustrates the process of data generation.



BEFORE THE IP
What were the novice teachers' experiences and understandings of the teaching of NS **before** the intervention programme?

Data Collection Process before the IP:
Questionnaire - to ascertain the biographical details of the NTs.
Semi-structured individual interviews – to ascertain their prior knowledge of Natural Science in the Curriculum and Assessment Policy Statement (CAPS), CK, PK and instructional strategies and self-directed learning needs.
Classroom observations – to understand NTs' initial teaching practices (social, cognitive and teaching presence) to identify areas that require support which informed the development of the IP.

DURING THE IP
How did the novice teachers develop cognitive and higher-order thinking abilities **during** the intervention programme?

Data Collection Process during the IP:
Reflective journals – the NTs reflected on their practices, their successes and challenges.

Researchers field notes – after every session the NTs reflected on their learnings and discussed any needs.

AFTER THE IP
What were the novice teachers' experiences and understandings of the teaching of NS **after** the intervention programme?

Data Collection Process after the IP:
Individual semi-structured individual interviews – after the completion of the IP to reflect on their new teaching NS experiences

One group interview was held a month later - to gain insights into the NTs understanding of teaching NS in FP.

Figure 4.2: Progression of the data generation through the different phases of the IP

4.5.3.1 Piloting the instruments

Pre-interview:

The pre-interview schedule was piloted with two FP subject advisors (SAs) and two FP teachers, one being a Grade 3 NT and the other a Grade 2 teacher with ten years' experience. Both the SAs and teachers agreed that the questions were straightforward and unambiguous. The teachers recommended that one question be added to the interview schedule as they believed it would provide important information about the NTs' understanding of NS prior to the IP development and a good way of cross-checking whether the NTs' answers aligned with the rating they assigned to themselves. The proposed new question was: How would you rate your CK of the NS and the practical teaching of the subject, on a rating scale from 1 to 5, with 1 having no content and practical NS teaching knowledge, and 5, having comprehensive content and practical knowledge of teaching NS. Why would you say so?

According to Creswell and Poth (2018), the rating scale provides quantifiable insights which could be beneficial to the researcher in determining gaps in the NTs' knowledge of NS. The question also encouraged each NT to reflect on their teaching practice, knowledge of NS and self-confidence. The researcher could gather from the ratings whether the NTs thought they were prepared to teach NS, and with what level of confidence.

During discussion with the supervisors of this study, the researcher was asked to make the SMK questions more open-ended, to provide opportunities for the NTs to speak about their teaching experiences and pedagogical content knowledge. Teachers would in the process refer to their subject knowledge. Table 4.3, below, highlights the proposed and revised questions.

Table 4.3 The proposed and revised interview questions

Proposed questions	Revised question
What are some of the topics in the NS curriculum that you teach?	How familiar are you with the Natural Science requirements in the CAPS document?
How do you teach the life cycle of a frog to your learners to help them understand the different stages of development?	Which specific NS concepts in the CAPS of Natural Science present a problem for you to teach? Why do you say so?
Can you tell me about the pedagogical strategies you used in the classroom recently linked to a topic?	What pedagogical practices and strategies do you use to teach Natural Science lessons? Can you tell me about them?
Briefly outline how you would integrate technology in a lesson about the life cycle of a butterfly	What kinds of resources do you have to teach Natural Science, and were you trained to use technology in your teaching practice?

Intervention programme

A pilot of the IP was conducted using three one-hour, face-to-face sessions. An open invitation was sent to a few schools in the vicinity of where the researcher worked, to attend the NS pilot sessions. The same two subject advisors who participated in the interview pilot and 25 FP teachers responded positively to the call. Teachers had a wide range of experience, but in every case it included teaching Grades 1, 2 and 3. The general guideline suggested by Thabane et al. (2010) is that a pilot should be large enough to establish the feasibility of the proposed research process and evaluate its effectiveness. The pilot was conducted using only Sessions 1, 4 and 5 of the IP, which were representative of all the sessions in which CK, PK and PCK were being developed.

The contents of the eight-week programme were presented to the participants in Session 1. On the basis of this overview, they were asked to evaluate aspects such as the content, progression, and time allocated. No recommendations for the improvement of the programme were forthcoming, however, because it was felt that it went so much further than the CAPS document for NS. At the end of Session 1, the participants were asked to explore the CK of the NS CAPS

Only 15 teachers and the two SAs participated in Session 4. Participants applied the knowledge gained from the self-study to determine whether the multi-layered activities in which skills and concepts were to be applied to NS topics were clearly understood or whether the programme needed refinement. After the sessions, the teachers paired off, discussed and gave feedback on the feasibility and proposed mediation. Ten of the teachers indicated that ‘more time’ should be given to the NTs to complete the activity because it was quite complex and had to be thought through. After some discussion, the other five teachers agreed. They were of the opinion that the activity, because of the opportunity to apply new knowledge that it afforded, would give the NTs a sense of accomplishment. The period allocated was adjusted to double the original time of one hour.

In Session 5, the number of participants declined further to 10 teachers and two SAs. Participants had to use the knowledge gained in Session 4 to guide them in developing a lesson plan. All the participants agreed that the activity supported the application of CK, PK and PCK, which was useful given the current poverty of scientific literacy and NS knowledge in FP. They indicated that more time should be spent on developing scientific process skills, with more demonstrations and hands-on activities. Participants endorsed the in-depth engagement with scientific literacy and claimed that they had learned from the process. The Life Skills resource file was referenced as a useful tool. The time allocated was extended as recommended, but the suggestion to include more demonstrations with hands-on activities could not be heeded because of the onset of COVID-19 and the consequent shift to an online platform. A compromise was attempted by using short 2-to-3-minute videos to explain experiments which would have been done hands-on.

While time constraints were encountered in conducting the pilot IP, the overall programme was well received. Participants particularly appreciated the check-ins, motivational elements, and times for reflection before and after each session. Initial teacher feedback indicated potential benefits in terms of improved teacher knowledge and skills, which supported the implementation of an IP for NTs.

4.5.3.2 Semi-structured individual interviews

Before the IP, semi-structured individual interviews were chosen as the most appropriate means to explore the complexities of the NTs' knowledge, given their divergent experiences and contexts (Holton, 2024). Interviewing is an intensive and reflexive method offering a good response to questions of 'how' and why', which are the questions that interested the researcher (Holton, 2024).

Semi-structured individual interviews were conducted to ensure the collection of rich and reliable data. The interviews included some open-ended questions to ensure that the participants were uninhibited in their communication and felt free to provide extensive detail. The researcher prioritised establishing a rapport with seven NTs by putting them at ease, as recommended by Creswell and Creswell (2022). This was achieved through careful explanation and consistency in the interviews, using the same interview guidelines to enhance reliability and not offering any personal opinions. Through the semi-structured individual interviews, the NTs provided rich, detailed data on complex issues concerning their practice.

To mitigate potential bias, the researcher was mindful throughout of her role as interviewer, particularly given the fact that she was a WCED official in a more senior position than the teachers (Saldaña & Omasta, 2021). Being aware of her tone of voice, actions and facial expressions, and listening without being judgmental, were foremost in the researcher's mind (Burgoon et al., 2021). By applying these strategies, the researcher ensured that the data generation process was objective, precise and fair (Creswell & Creswell, 2022).

Semi-structured individual interviews were conducted using the video conferencing software, Microsoft TEAMS, during the COVID-19 pandemic. Creating a comfortable environment was challenging since most of the interviews were planned to be conducted online, an unfamiliar setting with its own challenges. Two of the interviews were successfully conducted online. The remaining NTs found the online platform and other technical issues difficult to manage. As a result, a decision was made to conduct face-to-face interviews with the required COVID-19 protocols at the NTs' respective schools. The remaining five NTs' interviews were conducted in their classrooms, a familiar environment, after their learners were dismissed for the day. The planned semi-structured individual interview schedule (Appendix 3) was closely adhered to, with the researcher exercising some flexibility in probing more deeply into relevant topics to gather more comprehensive data (King et al., 2018). Each interview was audio-recorded with the participants' permission and lasted between 25 and 40 minutes.

Even though the platform was unfamiliar, online interviewing enabled much the same range of data to be collected. The researcher could still connect with the NTs, establish a sense of trust, and adapt the questions when needed by rephrasing a question or probing for clarity or more information (Saldaña & Omasta, 2021; Creswell & Creswell, 2022). Notable disadvantages of the online interviewing were the absence of certain non-verbal cues, which limited the richness of the data (Archibald et al., 2019), and disruptive technical problems with connectivity (Gray et al., 2020).

The disadvantage of conducting interviews in a classroom setting was the challenge of constant interruptions. Even after school hours, the environment was disruptive, which affected the interview process and threatened to compromise data quality. As a result, probing questions were not always asked during two of the interviews, limiting the depth of data generation. At various points during the research, the researcher was compelled to make multiple adjustments to the data generation process because of the COVID-19 pandemic, such as transferring to online interviews and changing the dates of the interviews (Zammit, 2024).

4.5.3.3 Classroom observation

Classroom observation is a qualitative research instrument selected to gather first-hand data to complement the in-depth interviews. Data was collected through the direct observation of actions, behaviours and interactions. The purpose of such observation was to gain an understanding of the NTs' approach to teaching NS lessons (Taherdoost, 2021). Again, because of COVID-19 restrictions, traditional classroom observation was not feasible. Instead, an agreement was reached with the NTs for them to video record their NS lessons. This method, while innovative, presented several challenges and required significant adaptations. The NTs nevertheless recorded their lessons, and at their convenience, which served to reduce the pressure and scheduling conflicts associated with in-person observation. The teachers were given six weeks to plan, teach and record their NS lessons.

An observation schedule (see Appendix 4) was developed for the researcher to make notes on the videoed lessons. These notes included the date, time and grade of each lesson observed, together with details such as classroom environment, use of learning and teaching support materials (LTSM), pedagogical approaches and whether the lessons were learner- or teacher-centred. The schedule was closely aligned with the aims of the study, especially RQ 1's concern with the teachers' preparedness, practices and subject matter knowledge (SMK). By consistently documenting these details, the researcher aimed to gain a clearer understanding of the factors influencing the NTs' approach to teaching.

Some NTs struggled with setting up the equipment and ensuring continuity in their recordings. The challenge of maintaining consistent video quality and uninterrupted recording was compounded by the lack of technical support, leading to fragmented video submissions. Situations like this, where logistical challenges have detracted from the ease and quality of data generation, have recurred in educational research (Creswell & Creswell, 2022; Mirhosseini, 2020).

Despite these challenges, each participant was able to submit a video in two or three parts. Video recordings were a rich source of visual data that enabled a detailed analysis of teaching practices and classroom interactions, offering insights that traditional observation might have missed (Creswell & Creswell, 2022; Mirhosseini, 2020). The video recordings yielded sufficient data to analyse and yield meaningful conclusions about the NTs' instructional competencies in their teaching of NS. The experience highlighted the importance of flexibility and resilience in research implementation, particularly in crisis-affected environments (Creswell & Poth, 2018).

The videoed class observation schedule allowed for consistency and structure, with a predetermined framework to record specific variables, for example, lesson structure and teacher and learner interaction. An added advantage was that the video could be watched multiple times, offering the NTs an unexpected reflective tool. It was relatively straightforward to compare the NTs' actions and interactions during the lessons to determine commonalities and differences. Since the lessons observed were not face-to-face, the videos could be used with more flexibility and adjustments could be made. A disadvantage was the possibility of missing nuances in a classroom setting, as the video recordings could not provide a view of the entire classroom.

Conducting self-reflection enabled the NTs to identify areas for improvement and deepen their understanding of their teaching strategies. The presence of the camera may, admittedly, have influenced their behaviour and teaching style, a phenomenon known as the Hawthorne effect (Shah, 2024). Knowing they were being recorded, teachers might have altered their instructional methods, compromising the authenticity of the data.

4.5.3.4 Reflective journaling

During the first IP session, the NTs were introduced to reflective journaling, and we discussed its value (see Appendix 5). They were each provided with a notebook and were encouraged to engage in reflective journaling practices throughout the IP, to record their self-reflection and awareness of what they were doing (Alt & Raichel, 2020). The resultant metacognition was intended to help NTs reflect on their strengths, identify areas where they needed more support, and document their thoughts and feelings about their teaching experiences (Dreyer, 2015; Kostoulas et al, 2019). Reflective journaling is widely recognised as a powerful tool in teacher professional development as it promotes the development of self-awareness and critical thinking, and conduces to continuous improvement (Kostoulas et al., 2019; Alt & Raichel, 2020). Through journaling the NTs could gain deeper insight into their pedagogical practices and develop a more reflective approach, moving towards critical reflection in their teaching (Alt & Raichel, 2020).

This study highlighted that journaling supported continuous professional development (CPD) by providing a structured way for teachers to reflect on their experiences, learn from them, and apply the insights gleaned to their practice (Dreyer, 2015; Kostoulas et al., 2019; Alt & Raichel, 2020). Reflective journaling thus led to improved teaching practices as the NTs were able to evaluate their pedagogical practices, understand their impact on learning, and make the necessary modifications (Dreyer, 2015; Kostoulas et al., 2019). Reflective journaling was also a means of managing stress and enhancing emotional wellbeing (Dreyer, 2015).

A significant challenge noted in the study was that not all the NTs consistently engaged in reflective journaling. This inconsistency affected the depth and quality of reflection, limiting the benefits of journaling (Dreyer, 2015). Although guidance and support were offered for effective reflective journaling, the teachers often faced time constraints that made it difficult to dedicate a regular time to journaling, which led to superficial reflections and diminished the potential benefits of the practice. The reflections that were recorded nevertheless offered a window into the NTs' thought processes, highlighting their adaptations and successes resulting from critical reflection, as well as the areas where they felt they needed more support (Alt & Raichel 2020).

4.5.3.5 Use of field notes and recorded sessions

Field notes written by the researcher (Appendix 6) documented the NTs’ actions and social interactions and provided rich critical insights (Saldaña, 2020). The notes made possible the continuous collection of relevant data (Creswell & Poth, 2018; Creswell & Creswell, 2020). They were especially valuable in identifying recurrent patterns and understanding the dynamics of conversations. The researcher was intentionally selective, focusing on specific significant aspects such as what the NTs were saying about the content of the session, what they had learned and implemented and what they found challenging.

4.5.3.6 Intervention Programme (IP)

A comprehensive eight-week IP was designed, integrating theoretical, practical, and collaborative components, all reinforced by an inquiry-based framework. The programme was developed on the basis of data gathered from initial interviews with NTs and classroom observations (King et al., 2018).

The IP aimed to address the needs identified from the data, to improve the NTs' CK and pedagogical practices in the teaching of NS lessons in the FP. The programme covered a wide range of topics, scenarios and concepts relevant to the subject, ensuring comprehensive treatment of essential content and learner-centred pedagogy. Opportunities were built into the daily sessions for NTs to reflect on how their knowledge, attitudes and assumptions affected their instructional classroom practices (Hamilton, 2020).

The researcher designed the eight-week IP to scaffold learning. A gradual release model was employed, providing opportunities for exploration, discussion, direct teaching, guided practice and independent application, heading toward mastery in the course of time. Each session was structured to build on the previous one, in pursuit of cumulative knowledge and skills development. Professional collaboration was created by working together in a structured and purposive manner to strengthen teaching practices through shared responsibility, mutual learning and sustained impact (Hargreaves & O'Connor, 2018).

Inquiry-based strategies were employed to facilitate active hands-on learning and develop a clearer understanding of the content of the IP. These methods emphasised active engagement and the practical application of knowledge, a critical component of effective learning (Harris & Jones, 2019). By bridging the gap between theory and practice, the IP aimed to equip NTs with the necessary tools to meet their own learning needs to be fully prepared for teaching (Hadar & Brody, 2016).

Each of the eight sessions began with a check-in, allowing participants to share their thoughts, concerns about COVID-19, the split-class scheduling system, and any other challenges they faced. This was followed by motivational input to maintain a supportive environment. Each session concluded with reflection on their learning outcomes. These reflection periods granted the NTs the opportunity to ask questions for clarity, grapple with their understanding of teaching NS in FP classes and share their perspective on their practice and progress. The IP process is represented in Table 4.4.

Table 4.4 The topics taught during the IP

THE IP TOPICS	
SESSION 1 • 30-minute non-judgemental self-reflection • Introductions and personal journey • Reflective thinking and journaling • Discussion: Science and the nature of science • Reflective thinking and journaling	**SESSION 2:** • FP CAPS Life Skills overview, requirements • Aims, principles and the BKPSW topics • Discussion of CK for specific grades • Reflective thinking and journaling
SESSION 3 • CAPS overview – focus on NS and content knowledge • Introduction to scientific process skills and concepts • Reflective thinking and journaling	**SESSION 4: LESSON DEVELOPMENT AND TEMPLATE** • CAPS continued – with a deeper focus on Natural Science content knowledge • Topics per Grade: application of knowledge • identify one NS topic (grade), choose the appropriate NS concept, develop the CK and choose the skills • Comprehensive lesson plan • Reflective thinking and journaling **Started a lesson template*
SESSION 5: PEDAGOGICAL KNOWLEDGE • Discussion of the appropriate pedagogy; inquiry-based and appropriate strategies. Constructivist classroom; constructivist teacher • Additions to the lesson template • Reflective thinking and journaling	**SESSION 6: SCIENTIFIC SKILLS AND CONCEPTS** • Discussion, exploration of the relevant CK for the chosen topics, NS concepts, and skills required for their new lesson plan; integrate this information with their existing NS knowledge and incorporate the new pedagogy, inquiry-based teaching. • Discussion of scientific attitudes and values • Reflective thinking and journaling
SESSION 7: SHARING OF IDEAS AND ICT PLATFORMS • Discussion, support and guidance; sharing of lesson plans, ideas, websites, ePortal etc. • NTs worked towards the completion of their final lesson plan. Informal session • Discussion, sharing ideas and LTSM • Reflective thinking and journaling	**SESSION 8:** • Practising their lesson • Reflection on their progress throughout the IP
RESOURCES USED THROUGHOUT THE IP	
• CAPS Document • Motivational videos • PowerPoint • WCED Life Skills resource document • Lesson plans • Links to videos	

To ensure the relevance and effectiveness of the IP, the researcher continuously monitored the pace and content, adjusting it as needed to align with the NTs' needs. This flexibility allowed for tailored support and maximised the programme's impact. Implementing the IP via an online platform presented significant challenges because its hands-on nature was ideally suited to face-to-face interaction. Elements in the design of the IP included a focus on the development of PCK, engagement, flexibility, NTs' individual contexts, hands-on learning activities, the relevance and application of knowledge and skills and, finally, reflection (Bragg et al., 2021). Technical difficulties and maintaining participant engagement were initial hurdles. While the eight-week format provided for a comprehensive overview and in-depth study, instances arose where the NTs required more time to grapple with the content, which typically involved discussion and clarification of previous content covered. Since the previous content was the building block to the next process, more time was extended to the NTs for this purpose. Despite such challenges, a supportive learning environment was maintained. Face-to-face interaction would have enhanced the programme's effectiveness, particularly in addressing individual learning needs. The feedback from the participants nevertheless indicated that the IP was valuable in enhancing their CK, PCK and pedagogical practices. Though some noted the challenges associated with adapting to the online platform, they all expressed their appreciation for the structured approach and the opportunity for collaborative learning.

4.5.3.7 Post-IP individual semi-structured interviews

One month after the implementation of the IP, four individually developed NS lesson plans were collected (see Appendices 8 to 11). A day later, the researcher followed up with four individual semi-structured online interviews (see Appendix 8). The interviews were conducted with the four NTs to gain more information about the strategies they had employed to adapt to IBT in teaching NS after the IP, and to acquire further insight into their affective and cognitive development. To ascertain how they were coping with the new pedagogy, they were asked what challenges they faced in the teaching of NS. This afforded a space for the NTs to speak about their experiences, beliefs and difficulties (Saldaña, 2021).

The NTs were now familiar with Microsoft TEAMS and were more relaxed during the interview and in fielding the probing questions which sought clarity. A disadvantage was that the NTs switched their cameras off because of connectivity issues and non-verbal information was not captured. The researcher asked the NTs four main questions during the individual semi-structured interviews to gather the required information about their changed instructional practice.

4.5.3.8 Semi-structured focus group interview and discussion

Ten months after the IP, there was a face-to-face informal group interview and discussion with the NTs (1, 4, 5 and 7). In a relaxed atmosphere, various questions were posed to them (see Appendix 9). The NTs requested a different venue for the interviews as meeting in school classrooms had previously proved problematic. They believed that such a venue would provide a more casual and neutral environment. The NTs informed the researcher that a specific section in a restaurant near the researcher's workplace would be allocated for these focus group discussions, promising a quiet and focused environment. She agreed to go along with their decision. However, the space did not turn out to be as private as was expected, as a few patrons arrived an hour earlier than anticipated.

Questions were posed to establish the knowledge, understanding and skills that the NTs had gained during the IP (Creswell & Creswell, 2022); in brief, to find out how much of the IP learning had been transferred into their classroom NS teaching. The conversation flowed naturally as the NTs shared their thoughts, experiences and growth over the 10 months of teaching NS lessons. Despite the disruptions, the discussion was productive and yielded valuable data. The informal setting encouraged the NTs to speak candidly, resulting in rich, authentic data that may not have emerged in a more formal interview setting (Merriam & Tisdell, 2016).

One of the advantages of conducting a focus group interview in a restaurant was that the wide-ranging data was gathered within a single day. The nature of the focus group discussion encouraged the NTs to reconnect and talk about their challenges and how they relied on peer support during the IP and the COVID-19 pandemic. A disadvantage to the spontaneity of the discussion was the lack of continuous direction or formal protocols, such as not interrupting when someone was speaking, which no doubt resulted in the loss or curtailment of some NTs' responses (Patton, 2015).

4.6 DATA ANALYSIS

According to Creswell and Poth (2018), data analysis involves refining and interpreting textual or image data in relation to the aims of the research. The substantial volume of data generated by seven individual interviews, one focus group interview, five classroom observations, four participants' journal entries and the researcher's field notes required rigorous data management and analysis strategies. Creswell and Poth (2018) recommend systematic manual analysis to develop codes and themes from the datasets.

4.6.1 Interviews

The researcher transcribed the interviews with NTs 1, 2, 3, 4, 5, 6 and 7 almost immediately after the interviews were conducted. The same process was followed with the recorded classroom observations of NT 1, NT 4, NT 5, NT 6 and NT 7. Transcription is a significant step in qualitative research, so the audio and video-recorded data was carefully transcribed verbatim as text in a word processing document (Lareau, 2021; Saldaña, 2021). An excerpt in Table 4.5, below, gives an example of the interview coding process.

Table 4.5 The interview coding process

INTERVIEWS: NTs		
NT 1 RED **NT 2 BLUE** **NT 3 PURPLE** **NT 4 TURQUOISE** **NT 5 GREEN** **NT 6 BROWN** **NT 7 BLACK**		
RBPTGBB So, I've got …**BA, Psychology and Linguistics.** And then **I've got a PGCE Foundation Phase.** **PGCE** Or teach NS how I would like to teach it. But it was also the beginning stages of the year to teach Natural Science It was also the beginning stages of my teaching career, so I was **figuring things out.** **FINDING CLARITY/ ADAPTING [FIRST YEAR]** **Too scared to explore or let the learners explore** because I was **trying to figure out where I am** in the classroom **HESITANT /NAVIGATING** So **that was quite difficult for me** and I **mostly did it with discussions** with the class and maybe like **more concrete things like planting**, like the small things easier things like planting **CHALLENGING/ CONTEMPLATING / PRACTICAL-** **Not things where I have to take risk** and not know if they be able to do it will it be a big mess not now, **NO RISK/ APPREHENSIVE** **Still finding myself or my feet in the classroom** so it was quite hard. **NAVIGATING** Only had one term to do things with them. Now it's all different. **ADAPTING/UNSETTLED/ CHALLENGING** Okay, **I went as far as Matric with Physical Sciences and then Life Sciences.** **HS -PGCE** But after matric, I did not do anything in the science field. I just did, maybe like **psychology and my languages** and then my **PGCE**, so education subjects but **no natural sciences after high school.** **SCIENCE EXPOSURE HIGH SCHOOL PHY SC/LIFE CS** School, **I would say none except for whatever we covered briefly in my bachelor's degree, but I wouldn't say that there's any sole focus on natural science**, and **I didn't do it in high school.** **B Ed, BRIEF EXPOSURE HEI** **No, no Science** **NO HS SCIENCE EXPOSURE** **I did not do any Science on High School**, however, did Physics and Bio in second year and third year I did… I think I did Physics and Bio in third year also. **NO HS SCIENCE EXPOSURE/ UNSURE PHYSICS & BIOLOGY 3RD YEAR** From Primary and up until Grade 9 I was doing all subjects like in South Africa we do all subjects; Natural Science, Social science, everything. Going to Grade 10 now I had to choose a stream which **I was in science stream, and I was doing Physics and Life Science, Geography and Math.** **HS SCIENCE STREAM/ EXPOSURE**. So, I am currently teaching **Grade 3** and this will be my **second year** teaching in the FP. **[SECOND YEAR]**	PGCE SCIENCE EXPOSURE PS/LS HS HS -PGCE SCIENCE EXPOSURE HIGH SCHOOL PHY SC/LIFE CS B Ed, BRIEF EXPOSURE HEI NO HS SCIENCE EXPOSURE/ UNSURE PHYSICS & BIOLOGY 3RD YEAR HS SCIENCE STREAM/ EXPOSURE	AFFECTIVE QUALIFICATIONS

The researcher read through the transcriptions while simultaneously listening to the recordings to cross-check for accuracy and to make sure that the participants' intended meaning was faithfully captured (Creswell & Poth, 2018). She immersed herself in the data to familiarise herself with the initial thoughts and experiences, such as practical applications, hands-on activities, interactions and observations of the participants and noted significant statements or critical ideas that resonated with the research questions (Creswell & Poth, 2018). The emerging ideas and patterns were used for coding later. Certain interesting phrases or anomalies were highlighted for further examination (Patton, 2015). These early insights gave the researcher a global understanding of the content.

practical applications, hands-on activities, interactions, and observations.

Thereafter, each NT's transcribed data received closer scrutiny by being broken down into smaller chunks to enable the researcher systematically to colour, highlight and assign codes to what seemed to be key ideas, concepts and recurring topics. Coding is a cyclical process in which data is taken apart (analysis) and then synthesised into new groupings of meaning (Saldaña & Omasta, 2018; Saldaña, 2021).

After both data sets – interviews (NT 1 to 7) and observations (NT 1, 4, 5, 6 and 7) – had been analysed, the researcher compared each interview and each observation to identify similarities in coding or phrases. This was done through an iterative coding process, during which categories were built and refined (Saldaña, 2021).

The researcher moved from initial coding, which involved colour-coding ideas, concepts and topics, to naming them with words or phrases. Open coding was used for this purpose (Saldaña, 2021). For the interviews, however, the themes identified were linked to interview questions. The process of categorisation culminated in the development of distinct new themes that more precisely captured the complexity of the data. The main theme of "development" was pivotal in guiding the analysis and findings of the study.

4.6.2 Classroom observations

The observation method was employed to gather first-hand data by watching the NTs' videoed classroom teaching (Taherdoost, 2021). The same process of analysis was followed as for the interview data. Verbatim transcriptions were made, with added descriptions of the actions that the teachers performed and how the learners acted or responded. The iterative process of playing the footage, stopping and rewinding ensured that the researcher did not miss any details pertinent to the class teaching (Creswell & Poth, 2018).

The researcher used Saldaña's (2021) technique of descriptive coding, with the addition of quantitative coding, breaking down the recordings to code behaviours, actions and verbal exchanges. The emerging patterns and trends were quantified within the overarching qualitative thrust of the analysis. The quantitative aspect was included solely to help identify trends through the recorded frequency of behaviours, actions or statements. Saldaña (2021) emphasises that quantifying elements in this way supports pattern recognition within a qualitative framework and does not turn the study into quantitative research. Table 4.6, below, presents an excerpt from the classroom observation coding process, while Table 4.7 depicts the colours assigned to the different themes and Table 4.8 reflects the frequency of the actions or strategies used within the lesson.

Table 4.6 The observation coding process

	Strategy	Frequency	THEME	FREQUENCY
1.	Direct question – closed	8	QUESTIONING TECHNIQUE	36
2.	Gives a hint	1	QUESTIONING TECHNIQUE	/
3.	Repeats learner response	6	REINFORCE	6
4.	Gesticulate / animation	2	DEMONSTRATION	7
5.	Open-ended Questions	16	QUESTIONING TECHNIQUE	/
6.	Prediction	2	LEARNER AGENCY	2
7.	Direct instruction	7	DIRECT TEACHING	12
8.	Explanation	5	DIRECT TEACHING	/
9.	Reprimands/Call to order	9	CLASSROOM MANAGEMENT	9
10.	Visualisation	5	VISUALISATION	5
11.	Demonstration	5	DEMONSTRATION	/
12.	Prompt /probing	5	QUESTIONING TECHNIQUE	/
13.	Paired/ group discussion	5	COLLABORATION	5
14.	Learning atmosphere	0	CONDUCIVE LEARNING ATMOSPHERE	0
15.	Use of LTSM	5	LTSM	5
16.	Use of Technology	2	TECHNOLOGY	2
17.	Checking in	1	TEACHER DISPOSITION/ CARE	1
18.	Values	2	VALUES AND ATTITUDES	2
19.	Question directed to a learner	1	QUESTION TECHNIQUE	/
20.	Affirmation	0	Affirmation/MOTIVATION	0
21.	Classroom /Time Management	1	CLASSROOM MANAGEMENT	1
22.	Learners' Choice	2	LEARNER AGENCY	2
23.	Learners read – HL	0	INTEGRATION	0

Table 4.7 Colour codes for each theme

COLOUR-CODE PER THEME
QUESTIONING TECHNIQUE
DIRECT TEACHING
CLASSROOM MANAGEMENT
DEMONSTRATION
REINFORCEMENT
VISUALISATION
COLLABORATION
USE OF LTSM
AFFIRMATION/MOTIVATION
SCIENTIFIC PROCESS SKILLS
LEARNER AGENCY
USE OF TECHNOLOGY
TEACHER DISPOSITION/ CARE
VALUES AND ATTITUDES
CLASSROOM MANAGEMENT
LEARNER AGENCY
USE OF AN ANALOGY

Table 4.8 The frequency with which the NTs executed these actions or strategies

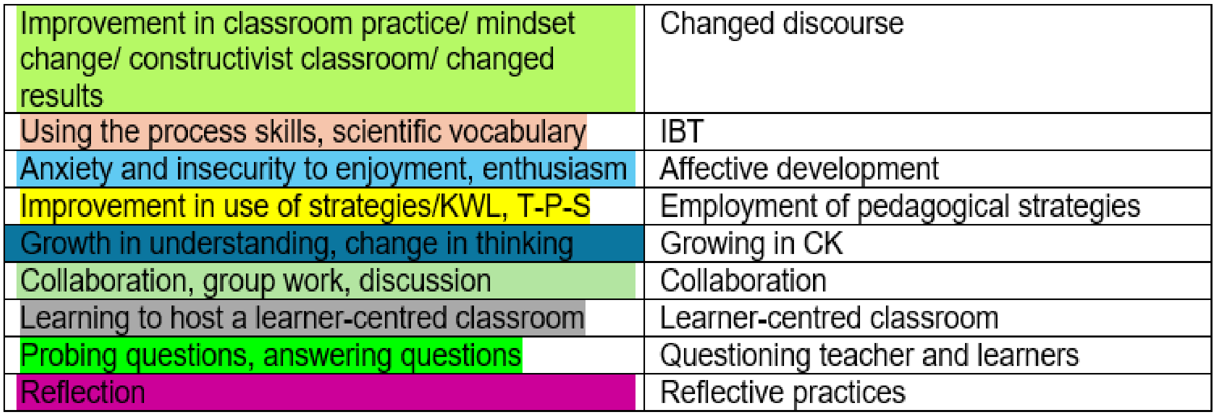
OBSERVATION THEME	FREQUENCY
QUESTIONING TECHNIQUE	41
COLLABORATION [IBSE]	18
LEARNER AGENCY	17
REINFORCE	13
CLASSROOM MANAGEMENT	12
STRATEGY /INQUIRY-BASED SCIENCE	10
TEACHER SUPPORT	9
DIRECT INSTRUCTION - WHAT TO DO	7
LTSM	6
DEMONSTRATION	4
TECHNOLOGY	2
AFFIRMATION	2
MODELING	1
ACTIVITY FOR REVISION/CONSOLIDATION	1

4.6.3 Reflective journaling

The approach to the analysis of the reflective journaling content was the same as for the interviews and the observations. The content was analysed using a thematic approach, with the content coded according to themes, patterns or categories that reflected the NTs' experiences and learning during the IP (Creswell & Creswell, 2022). The aim was to track how the NTs' practices and attitudes changed over the IP period, notably their CK, SMK and PK and their application of pedagogical strategies.

Since critical thinking and affective behaviour were inextricably linked in their professional development during the IP, the NTs' personal reflections were of central interest (Creswell & Creswell, 2022). The tracking of their reflective thinking focused on whether the NTs moved from surface-level reflections to a deeper level with the new knowledge and teaching approach evident in their lesson plans. The analysis was sensitive to alignment between their learning intentions and the implementation of learner-centred pedagogic practices (Patton, 2018). The self-reported findings from the reflective journals were triangulated with data from the lesson plans and individual and focus group interviews to gauge the accuracy of the NTs' sense of having changed their discourse on teaching practice (Creswell & Creswell, 2022). The final themes which emerged from the analysed reflective journals are presented in Table 4.9, below.

Table 4.9 Themes from the reflective journals



Improvement in classroom practice/ mindset change/ constructivist classroom/ changed results	Changed discourse
Using the process skills, scientific vocabulary	IBT
Anxiety and insecurity to enjoyment, enthusiasm	Affective development
Improvement in use of strategies/KWL, T-P-S	Employment of pedagogical strategies
Growth in understanding, change in thinking	Growing in CK
Collaboration, group work, discussion	Collaboration
Learning to host a learner-centred classroom	Learner-centred classroom
Probing questions, answering questions	Questioning teacher and learners
Reflection	Reflective practices

4.6.4 Written field notes

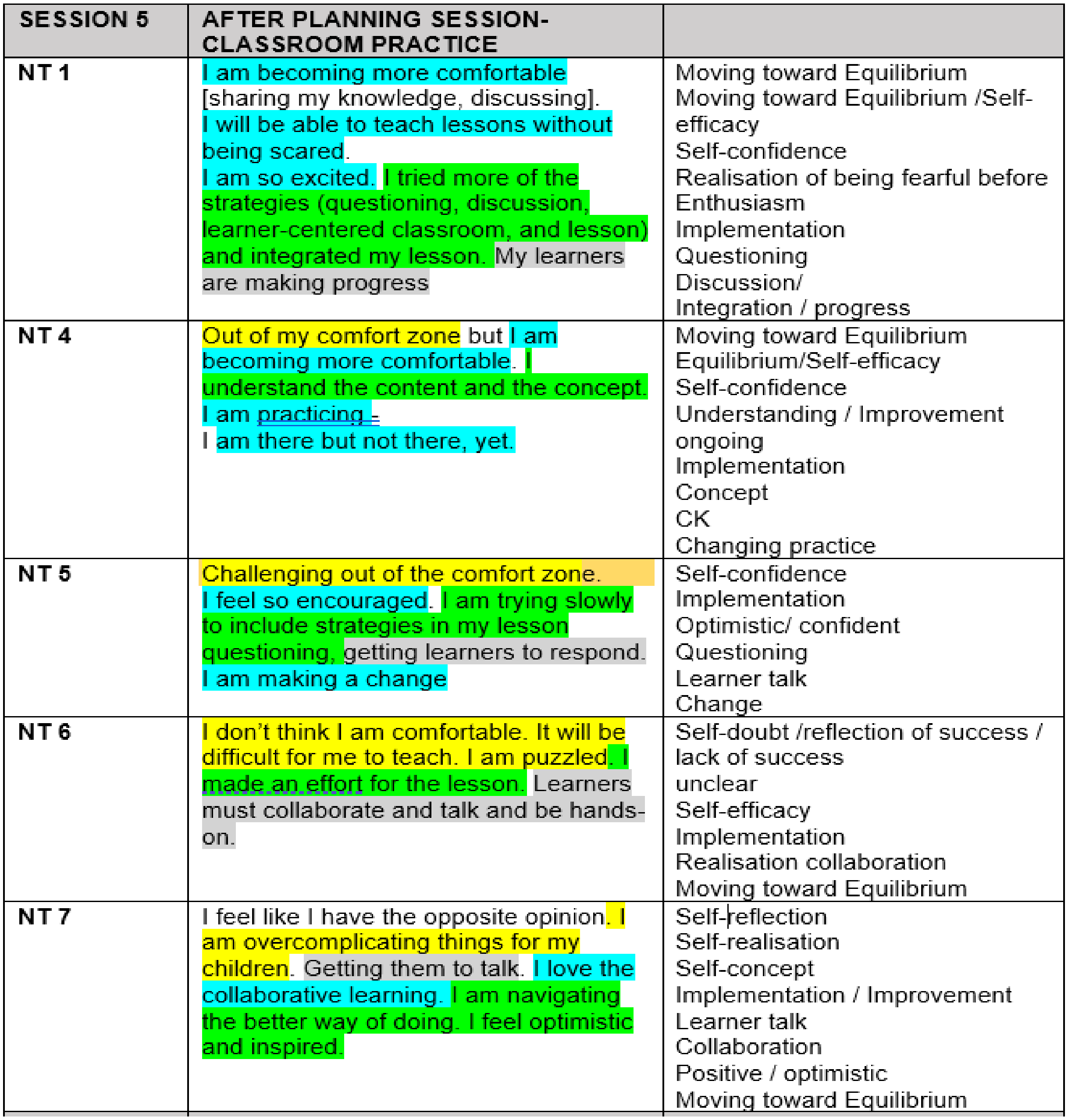
The researcher also analysed her field notes made during the pre- and post-IP sessions. Although informally recorded, these notes provided evidence of the NTs' spontaneous thoughts and emotions during their learning process, which contributed to a fuller understanding of their experiences (Merriam & Tisdell, 2016).

The ideas, concepts and topics were named using open coding and given a common name, a word or phrase, which referred to how they were interrelated or fell within broader categories that encapsulated themes (Saldaña, 2021). These names covered their behaviour, thoughts and emotions during the IP and implementation of the newly learned pedagogical practices. During the analysis, different data pieces were scrutinised to identify patterns, themes and relations. The themes – uncertainty, eagerness, growing in confidence, fostering an inquiry-based mindset and improvement – were assigned to recurring patterns in the field notes data groups (Creswell & Creswell, 2022). Table 4.10 presents an extract from one session, Session 5's post-IP reflections.

The chief advantage of the field notes lay in the rich detail the researcher could glean from the NTs' verbalising their thoughts and feelings (Merriam & Tisdell, 2016). The notes functioned as a reflexive tool that enabled the researcher to reflect on her own thoughts and feelings in real time as she interacted with the NTs. The field notes were a valuable data source, especially combined with the interviews and observations for the purpose of triangulation. They provided additional context to enhance the reliability of the research results.

The main disadvantage was that the writing of the field notes required time and effort. Although the sessions were conducted on an online platform and it was easier to be discreet, the researcher needed to be present and not look away from the screen to record comments. This could have inhibited the compiling of more comprehensive field notes with important details. Nevertheless, the field notes contributed useful insights into what the NTs experienced during the IP. Table 4.10 presents an extract from one session, Session 5's reflections, together with the phrases assigned to determine trends.

Table 4.10 Presentation of an extract from Session 5, including phrases



SESSION 5	AFTER PLANNING SESSION-CLASSROOM PRACTICE	
NT 1	I am becoming more comfortable [sharing my knowledge, discussing]. I will be able to teach lessons without being scared. I am so excited. I tried more of the strategies (questioning, discussion, learner-centered classroom, and lesson) and integrated my lesson. My learners are making progress	Moving toward Equilibrium Moving toward Equilibrium /Self-efficacy Self-confidence Realisation of being fearful before Enthusiasm Implementation Questioning Discussion/ Integration / progress
NT 4	Out of my comfort zone but I am becoming more comfortable. I understand the content and the concept. I am practicing - I am there but not there, yet.	Moving toward Equilibrium Equilibrium/Self-efficacy Self-confidence Understanding / Improvement ongoing Implementation Concept CK Changing practice
NT 5	Challenging out of the comfort zone. I feel so encouraged. I am trying slowly to include strategies in my lesson questioning, getting learners to respond. I am making a change	Self-confidence Implementation Optimistic/ confident Questioning Learner talk Change
NT 6	I don't think I am comfortable. It will be difficult for me to teach. I am puzzled. I made an effort for the lesson. Learners must collaborate and talk and be hands-on.	Self-doubt /reflection of success / lack of success unclear Self-efficacy Implementation Realisation collaboration Moving toward Equilibrium
NT 7	I feel like I have the opposite opinion. I am overcomplicating things for my children. Getting them to talk. I love the collaborative learning. I am navigating the better way of doing. I feel optimistic and inspired.	Self-reflection Self-realisation Self-concept Implementation / Improvement Learner talk Collaboration Positive / optimistic Moving toward Equilibrium

4.7 TRUSTWORTHINESS

In qualitative research, trustworthiness is key to any consideration of the rigour and credibility of a research study. Trustworthiness refers to the degree to which the data and its analysis conform to accepted standards of credibility, transferability, dependability, and confirmability. These criteria offer researchers a framework for authenticating their findings and determining their trustworthiness (Creswell & Poth, 2018).

4.7.1 Credibility

Research credibility was assured in this study through triangulation, a method used by qualitative researchers to establish the validity of their findings by approaching a research question from multiple perspectives (Patton, 2015). The collection of data from questionnaires, interviews, observations, and document analysis ensured that the findings were corroborated.

Additionally, following Creswell and Poth's (2018) recommendations, member checking was conducted by sharing preliminary findings with NTs to confirm the accuracy of the researcher's interpretations. The NTs were encouraged to provide feedback to correct inaccuracies or add insights to ensure that their perspectives were accurately represented. The NTs authenticated the researcher's transcriptions of interviews and the researcher's notes.

The researcher engaged with the NTs for an extended period of time, before the commencement of the research study, during the interviews, over the eight-week IP (some of which was conducted face-to-face) and after the IP. From visiting them in their classrooms at their respective schools, she came to understand the social, cultural and environmental contexts which influenced their behaviour and perspectives. During the time of contact, relationships were built and trust developed, which encouraged the NTs to be open and forthcoming in sharing their experiences, including their fears and anxieties during the COVID-19 pandemic. This openness enhanced the credibility of the qualitative research.

By engaging with her supervisors throughout the data refinement process, the researcher acquired a more sophisticated grasp of the findings, which also enhanced the credibility of the study. According to Merriam and Tisdell (2016), supervisory collaboration in qualitative research enhances the rigour of the research.

4.7.2 Transferability

Transferability was achieved through detailed descriptions of the context of the participants and the research procedures followed, to put other researchers in a position to determine whether the findings might be applicable to their own and other settings. The researcher used “thick description” (Bhattacherjee, 2012:111; Creswell & Poth, 2018) by offering comprehensive accounts of NTs’ experience, knowledge and practice. This degree of detail also facilitates any assessment of the transferability of the research.

4.7.3 Confirmability

Creswell and Poth (2018) refer to confirmability as a measure of how directly the research findings can be traced back to the data collected (see Tables 4.5 to 4.9). Confirmability is thus an index of objectivity, which can in large part be secured by ensuring that the researcher's biases do not affect the findings (Taherdoost, 2021). Several strategies were employed to establish and maintain confirmability. The researcher continually reflected on how her own beliefs, assumptions and experiences could possibly influence the data generation and analysis. Moreover, a high degree of neutrality was achieved by the researcher’s attempt to suppress her voice and only allow that of the NTs to be heard. The researcher also regularly engaged with her supervisors for debriefing sessions to discuss her data interpretations and overall findings, which also contributed to the objectivity of the study (Lincoln & Guba, 2016).

4.7.4 Dependability

Dependability is a decisive factor in the evaluation of trustworthiness in qualitative research. It is measurable in terms of consistency, the transparency of the research process and the capability of its being replicated or reviewed, with similar outcomes (Bhattacherjee, 2012; Creswell & Poth, 2018). According to Lincoln and Guba (2016), dependability reflects the constancy and trackability of data generation and analysis over time. To improve dependability in this study, detailed records of all research activities were maintained, including how the data was collected, analysed and interpreted. These records are saved on my personal computer and my Google Drive with secure passwords known only to the researcher. Uniformity was also pursued throughout the study, ensuring that all the data was processed in an organised, systematic and replicable manner.

4.8 RESEARCHER’S ROLE

In this qualitative study, the researcher assumed a central role as the primary instrument in the collection and interpretation of the data (Merriam & Tisdell, 2016; Creswell & Poth, 2018). Throughout the study, she maintained a reflexive stance, being cognisant of her positionality and how it might affect her interaction with the NTs and the interpretation of data. This was compounded by the sensitive COVID-19 pandemic period in which the research data was collected and she had to make changes to the programme dates, deadlines and pace.

The researcher was both a neutral, passive observer during direct classroom observations and a participant-observer in the focus group interviews, discussions, planning and IP sessions. The researcher had to navigate constantly between insider and outsider perspectives. Shared experiences with the NTs enabled her to assume an insider perspective, which promoted the building of trust and cultivated a thorough understanding of their context and experience. When in the outsider position, disconnection allowed for critical evaluation without being influenced. The researcher remained cognisant that this balance was imperative for maintaining the validity and trustworthiness of the study (Merriam & Tisdell, 2016). Continuous member checking ensured accurate research data, minimising the potential for personal bias.

4.9 ETHICAL CONSIDERATIONS

Ethical considerations are foundational to conducting rigorous and respectful qualitative research. Due process was followed in applying to the Research Ethics Committee of the Cape Peninsula University of Technology (CPUT) for ethical clearance to conduct this study (Reference number: EFEC 3-8/2020, Appendix 14).

Approval from the Western Cape Education Department (WCED Reference number 20200918-8162) to conduct research in primary schools in the Metro Central Education District, Western Cape (21 September 2020 to 30 September 2021) is attached as Appendix 15. The researcher visited seven schools within a 20-kilometre radius to invite seven newly qualified teachers to participate in the research study. Positive responses were received and an appointment was scheduled for each of the schools. Thereafter, sites and participants were selected, as described in sections 4.5.1 and 4.5.2, above.

Informed consent was prioritised as an ethical responsibility, which meant ensuring that all the NTs understood the nature and purpose of the study before agreeing to participate. Clear information was provided regarding their right to withdraw at any time during the study without any question, and the fact that their identities would be kept anonymous. The NTs were required to indicate that they would be voluntarily participating in the study (Creswell & Poth, 2018). Consent letters were signed (Appendix 2), and dates were negotiated for the interviews and dates and venues for the IP sessions.

Throughout the research process, the researcher maintained the NTs' anonymity and kept sensitive information confidential. NTs' names and any identifying details were removed from all documentation and pseudonyms were used where necessary: NT 1, NT 2, NT 3, NT 4, NT 5, NT 6 and NT 7. These measures ensured that the NTs' identities were secure and that any possible harm from their involvement in the research was avoided (Patton, 2018). During the study, records of the interviews and classroom observations were made available to the NTs to confirm their integrity (Creswell & Poth, 2018).

The researcher was mindful of the power dynamic between the NTs and herself – the Senior Curriculum Planner for Life Skills in the Western Cape – and how it might influence how they behaved and responded (Creswell & Poth, 2018). The researcher therefore from the beginning set out to create an open, respectful and relaxed environment in which the NTs could express themselves freely without fear of judgement or coercion. Adherence to these ethical guidelines enabled the researcher to uphold the integrity of the study whilst protecting the rights and dignity of all the NTs.

4.10 CHAPTER SUMMARY

This research study employed a qualitative research approach within the interpretive paradigm to explore the subjective perspectives and experiences of a sample of NTs. The focus was on their perceptions of teaching NS. Employing a collective case study design, the study's main research sites comprised three public urban primary schools in the Cape Town metropole where the NTs taught.

The data generation instruments employed included a questionnaire, individual semi-structured interviews, classroom observations, reflective journals, researcher's field notes and one focus group interview (Cohen et al., 2018). A pilot for the study resulted in the refining of interview questions and the proposed intervention. This chapter featured discussion of the thematic analysis to which the various qualitative data sets were subjected.

Measures such as triangulation and member checking sought to enhance the trustworthiness of the study and render the research credible, transferable, confirmable and dependable. The researcher's role was acknowledged and discussed. All ethical requirements were met by the researcher, including permissions and full confidentiality. The next chapter, Chapter 5, presents the findings in respect of Research Question 1.

CHAPTER 5

RESULTS AND DISCUSSION – RESEARCH SUB-QUESTION 1

5.1 INTRODUCTION

This is a qualitative case study conducted within an interpretive research paradigm, using a multiple case study design. The study focuses on how NTs understand and interpret the Curriculum and Assessment Policy Statement (CAPS), their instructional practices when teaching Natural Science (NS) in Foundation Phase (FP) classrooms; and their thoughts about their Initial Teacher Education (ITE) at their respective Higher Education Institutions (HEI). The study examines the gaps in the Natural Science curriculum within the Life Skills subject.

The main research question guiding this research study is: What framework can be developed to support novice teachers' instruction competencies in Natural Science (NS) in the Foundation Phase (FP)?

To answer the main research question, the following three sub-questions are discussed:

(1) What were the novice teachers' experiences and understanding of the teaching of NS **before** the intervention programme (IP)?
(2) How did the novice teachers develop cognitive and higher-order thinking abilities **during** the intervention programme?
(3) What were the novice teachers' experiences and understandings of the teaching of NS **after** the IP?

It is the intention in the remainder of this chapter to consider the data emerging in response to sub-question 1.

5.2 RESEARCH SUB-QUESTION 1

What were the novice teachers’ experience and understanding of the teaching of NS **before** the intervention programme (IP)?

The findings for Research Question 1 were obtained from inductively analysing the questionnaire, seven semi-structured pre-interviews and pre-observations which were transcribed verbatim, coded, and then categorised into themes. Four major themes were identified:

5.2.1 Qualifications and experience in teaching Natural Science**;**
5.2.2 Content knowledge;
5.2.3 Pedagogical practice, and
5.2.4 Self-efficacy.

To understand and explicate the NTs’ initial discourse as arising from their experience and understanding of the teaching of NS **before** the IP, the following theoretical structures (fully explained in Chapter 2) were deployed:

- Shulman’s (1986) theory of pedagogical content knowledge (PCK) adopts a methodical, constructivist approach to describe the integration of the knowledge base with pedagogical strategies for effective teaching practice. The components in PCK are thus content knowledge (CK) and pedagogical knowledge (PK);
- Knowles’s (1984) characterisation of andragogy or adult learning because of its emphasis on factors such as participation, readiness to learn, self-image, experience, willingness, orientation, and motivation to learn (Kearsley, 2010); and
- Bloom’s taxonomy (1956), with its six categories of knowledge as a continuum from simple to complex levels of critical thinking: remembering, understanding, applying, synthesising, evaluating and creating.

5.2.1 QUALIFICATIONS AND EXPERIENCE IN TEACHING NATURAL SCIENCE

According to the South African Qualifications Authority (SAQA, 2006) and the National Qualification Framework (NQF), a qualified NS teacher in FP is one who has the necessary qualifications to teach all subjects in a FP classroom. The award of the qualification assumes that "a planned and systematic programme of learning was followed and successfully completed through formal or informal learning and work experience" (DHET [MRTEQ], 2015:16).

According to SAQA (2006), the formal qualifications of a teacher in FP could be a certificate, diploma, or degree recognised for the employment of a teacher in a public school in the teacher's country of origin. The possession of a valid qualification thus assumes that the teacher has sufficient subject expertise to interpret the curriculum, understand the pedagogy to be employed and comprehend the stage of the learners' development.

Fundamental learning, as described by the Norms and Standards for Educators (NSE) (DoE 2000:7) is "the learning which forms the grounding or basis needed to undertake the education, training and further learning required in the obtaining of a qualification." It includes an understanding of how language mediates learning, of learning styles and how learners learn at different ages, subject-specific pedagogic content knowledge (PCK), teaching strategies and the use of media, as well as the recognition of barriers to learning and the importance of social context (DoE, 2000:15). Together with these competencies are the seven roles included in the multi-faceted skillset required of a teacher: earning mediator, interpreter and designer of learning programmes and materials, leader, administrator and manager, scholar, researcher and lifelong learner, a pastoral role in the community, assessor, learning area [subject and phase] specialist.

Budding FP teachers are trained to teach the four required subjects – Home Language, First Additional Language, Mathematics and Life Skills, the latter including NS. They are expected to acquire content knowledge (CK), NS concepts (the "what" to teach), pedagogical knowledge (PK) which includes classroom management and organisation, and pedagogical content knowledge (PCK), which refers to the "how" to teach NS.

The next section discusses what the data revealed about the NTs' training:

5.2.1.1 Qualifications of the seven novice FP teachers
5.2.1.2 NTs with a Grade 12 qualification, including Science as a subject
5.2.1.3 NTs with a Grade 12 qualification excluding Science as a subject

5.2.1.1 Qualifications of the seven novice FP teachers

The information in Table 5.1 was gathered from the seven novice teachers' questionnaires and interviews. The four HEIs (using pseudonyms: A, B, C and D) where the NTs had received their qualifications have been included (the information compromises neither the NTs' nor the HEIs' anonymity).

Table 5.1 Teachers' qualifications and experience with NS as a subject

	A Grade 12 certificate with Science as a subject	**A Grade 12 certificate excluding Science as a subject**	**Bachelor of Arts (BA)** **3-year degree**	**Post Graduate Certificate in Education (PGCE)** **3-year degree + one year = 4 years**	**Bachelor of Education (B Ed) 4-year degree**
NT 1	√		BA Specialisation Psychology and Linguistics (HEI A)	PGCE FP (HEI A)	
NT 2	√		BA Specialisation Psychology and Linguistics (HEI A)	PGCE FP (HEI A)	
NT 3		√			B Ed FP (HEI B) Specialised in Music
NT 4		√			B Ed FP (HEI B)
NT 5		√			B Ed FP (HEI C)
NT 6	√				B Ed FP (HEI D)
NT 7	√				B Ed (HEI D) Intermediate and Senior Phase (IP/SP) Specialisation Mathematics and English

It was found that the seven NTs received their ITEs at four different HEIs and had a variety of qualifications and teaching experiences with regard to NS. There were four NTs (NTs 1, 2, 6 and 7) who had had NS input during their Grade 12 year and three NTs (NTs 3, 4 and 5) who had had no experience of NS content during their Grade 12 year. Two NTs (NTs 1 and 2) completed their BA degree specialising in Psychology and Linguistics and then completed an additional year doing a PGCE in FP. According to the interviews, only

NT 1 had experience of teaching NS during teaching practice. Four NTs (NTs 3, 4, 5 and 6) completed a four-year Bachelor of Education degree in FP. NT 7 completed a four-year General Education and Training (GET) degree specialising in Mathematics and English.

5.2.1.2 NTs with a Grade 12 qualification including Science as a subject

This section describes the NTs' qualifications in terms of their exposure to Science at high school. Three of the seven NTs had Science as a matric or Grade 12 subject and responded to the question *What qualification(s) do you have in Natural Science?* as follows:

> NT 2: *I went as far as Matric with Physical Sciences and then Life Sciences ….*
>
> NT 6: *I was in the science stream ….*
>
> NT 7: *… in high school, I actually took … Life Science ….*

NTs 2, 6 and 7 revealed that they had studied either Physical Science or Life Sciences in Grade 12. A Grade 12 qualification would mean that the teachers had acquired foundational knowledge (DoE, 2000:7b). The NTs should therefore be able to understand the subject and its terminology, and have the ability to interpret and explain the content and processes to be taught at a fundamental level in FP (DoBE, 2011:4a). However, NT 2 and NT 6 indicated that they felt ill-prepared for the task of teaching NS in FP despite having obtained a Grade 12 pass in the subject. They cited gaps in their understanding of the content of the Sciences they had studied. About NS they had this to say:

> NT 2: *… in my mind [NS] was just this completely complicated subject that I'm never going to actually understand …*
>
> NT 6: *I didn't get enough time to learn NS … how I can teach it?*

The MRTEQ (DHET, 2015) document describes the core curricula for ITE. This document specifies five distinct types of learning to be included in HEI basic teacher education programmes for a "purposeful teacher education qualification" (DHET, 2015:15). These are (i) Disciplinary learning; (ii) Pedagogical learning; (iii) Practical learning; (vi)

Fundamental learning; and (v) Situational learning. The findings indicate a deficiency on the part of the NTs in at least the first of these categories and point to their need for support and guidance in the interpretation, understanding and implementation of the CAPS Science content curriculum. NT 2 described the subject as “complicated”, and both NT 2 and 6 indicated their inability fully to understand and interpret the Science curriculum.

5.2.1.3 NTs with a Grade 12 qualification excluding Science as a subject

This section will expound on the NTs who had had no exposure to high school Science. NTs 3, 4 and 5 did not have Grade 12 Science.

> Researcher: What qualification(s) did you have in Natural Science/s at high school?
>
> NT 3: *I didn’t do it in high school* ….
>
> NT 4: … *no, no Science* ….
>
> NT 5: *I did not do any Science on high school* ….

NTs 3, 4 and 5 were teaching FP NS without any exposure to the subject in high school. The NTs believed that this lack of background diminished their confidence in teaching the subject. When asked about their background knowledge of NS they stated the following:

> NT 3: *… just don’t know much about it … I think it’s necessary, I guess ….*
>
> NT 4: *I think I first need to go and check-up and read up and have my background and knowledge ….*
>
> NT 5: *… which I don't really know … I don't really have experience ….*

Teaching NS without a qualification in or exposure to the subject means that the teachers have no subject expertise, which presents significant challenges. Luft et al. (2020:719) describe this “out-of-field” teaching as the heart of the CK problem experienced by NS FP teachers. Hobbs (2013:1) also addresses the subject of “out-of-field” teaching and notes that teachers at all levels of experience who lack the requisite background knowledge and qualifications to teach a subject like NS face challenges with understanding and inculcating the concepts to be taught, while Childs and McNicholl (2007:1) observe that a lack of appropriate instructional strategies further hampers flexibility in an underqualified NT's teaching. This is all reflected in the NTs' responses. Their lack of exposure and "out-of-field" status suggests that upskilling in the necessary knowledge, skills, and concepts to teach the subject, is an urgent necessity.

Roehrig and Luft (2006) argue that Science-specific induction programmes and the continuous Teacher Professional Development (TPD) of novice in-service teachers could address the gaps in their content and pedagogical knowledge. The TPD programme should include appropriate NS content to ameliorate the NTs' CK, inquiry-based teaching strategies, the nature of Science and the philosophy underlying scientific enquiry (Roehrig & Luft, 2006).

With evolving practices and new pedagogies in education, qualification is a minimum requirement for entry to the teaching profession but is by no means the sole factor determining how efficient and effective a NT of NS in FP can be. MRTEQ (DHET, 2015) stipulates a comprehensive core structure for a teacher qualification. To this should be added ongoing, daily practical experience in the classroom with support, as well as comprehensive continued teacher professional development. This will improve NTs' competencies, knowledge and practice.

5.2.2 CONTENT KNOWLEDGE (CK)

The CAPS FP document (DoBE, 2011:8) describes NS content knowledge as subject knowledge of the four NS concepts identified: Life and Living, Energy and Change, Matter and Materials and Planet Earth and Beyond. These four NS concepts, also known as knowledge strands, serve to organise content in the subject NS.

5.2.2.1 Novice Teachers' knowledge of Natural Science content

To teach NS effectively, teachers need to have sound knowledge of the subject. The NTs commented on their knowledge of content and appropriate topics for teaching NS in FP as follows:

NT 1: *I wouldn't say I am very familiar with it.*

NT 2: *I'm not really familiar with that, the CAPS requirements for Natural Sciences.*

NT 3: *There's Natural Science in the CAPS? I didn't know that.*

NT 4: *Not that great, to be honest ….*

NT 5: *Do I know … don't I know … I just know enough ….*

NT 6: *I did not familiarise myself with that … do not have much knowledge of CAPS.*

NT 7: *I would say not say very familiar.*

A prerequisite for teaching NS is an understanding of the FP CAPS requirements, which include the CK per grade and the sequencing of factual knowledge. CK is characterised by Robinson (2017, citing Shulman, 1986) as the components and the organisation of the topics which define the particular subject.

Given that the CK for NS is defined in terms of four NS concepts – Life and Living, Energy and Change, Matter and Materials and Planet Earth and Beyond – the NTs were asked about these. Excerpts from their responses appear below:

NT 1: *I wouldn't say I am very familiar with it … Earth and Beyond, I think ….*

NT 2: *I haven't really thought about it … I think that Matter and Materials… I'm not really familiar with that … I'm really not clued up.*

NT 3: *You say all those things and they ring a bell… I'm not … [knowledgeable].*

NT 4: *Sorry, this is a tricky question ….*

NT 5: *It's foreign to me … it's literally all foreign.*

NT 6: *I did not familiarise myself with that … not much knowledge ….*

NT 7*: I haven't been taught about those … terminologies … I just don't have sufficient knowledge or training.*

The seven NTs thus admitted to having little to no CK regarding the four NS concepts to be taught in the FP. For qualified NTs to teach learners NS according to the NSE (DoBE, 2000:15), they should demonstrate sound CK (DoE, 2000:15b). MRTEQ (DHET, 2015:11) cites disciplinary learning, that is, CK, as a foundational aspect of an education qualification. A deficit in CK, according to Crippen (2012) and Oh and Kim (2013), can hinder effective Science teaching and result in predominantly teacher-centred lessons. This kind of teaching can stifle learner creativity and curiosity (Nilsson & Loughran, 2012; Cofré et al., 2015) and lead to a lack of interest and underperformance in Natural Science (Cone, 2012; Fitzgerald et al., 2013; McConnell et al., 2013; Nowicki et al., 2013; Cofré et al., 2015).

5.2.2.2 Willingness to empower themselves in content

The novice teachers acknowledged that they had not acquired CK in NS during their initial teacher education but evinced a willingness to upskill themselves in this direction. They explained that they had to research their topics from scratch before they taught NS lessons. Their keenness to learn manifested in various ways.

The following statements from NTs 1, 4, 5, 6 and 7 demonstrate their willingness to increase their content knowledge:

NT 1: *… trying to learn as much as I can … before I need to teach the learners….*

NT 4: *I can steal an idea here and there … I think I first need go and check up and read up and have my background and knowledge … as in-depth knowledge….*

NT 5: *… do I know, don't I know … research … then I'll teach … when I do research … I was so invested ….*

NT 6: *I still need to learn how to teach NS ….*

NT 7: *I get pictures … ideas off the internet ….*

These statements suggest that five of the seven NTs wanted to improve their content knowledge through research and learning from others, in this way assuming an active role in their own professional development (Van Eekelena et al., 2006). Their self-reflection on the challenges they faced in their teaching of NS (Bandura, 1997) stimulated a "will to learn", a psychological state that precedes almost any active involvement in the learning process (Van Eekelena et al., 2006). Solis (2015) recommends that teachers take responsibility for their professional learning to redirect their thinking towards impactful teaching practice. Interest and motivation stimulate a responsiveness that positively affects teachers' classroom practice and learner achievement.

5.2.3 PEDAGOGICAL PRACTICES

Pedagogical practices, including the effective handling of 3-dimensional (3D) learning and teaching support material (LTSM), are a fundamental consideration for teachers planning and preparing to teach NS in FP (Feyfant, 2011). To determine the initial pedagogical knowledge of the NTs, semi-structured interviews were conducted with all seven NTs, followed by classroom observation of the remaining five after two opted out of the research. Kapur (2020) argues that pedagogical practices are significant in fostering sound learning and enhancing the achievement of learning objectives. What Shulman calls PCK refers to teachers' pedagogical and content knowledge of the specific teaching practices to be employed for learners to comprehend science concepts (Durden, 2016).
Effective implementation of PCK and a wide repertoire of pedagogical practices determine quality teaching, promote learning and achieve academic goals (Kapur, 2020). The NTs offered the following narratives in their interviews:

NT 1: *I would usually inquiry-based learning … getting the learners to talk to each other build on their knowledge and each other knowledge … I would try to bring in the concrete … I would start off by showing the learners a video … we would do the practical planting bean … .*

NT 2: *… concrete objects … observe… tell me what you notice... inquiry-based learning … in groups. Let them talk about it, discuss what do you notice about it? What's on it? What isn't on it?*

NT 3: *… more concrete things … .*

NT 4: *… the method we would do is group work … they touched it physically. The trunk of the tree, roots, leaves etc. We also planting our bean … .*NT 5: *It was gathering of all the soil ….*

NT 6: *I just know it's about experiments … I send two learners to check how's the weather… When we do plan … go outside and check the types of plants ….*

NT 7: *… I do enjoy taking them out … to engage practically ….*

The interview data from NTs 1 to 7 revealed that every teacher used one or two of the pedagogic strategies within the set of hands-on, minds-on practices such as learner talk, ICT collaboration, practical activities, a few scientific process skills, and experiments. NTs 2, 3, 4 and 5 mentioned that they used 3D objects and LTSM, whilst NTs 2, 4, 6 and 7 referred to some form of hands-on inquiry using one or more of the scientific process skills, such as observation and experimentation. NT 1 employed learner talk, LTSM, ICT and practical demonstrations, while NT 6 made use of an experiment and scientific process skills such as observation, comparison and classification. Both NTs used the question-and-answer approach frequently in the teaching practice observed by the researcher.

From analysis of the data obtained from the seven interviews and five lesson observations, the following four most common pedagogical practices were identified. These are presented in Table 5.2, below:

Table 5.2 The most common pedagogical practices used by the NTs

PEDAGOGICAL PRACTICES USED BY FIVE NTs	NT 1	NT 4	NT 5	NT 6	NT 7
Question-and-answer pedagogical strategy	X	X	X	X	X
Direct instruction	X	X	X	X	X
Scientific process skills / Inquiry-based teaching				X	
Group work / Collaborative learning	X				

These four pedagogical practices will be discussed in detail, starting with the most prominent: the question-and-answer pedagogical strategy. Evidence will be provided from the seven interviews and five classroom observations and juxtaposed with references to international and local literature and making connections to the theoretical framework.

5.2.3.1 Question-and-answer strategy

Effective questioning is part of pedagogical knowledge (DHET, 2015) and one of the components of quality teaching (Coe et al., 2014). Questioning as a deliberate pedagogical strategy can actively involve learners in the learning process, support them in understanding concepts more thoroughly, promote collaboration and build learners' confidence (Tofade et al., 2013; Döş et al., 2016).

The scientific process skills (i.e., observe, compare, classify, measure, experiment and communicate) to be developed during scientific inquiry in FP lends itself to the cognitive levels as proposed in the Amended CAPS (DoBE 2019:5). Bloom's Taxonomy is a widely accepted framework for the effective composing of questions (Lewis, 2020; Bloom 1956) that teachers employ to develop a range of cognitive levels and thinking skills. The lower cognitive level is employed for simple knowledge-based recall questions (convergent thinking), progressing to the higher-order cognitive level to check learners' understanding by asking challenging questions (divergent thinking) (Bloom, 1956).

During the observations, NTs 1 and 6 used the question-and-answer approach as a pedagogic approach even though neither of them mentioned this during their interviews. Brief excerpts of both NTs' lessons follow showcasing the abovementioned approach.
NT 1: An extract from the observed Grade 2 lesson about 'Air'.

NT 1 asked a question: *Now tell me something, what is air?*

L 1 responded: *It's like wind.*

NT 1 repeated the question: *It is like what?*

L 1 responded: *It's like wind.*

L 2 responded: *Air keeps us breathing.*

L 3 responded: *If we go underwater, we can't breathe. It let us die.*

NT 1 responded: *Ok, if we go. Ok, if we go underwater, we can die. We need air to breathe underwater. We can die. We need air to breathe.*

NT 1 explained *Right. On your table, you have 2 pieces of paper you did not use yet. I want you to do a little science experiment with it and I want you to do something like this. She begins to crumple it.*

NT 1 asked a question: *L 4 [pseudonym], what do you think, will the crumpled piece of paper go further or the flat piece of paper go further?*

L 4 responded: *The ball … The round one because it has more aerodynamics.*

NT 4 responded: *Ok, ok, L 4.*

NT 1 posed the question to her learners: What is air? This question did not yield the required response from her learners. She did not attempt to probe or solicit more accurate responses, nor did she respond to the answers provided by Ls 1, 2 or 3. At the end of the questioning process, the learners could still not answer the first question correctly, yet NT 1 continued to introduce a second question relating to a completely new concept which was ‘movement through air’.

It is evident that NT 1 did not consider the selection of content for the question purposefully; did not select questions adapted to the level of difficulty of the class; did not phrase her questions based on her learners’ previous knowledge or anticipate possible responses from her learners (Bloom, 1956; Lewis, 2020). Further ‘gaps’ in the use of the question-and-answer approach include the absence of intentional specific inquiry, metacognitive thinking (Tanner, 2012), and problem-solving opportunities (Hu, 2015). Questions were asked to pique her learners’ interest, but she lacked the skill and understanding of the critical components to create an opportunity for them to engage on a higher cognitive level and think critically. The conceptual knowledge of ‘air’ was not evident; in Shulman’s (2004) terms, the CK and the PCK of teaching NS were seemingly neither understood nor applied by the teacher.

NT6: An extract from the transcribed Grade 1 lesson about ‘Objects that dissolve in water’.

NT 6 wrote the word ‘Dissolve’ on the blackboard.

NT 6 asked a question *When you look at this word. Look here. What do you think? Something dissolves in water. What do you think it means? Raise your hand. L 1, what do you think? So when we say something dissolves in water what does it mean?*

Learners raise their hands.

L 1 responded *It means put the water in.*

NT 6 repeated L1's response: *You must put water in. What do you think? You must think. What do you think you are going to do there? What do you think we are going to do? We going to put something in the water. Check if they?*

L 2 responded: *Float.*

NT 6 prepared well for the experiment with her Grade 1 class, which allowed her to pose leading questions about what they were discovering. The collaborative engagement with the scientific process, during the experiment, should have yielded an understanding of which substances dissolved and which did not. But rather than lead them through the process, NT6 simply told her learners what to do, revealing her lack of CK and PCK (Shulman, 2004).

NT 6 proceeded by asking the question: "What do you think we mean when we say something dissolves in water?" This question was pitched too high; the learners would have had everyday experience (prior knowledge) of the concept of 'dissolve' such as making coffee and tea, yet they did not adequately answer the question. She did not ask leading questions linked to L 1's response about 'add water' to evoke deeper thinking. NT 6 did not pose questions to scaffold her learners' knowledge to the next cognitive level of understanding, as advocated in the Amended CAPS (DoBE 2019:5). NT 6 needs skill development in formulating structured questions to address lower-order questions and then gradually scaffolding to more complex, higher-order questions. Even though NT 6 had apparently prepared carefully for her investigative lesson, it lacked evidence of metacognitive thinking (Tanner, 2012) and problem-solving opportunities (Hu, 2015).

5.2.3.2 Direct instruction (DI)

NT 6 used the DI pedagogical practice when she stood in front of the class and attempted to conduct an experiment by presenting certain information and asking her learners questions (Renhard, 2019). She divided the class into five groups for this hands-on activity on ‘substances that dissolve in water’. The LoLT of the teacher and learners was English with isiXhosa being their home language. There were no examples of code-switching during this DI lesson.

An extract from NT 6’s Grade 1, DI lesson about ‘substances that dissolve in water’ follows:

NT 6 asked a question:	*What do you think? Something dissolve in water.* *What do you think it means?*
L 3 responded:	*It means put water in.*
NT 6 repeated response and asked a question:	*You must put water in. What do you think?*
NT 6 answered her own question:	*And check if they dissolve in water.*
NT 6 continued to explain:	*Dissolving in water. We make a solution by mixing in to make something, né?*
NT 6 asked a question:	*For example, if I make a tea, what do I do?*
NT 6 made a statement and asked another question:	*For example if you making a tea and then you pour what?*
L 4 responded:	*The sugar.*
NT 6 asked a question:	*The? What do you do then?*
NT 6 answered her own question:	*You stir. By stirring we dissolve the sugar in water.*
NT 6 asked a question:	*Do you see the sugar afterwards?*
NT 6 answered her own question and asked a new question:	*It disappears. That means?*

NT 6 asked a question: *What did it do? It dissolves in water.*

NT 6 called learners to attention: *Ok. Let's look here. Now we are going to. We are going to predict. We are guessing now. We don't know if it's true or if its false. We going to check. Is it true or is it false? If something dissolves we make a tick or if it does not dissolve we put a cross.*

NT 6 asked a question: *You going to tell me. Who knows rice? Raise your hand if you know rice. Do you know rice? Does it dissolve or disappear*

L 5 responded: *It stays there.*

NT 6 asked another question: *Does it dissolve or not dissolve?*

L 6 responded: *It dissolves*

NT 6 asked another question: *Shall I put a cross or a tick? It does not dissolve in water*

L 6 responded: *A cross*.

NT 6 poured water on the maize meal and asked a question: She stirs it. *Can you see? Is it dissolving? Maize meal does not dissolve in water. I am going to put maize meal just to check. Does it dissolve? Do you see it?*

NT 6 directed her learners and provided the LTSM for the planned experiment to teach the concept of 'dissolve'. The lack of learner response prompted her to continue talking, offering information, and answering the questions she posed to her learners. Uninterrupted silences can be uncomfortable and seem long to a NT who has not had sufficient practice with a wait-time strategy (Muijs & Reynolds, 2005), that is, waiting at least three seconds for a learner's response.

In this excerpt from 'what dissolves in water', she imparted knowledge through DI. After posing questions, she allowed some observation and prediction during the experiment, leaning toward a scientific experience. Learners were asked to make a prediction about which substances would dissolve in water. She explained what "predict" means. She told them “We are going to predict. We are guessing now. We don’t know if it’s true or if it’s false. We going to check [using the experiment]”. Thereafter, she modelled and demonstrated the experiment in a step-by-step manner.

No time was allocated for learners to discuss or process what they were observing. Their observations determined whether the predictions made were correct. The learners were told to mark the activity sheet with a tick when the substance dissolved or a cross if it did not.

The lesson had the potential for conducting an experiment which would have provided an opportunity for learner agency, yet it was a teacher-directed, DI lesson. The NT’s seeming lack of PCK (Shulman, 2004) suggested that she did not know any better way of teaching this lesson. The types of questions posed (Lewis, 2020) and the limited learner interaction did not afford learners the opportunity to articulate their understanding of the concept.

An extract from NT 7’s lesson about ‘recycling’ to a Grade 3 class

NT 7 offered information: *So, we talk about recycling, Grade 3s. We think about 3 R’s. When we think about recycling, we think about the words reduce, reuse, and recycle. So sometimes we can do something about the things can put on the ground. Things that we do. Teacher gives you a half a piece of paper we don’t use a full sheet, so we reduce how much paper we use. Sorry, we reduce the paper we use. Then we talk about reuse. Then we talk about reusing. Who can give me an example of reuse? So that it has more than one use, then we talk about reuse.*

L 5 responded: *We can reuse our bottle.*

NT 7 asked a question: *Ok very nice. L 5 is saying sometimes we can reuse our bottle. A cooldrink or a jive or a coke or a juice. We can rinse the bottle and reuse our water bottle. We can also use what other kinds of items?*

NT 7 questioned a specific learner: *L 6*

L 6 responded: *Pens.*

NT 7 responded: *Pens we can't really reuse those. When it comes to bottle caps, we can reuse the caps. What can we reuse the caps for?*

L 7 responded: *In Mathematics we use the bottle caps.*

NT 7 responded and affirmed: *Very nice we use it for counting. Then we talk about reusing. Who can give me an example of reuse? So that it has more than one use. Then we talk about reuse.*

NT 7 asked a question: T*ell me what is the item I have in my hand? Ok, I cannot hear L 7.*

NT 7 responded: *L 8 put your mask on please baby and tell me what is the item in my hand? L 9 don't shout out we are giving L 8 a chance.*

NT 7 asked a question: *Tell me what the item is I have in my hand. Ok, I cannot hear.*

L 8 responded: *A chip packet.*

NT 7 encouraged a learner: *L 9 let's hear it girl, what is a chip packet made out of? The Item. I have in my hand. Hi L 10!*

NT 7 offered the information: *Plastic but also on the inside we have a foil material. So this foil material keeps what's inside the plastic fresh and also allows for no air to get out or no air or anything else to come in. Ok. So, this is a plastic but also a foil material, ok.*

Although teaching the Grade 3 class, NT 7 was not a trained FP teacher. She positioned herself in front of the class and asked the learners whether they knew anything about recycling. L 1 offered a response by giving an example of what could be recycled, and NT 7 did not follow up by asking leading questions to explain the concept of "recycling". She then made available multiple different recycled materials one by one in a step-by-step process. NT 7 posed direct questions to generate responses about the materials she presented, both lower-order questions – such as "What is the item I have in my hand?" – and higher-order questions – for example, "What is this made of?" (Lewis, 2020). Throughout the lesson, NT 7 accepted the learners' responses and did not invite further interaction.

Although learners engaged more during NT 7's lesson, deep or meaningful learner engagement was limited. Like NT 6, NT 7 did not promote discussion among the learners to stimulate deeper thinking about the properties of the materials, about why certain materials suited the particular packaging – for example, the chip packet – and whether it could be reused or recycled. NT 7 provided all the information that could have been elicited from the learners, indicating a DI lesson.

The pedagogical practice in the lesson (Grossman et al., 1989:27) was teacher-centred with no agency ceded to learners. Learners were not given the opportunity to scrutinise the various materials, to handle and compare them, or give explanations or express their thoughts and opinions.

5.2.3.3 Scientific process skills and inquiry-based teaching

As prescribed in the CAPS document (DoBE, 2011:8), teaching NS in FP requires teachers to use the six scientific process skills of observing, comparing, classifying, measuring, experimenting, and communicating. These skills allow learners to engage in inquiry through hands-on and minds-on activities, which develop critical thinking and problem-solving. Krogh and Moorehouse (2014) claim that involving learners in the processes and language of science helps to maintain the integrity of NS as a discipline.

The following narratives were shared by the NTs during the interviews when they were questioned about their NS teaching experience and the pedagogical practices they used. The following questions were asked to ascertain whether NTs taught deliberately using scientific process skills in the process of inquiry: *i) What methodologies and strategies do you use to teach Natural Science in your class?) ii) How familiar are you with the Natural Science requirements in the CAPS document? iii) How do you involve your learners during Natural Science lessons?* The following responses to the questions were recorded:

> NT 1: *I mostly did it with discussions … like more concrete things like planting … … I wouldn't say I am very familiar with it … [NS process skills and concepts] I would usually inquiry-based learning … learners to talk to each other, build on their knowledge and each other's knowledge … we would do the practical planting bean ….*

NT 2: *We don't really teach Natural Science … I'm not really familiar with that … [NS process skills and concepts] concrete objects … observe… tell me what you notice... inquiry-based learning … in groups. Let them talk about it, discuss what do you notice about it? What's on it? What isn't on it? …[compare].*

NT 3: *I don't really because we don't actually really teach it [NS] … I'm not CAPS, not … I honestly have no idea [NS process skills and concepts].*

NT 4: *Actually, I've never taught it [NS] as a subject … Not that great to be honest …I don't know [NS process skills and concepts] The trunk of the tree, roots, leaves etc. They touched it [trees] physically. We also planting our bean ….*

NT 5: *I taught [NS] in Grade 2, but I did not teach it in Grade 1 … last year I was so invested in soil … It was probably one of my best lessons …. It [the lesson] was gathering of all the soil … I am not … [familiar with NS process skills and concepts].*

NT 6: *… the float and sink experiment and I did the plants … I am also integrating Technology in it [NS lesson] … I did not familiarise myself with that [NS process skills and concepts] … I just know it's [NS] about experiments … I send two learners to check how's the weather … go outside check the types of plants ….*

NT 7: *I try to integrate it [NS] as much as I can in my Home Language subject so normally I will read comprehensions or activities when it comes to animal life or botanical … No, we do not teach Science as a subject … I would say not very familiar [NS process skills and concepts] … I do enjoy taking them out … to engage practically ….*

In these narrative fragments, many honest but contradictory statements were made by the NTs. The seven NTs' candid responses revealed that they were not familiar with the scientific process skills and concepts specific to NS to be taught in FP. NTs 1, 2, 4, 5, 6 and 7 referred to aspects of the inquiry process and exposed their learners to a few NS skills. Inquiry-based pedagogy was mentioned by NTs 1 and 2 as their pedagogy of choice, as it included engaging in practical activities (hands-on) with some processes, observation, comparison, group discussions (minds-on), collaboration and providing feedback (communication). NT 6 used experiments (processes), observation and comparison when teaching NS. Her learners were afforded the opportunity to hypothesise, observe, compare, experiment (hands-on and minds-on), communicate their findings and check whether their hypothesis was correct or not. NT 7 indicated that she did not teach NS as a subject but rather used NS topic-related texts for comprehension.

A few contradictory statements were made by NTs 2, 4, 5 and 7. They claimed that they did not teach NS but afterwards referred to practical activities like planting (hands-on) and observation. Even with the NTs' limited grasp of CK and PCK (Shulman, 2004) and lack of knowledge of the scientific process skills and concepts (DoBE, 2011:8), all of the teachers (except NT 3) developed the learners' skill of observation, while NTs 1, 2 and 7 used discussions (communication). Some exposed learners to practical experience (NTs 1, 4, 5 and 6). The NTs, including NTs 1 and 2 who claimed to teach NS using an inquiry-based approach, and NT 6 who used experimentation, were unaware of the concepts or the six scientific process skills, yet afforded the learners' opportunities to be experientially engaged in lessons.

The knowledge and efficacy of CK and PCK, as highlighted by Shulman (2004), and the integrity of NS as a subject taught in FP as emphasised by Krogh and Moorehouse (2014) and Patrick and Mantzicpoulus (2015), point to the importance of learners being allowed to engage with NS concepts and process skills to develop their own coherent notions about Science. Exposure to real 'hands-on' and 'minds-on' experiences under the guidance of a knowledgeable teacher is key to learner development.

5.2.3.4 Group work

Teaching NS in FP provides a natural opportunity for investigation in a group setting using scientific process skills to develop Science literacy (DoBE, 2011:8). In response to a question about their use of group work, the NTs had the following to say:

> NT 1: *They sit in groups. Different groups, they would have discussions. If they could, they would write the points they would want to give feedback to the class.*
>
> NT 2: *I would let them have group discussions … each group would have a topic of discussion … each group to tell me what they spoke about …as a class we talk about what each group spoke about [feedback].*

NT 3: *… into small groups to get them have their little turn or um discussions … .*

NT 4: *I would go over the activity with first group. Second group on mat. Go over it. Flash it. Do you understand. They need that extra [support]….*

NT 5: *… different groups. So one group will do one activity and a different group a different activity. There is differentiation over a week.*

NT 6: *… in Maths and I will have like my small groups. I will plan according to learners' ability groups.*

NT *7* *I am definitely more able to work within those individual groups especially when it comes to subjects like NS….*

During the interview, NT 6 spoke about group work in Mathematics and not NS. During the classroom observations, however, the researcher saw NT 6 working with small groups in a NS cooperative learning lesson, conducting experiments, making predictions, and recording their results (as recommended by Howe et al., 2007). In brief, NT 6 used group work effectively in an authentic classroom setting where learners were developing new knowledge.

NTs 1, 3 and 4 reported that they taught NS in small groups, which – to the extent that they are less teacher-centred – can result in more effective learning (Shulman & Shulman, 2004). According to Shulman and Shulman (2004:262), good classroom organisation includes being "proactive (hands-on) with multiple forms of group work" that enable learners to develop knowledge, skills and values. However, only NTs 1 and 3 used group work effectively, with the learners engaging in collaborative discussion. NT 1 allowed her learners to write down points for the feedback sessions. NTs 1, 5 and 7 claimed that they taught using different groups. NT 5, for instance, described how she assigned different activities to different groups, thus only using the groups for organisational purposes. NTs 1, 2 and 3 explained that they encouraged their learners to have group discussions for peer learning, as recommended by Thurston et al. (2007), with NT 2 mentioning that her groups had specific topics to discuss. NT 1 and NT 2 allowed their learners to "engage in this discourse" (Thurston et al., 2007) and provide feedback from the group discussion, thus using group work for the intended purpose, creating a more learner-centred classroom where learners were involved in co-constructing new knowledge with their peers (Vygotsky, 1978).

NT 4 explained that she used group work for revision of the topic on hand, using the flashcards with one group on the mat and checking their understanding, while the other groups were busy with an activity at their tables. NT 4's grouping practices to a large extent functioned to maintain learner attention and classroom control, rather than to serve a learner-centred social pedagogic approach (Baines et al., 2007).

It was interesting to observe that only NT 6 provided her learners with an opportunity for each group to predict, conduct experiments, record and communicate the results (Vygotsky, 1986; De Jong et al., 2013), thus creating the circumstances for meaningful learning through social interaction (Baines et al., 2007). The concept of collaborative group work (Shulman & Shulman, 2004) manifested in varying degrees. While some NTs facilitated productive interactions and meaningful cooperation, others displayed limited or unstructured interactions which resulted in less productive collaboration and effectiveness of collaborative learning.

5.2.4 SELF-EFFICACY

The NTs' self-efficacy in pedagogical practice is what determines their ability to teach effectively with successful outcomes. Since this study seeks to develop a framework to improve teacher confidence and competency, questions were posed to determine teacher self-efficacy. Bandura (1995:2) defines self-efficacy as "the belief in one's capabilities to organise and execute the course of action required to manage prospective situations". Such belief is a powerful predictor of behaviour with regard to a specific task, in this instance the teaching of NS.

Excerpts from NTs' narratives regarding their teaching experiences and perceived self-efficacy follow:

NT 1: *I don't feel prepared … Too scared to explore or let the learners explore … Not things where I have to take risk … I was figuring things out … Still finding myself or my feet in the classroom ….*

NT 2: *… it's a bit difficult because sometimes I'm not sure that I am teaching it … in my mind it was just this completely complicated subject that I'm never going to actually understand …*

NT 3: *OK, I don't feel very prepared at all…Um, I just don't know much about it. … it's a bit … difficult because sometimes I'm not sure that I am teaching it … It's not really a forte of mine ….*

NT 4: *I think I first need go and check-up and read up and have my background and knowledge … I don't know exactly what Natural Science is about … I think if I had a module, I would know my way forward. I would know where to start, what to do.*

NT 5: *I avoided [Science] at high school, but I am forced to do it now [teaching] … I am not going to put myself out there for NS basically … very complicated … so I am not even going to bother … it's literally all foreign ….*

NT 6: *I love Life Science … I was in the Science stream … I don't know strategies Science and all that … I do experiments … I neglected Science … still need to learn how to teach NS ….*

NT 7: *I am very capable of teaching the subject and have quite a joy for … my major at university and I studied it for 2 years … there is actually a definite gap in my um … practical knowledge about teaching … anxieties about not being FP trained ….*

The sense of self-efficacy regulates how people perceive themselves, which affects their cognitive processes (what they think), their affective processes (emotional state) and how they behave or improve themselves (Tahmassian & Jalali Moghadam, 2011). The ensuing discussion on the NTs' perceptions of self-efficacy will be structured as follows: i) negative self-efficacy of cognitive processes, ii) negative affective processes, iii) positive self-efficacy of cognitive processes, iv) positive affective processes, v) juxtaposing the affective and cognitive processes, and vi) a summary of the section.

5.2.4.1 Negative self-efficacy of cognitive processes

While cognitive processes, as defined by Bandura (1994), are thinking processes involved in the acquisition, organisation and use of information, the cognitive processes needed particularly for self-efficacy include cognition, self-evaluation, motivation and behaviour (Nabavi, 2012). The evidence provided shows that for four NTs there was low self-efficacy in all of the cognitive processes (Palmer, 2011). The lack of self-belief in cognition was evident in the remarks of NTs 1, 2, 3 and 4: "… a lack of preparedness to teach NS", "… unsure if what they were teaching was in fact NS …", "… it's a bit … difficult …" and "… I don't know exactly what Natural Science is about". A lack of motivation was explicitly expressed in NT 2's remark: "… this completely complicated subject that I'm never going to understand". Although self-evaluation was evident in NT 4's acknowledgement of her need for more background knowledge if she wanted to teach NS more effectively, her low self-efficacy was evident during the classroom observation when she imparted partial information about the root and stem of a plant, foregrounding a lack of CK. Collectively, these utterances suggest inadequate motivation, confidence and low self-efficacy (Morris et al., 2017) in the cognitive processes involved in teaching NS. This low self-efficacy would impact negatively on the NTs' ability to implement educational innovations and perform the professional tasks expected of them in NS curriculum delivery (Rahman et al., 2019).

5.2.4.2 Negative affective processes

Affective processes are defined as processes regulating emotional states and the elicitation of emotional reactions (Bandura, 1994). An expression of low self-efficacy was articulated by NT 1 when she expressed her unwillingness to explore or take risks and admitted that she was "still figuring things out" when teaching NS (Knowles, 1980). NT 7, on the other hand, shared her "anxieties about not being sufficiently FP trained". The emotions of fear, uncertainty and anxiety are evidence that NTs 1 and 7 were not "ready" to perform the NS tasks expected of them. Their self-efficacy seemed to be determined by affective attitudes and behaviours developed in earlier interactions with Science (Knowles, 1980; Avery & Meyer, 2012; Van Rooij et al., 2019:288).

NT 5 described her lack of exposure to NS and boldly stated that she was "not going to bother" with trying to understand NS. She declared that the subject was "literally all foreign", suggesting that a sense of hopelessness underlay her limited knowledge and lack of motivation to learn more about NS. A comment that she was now “forced” to teach NS also evinced her lack of self-efficacy (Bandura, 1997).

5.2.4.3 Positive self-efficacy of cognitive processes

The comments by NT 6 and NT 7 – “I do experiments” and “I am very capable of teaching the subject” – reveal self-efficacy through self-belief, self-evaluation, confidence and enthusiasm (Morris et al., 2017). NT 6’s and 7’s positive perception of their capabilities (Bandura 1995), will render them more successful in their teaching of NS (Rahman et al., 2019) and impact learner outcomes and competencies (Bergman & Morphew, 2015). NTs, like 6 and 7, who experience some small success grow in self-efficacy and are motivated to continue striving to improve their pedagogical practice (Morris et al., 2017).

5.2.4.4 Positive affective processes

The following positive affective declarations were made by NTs 6 and 7 – “I love Life Science” (NT 6) and “… have quite a joy …” (NT 7), which indicate a strong relationship between their thoughts and emotions. NTs 6 and 7’s sense of efficacy may encourage a sense of personal accomplishment and minimise feelings of vulnerability, fear, anxiety, and stress (Tahmassian & Jalali, 2011). This is likely to promote a willingness to try new instructional practices (Kearsley, 2010). Zee and Kooman (2016) endorse the idea that a teacher’s self-efficacy not only influences their pedagogical practices but affects their emotional wellbeing too.

5.2.4.5 Juxtaposing affective and cognitive processes

Cognitive and affective processes seem intimately intertwined (Bandura, 1997). A significant correlation was found between the NTs’ self-efficacy and their cognitive and affective processes. What is noteworthy is that although NT 6 and 7’s perceptions of their self-efficacy seemed high, after more questioning, perceptions of challenges also emerged. The reflections (NT 6 and 7) and comments such as “lack in my experience”, “definite gap” and “wish I had been taught more practical skills” point to the cognitive process of self-efficacy appraisal through recognising their limitations (Bandura, 1997). NTs 6 & 7’s perceptions of what they could do in the way of professional tasks and the skills they possessed (Bandura, 1986) enabled them to recognise their competence in one area and their lack of this in another. Self-efficacy and attitudes can have a negative or positive effect on NTs' CK, PCK, and classroom practice. The effect is likely to be transferred to their learners, influencing their attitudes and interests (Bergman & Morphew, 2015).

In summary, five NTs (1, 2, 3, 4 and 5) experienced low self-efficacy in their cognitive and affective processes. The positive declarations of NTs 6 and 7, which resulted from an increase in their success, sense of positivity, and perceived sense of knowledge, expressed greater self-belief (Morris et al., 2017). This augured well for the development of their teaching practice in their initial years in the profession (Reyhing & Perren, 2021), especially for NT 7, who had not been trained in FP. Teachers' daily teaching practice reflects their professional development, CK and PCK. Bergman and Morphew (2015) suggest that NTs' self-efficacy can create a less stressful and threatening teaching environment for all and have a direct influence on their learners' achievement and motivation. Their high self-efficacy enabled positive expectations as NTs 6 and 7 saw their challenges as learning opportunities and were able to monitor and motivate themselves, whereas the NTs with low self-efficacy doubted their teaching abilities (Morris et al., 2017; Reyhing & Perren, 2021), were fearful, avoided challenging tasks, saw challenges as threats and focused on their shortcomings. It was evident that factors such as personal emotions, behaviour, and the environment were reciprocally influential in the formation of self-efficacy (Morris et al., 2017; Bandura, 2012).

5.3 CONCLUSION

Chapter 5 explored RQ 1, which was directed at the situation before the intervention: the NTs' perceptions of NS, their knowledge and interpretation of NS CAPS, their pedagogical practices and the NS training received at their respective HEIs. The understanding of the initial discourse was imperative since the findings would inform the development of a tailored intervention plan (IP) to address the learning needs identified. Three theories were invoked to inform the analysis of findings regarding RQ 1: Shulman's (1986) theory of pedagogical content knowledge (PCK), the theory of andragogy (Kearsley, 2010) and Bloom's taxonomy (1956).

The evidence showed that, although the NTs' Natural Science qualifications, experience and training varied, what they had in common was inadequate NS teacher training. Most of the NTs reported having had no experience of Science in their matric year. Only one (NT 1) had some experience with NS during teaching practice. The NTs felt that the training received from their respective HEIs was insufficient since they were not made unaware that NS was embedded in the Life Skills area in the CAPS (Williams & Rhodes, 2016). All the NTs cited gaps in their NS content knowledge and pedagogical practice as shortcomings in their disciplinary and pedagogical learning. Although the NTs displayed pedagogical knowledge by using strategies such as direct teaching, group work and the question-and-answer method, only two NTs displayed evidence of strategies linked to inquiry-based teaching (IBT). There was evidence of low levels of confidence and self-efficacy as a result of their realisation that they did not possess the requisite skills to teach NS effectively.

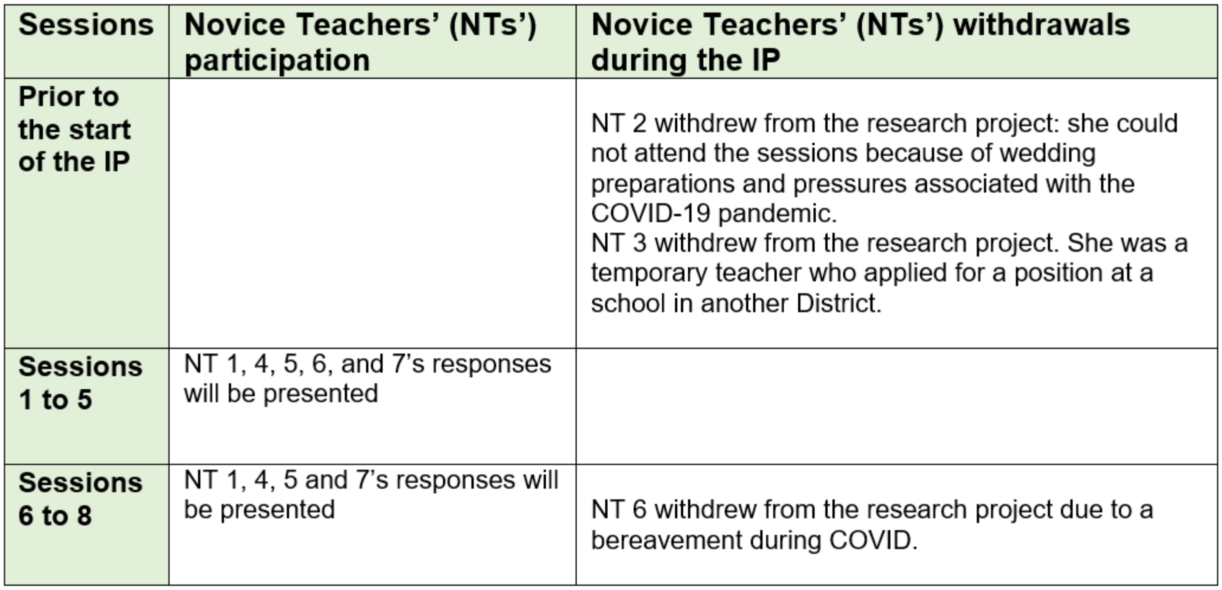
CHAPTER 6

RESULTS AND DISCUSSION – RESEARCH SUB-QUESTION 2

6.1 INTRODUCTION

This chapter presents the findings, obtained during the eight-week IP, that respond to Research Sub-Question 2: How did the novice teachers develop cognitive and higher-order thinking abilities **during** the intervention programme? NTs 2 and 3 withdrew from the research project after the initial interview, before the start of the IP. NT 6 withdrew after Session 5 of the IP. Table 6.1 provides a summary of the NTs who participated in each session and indicates reasons for the withdrawal of some of them from the research project.

Table 6.1 NTs' participation in the IP



Sessions	Novice Teachers' (NTs') participation	Novice Teachers' (NTs') withdrawals during the IP
Prior to the start of the IP		NT 2 withdrew from the research project: she could not attend the sessions because of wedding preparations and pressures associated with the COVID-19 pandemic. NT 3 withdrew from the research project. She was a temporary teacher who applied for a position at a school in another District.
Sessions 1 to 5	NT 1, 4, 5, 6, and 7's responses will be presented	
Sessions 6 to 8	NT 1, 4, 5 and 7's responses will be presented	NT 6 withdrew from the research project due to a bereavement during COVID.

6.2 RESEARCH SUB-QUESTION 2 (RQ 2)

How did the novice teachers develop cognitive and higher-order thinking abilities **during** the intervention programme?

To explicate and understand the development of the NTs' cognitive and higher-order thinking abilities **during** the IP, the following theories (set out in Chapter 2) were used:

- Dewey's model of reflection (1933) as evolved into Strampel and Oliver's (2007) levels of reflection and cognitive development. Reflection is a cognitive process that includes stimulated, descriptive, dialogic, and critical reflection;
- Knowles's (1984) theory of andragogy. This drew attention to the NTs' participation, self-image, experience, and their readiness, willingness, orientation, and motivation to learn (Kearsley, 2010);
- A community of inquiry (CoI), as elaborated in John Dewey's progressive understanding of education. A CoI reflects the process of creating deep collaborative-constructivist (online) learning experiences, through developing the three interdependent elements of social, cognitive and teaching presence (Garrison et al., 2000) and;
- Bloom's taxonomy (1956), with its six categories of knowledge as a continuum from simple to complex levels of critical thinking: remembering, understanding, applying, synthesising, evaluating, and creating.

6.2.1 Session 1

This session commenced with introductions and thirty minutes of self-reflection on the part of the participants on their teaching practice and knowledge of the Natural Science (NS) to be taught in Foundation Phase (FP). All the NTs were interviewed, and selected data collected from the interviews is presented below.

NT 1: … *I don't know much about teaching Science* ….

NT 2: … *it's a bit difficult because sometimes I'm not sure that I am teaching it ….*

NT 3: … *I don't really know because we don't actually really teach it* ….

NT 4: … *I don't know … I don't know ....*

NT 5: … *I am really not interested* ….

NT 6: … *I am interested but I don't know what to teach ….*

NT 7: *… I need this ….*

The NTs' responses regarding their experience of teaching NS indicate a low level (basic recall) of stimulated reflection (Strampel & Oliver, 2007) and cognitive processing (remembering and understanding) (Bloom, 1956). As Strampel and Oliver (2007) maintain, reflection is a complex process comprising several levels. Stimulated reflection is the first level of reflection: a triggering event (the question asked) resulted in disequilibrium, as the NTs realised that something did not fit. This was evident in NT 1's response about her limited NS teaching experience: "I don't know". This indicates cognitive presence (Garrison et al., 2010).

In Session 1, the NTs were exposed to the importance of reflective practice and using a journal (Heyler, 2015) to record their thoughts about their teaching practice: a process of metacognition. The purpose of the journal was to encourage them actively to reflect on their practice, thus promoting self-development through an understanding of their own learning processes. It was hoped that this process of reflection would enable the NTs to develop skills or strategies such as questioning techniques, a group activity, the K-W-L chart (what I **K**now, what I **W**ould like to know, and what I have **L**earned), concluding, and considering future actions. The purpose was to enable concepts and theories to become entrenched in their practice, while simultaneously fostering continuous improvement (Heyler, 2015).

The NTs' journals included these entries:

NT 1: *… interesting to hear what the learners knew about air … learners' explanations … aerodynamic … not prepared for an answer like that … Grade 2… threw me off-guard. I completely dismissed it when I could have dug deeper … If I was better prepared and was more educated on the subject/topic I would have been able to take this much further ….*

NT 4: *… feeling a little awkward not knowing what to say or what to share ….*

NT 5: *… upset … had many meetings this week … unsure what to expect …. and after the session … not interested at all … Science is not my vibe … yeah, all in all, a strong <u>NO!</u>*

NT 7: *Recycling lesson … Group 2 … Lesson went great … learners interactive … raising hands and answering questions … could have – done a follow-up lesson with compost … slow lesson … [learners] took long to understand concepts … could have had more resources and used a YouTube video ….*

These stimulated reflections from NTs 1, 4, 5, and 7 reveal a state of disequilibrium (Strampel & Oliver, 2007). NTs 1, 4, and 7 realised their need to know more about NS teaching in FP (Knowles, 1984) whereas NT 5 decided that she could not accommodate the pressure of teaching NS on top of the traumatic stress inflicted by COVID.

6.2.2 Session 2

In this session, the activity planned to create a teaching presence was to introduce the NTs to the FP CAPS curriculum requirements, aims and principles, and the topics of Life Skills. At the end of the session, the collaborative reflection covered all the aspects dealt with during the session, including a discussion of NS in Beginning Knowledge. The NTs revealed their surprise and displeasure at not being exposed to the content during training at their Higher Education Institution (HEI). They responded:

NT 1: … *I really did not know all of this* [information] … *this really helped me, but it is scary* …

NT 4: … *I was not exposed to this. I did not know any of this* …

NT 5: … *really now, I am shocked … this is the first time I hear this* …

NT 6: ... *I did not know about all of this* …

NT 7: … *Ok, I definitely did not know this ….*

A state of disequilibrium (Strampel & Oliver, 2007) was evident in the NTs' recognition of how this gap in their content knowledge affected them as NS teachers in FP, and their realisation of their 'need to know' (Knowles, 1984). Piaget (1952) calls this state of disequilibrium a state of cognitive imbalance. The NTs encountered information that required them to develop new schema or to modify their existing schema so as to accommodate the new information. This process allowed the NTs to engage in further inquiry and discussion about NS in FP as stipulated in the CAPS document. This was the commencement of learning, a continual process of achieving the equilibrium of a state of "knowing” (Piaget, 1952). The NTs’ comments, questions and conversations shaped the sessions as an iterative process of evaluation and reflection. They went through the processes of brainstorming, building and refining their knowledge until they were satisfied.

6.2.3 Session 3

Although there was general anxiety about online communication resulting from the COVID pandemic, in this first online session the researcher planned to introduce certain skills and concepts and discuss the nature of NS. The six scientific skills – observe, compare, classify, measure, experiment, and communicate (OCCMEC) – and the four concepts – Life and Living, Matter and Materials, Energy and Change, and Planet Earth and Beyond – were introduced, taught, and discussed as the class navigated through the FP Life Skills (LS) CAPS document.

For the *teaching presence,* the researcher designed a 3-part scaffolded activity which included the identification of topics in NS, NS concepts and NS skills, and the explication of what each entails, since the curriculum document itself is devoid of relevant CK. She created a learner-centred, safe space in which she facilitated discursive collaboration, providing direct instruction when required (Pearson, 2016). This activity enabled the NTs to make meaning of their own CK, or lack thereof. To influence the NTs’ participation and engagement (Caskurlu et al., 2020), the researcher created a WhatsApp group. This enabled quick and easy communication about the tasks assigned and provided real-time chat opportunities. Since some NTs were reluctant to engage on the MS TEAMS platform, the researcher encouraged them to use the WhatsApp group instead. The combination of collaboration and direct instruction facilitated discourse-based, optimal learning (Wang et al., 2021).

As a triggering event to develop a *cognitive presence*, the NTs were encouraged to consider various higher-order questions for analysing, synthesising and evaluating the new knowledge. Questions were asked such as: *What exactly did you find out? How did it compare with what you discovered in …? What else do you need to know?* and *How could we apply it to* …? This activity ensured a deep and meaningful collaborative learning experience (Garrison & Akyol, 2013). During this activity, NTs 1, 4, 5, 6, and 7 responded as follows:

NT 1: *… I did not know any of these concepts and skills ….*
NT 4: *… I am making an effort. This is so much … skills and all that. No, I never heard any of that before …*
NT 5: *… I am understanding what exactly must be taught … an eye-opener ….*
NT 6: *… I learned a lot. It's making more sense ….*
NT 7: *… what an eye-opener for FP teaching ....*

During this collaborative activity, the 5 NTs identified the gaps in their NS CK and set about the purposeful construction of knowledge through collaboration and sustained reflection, as recommended by Strampel and Oliver (2007). The remarks quoted above show that the NTs felt they had benefitted from the session, where cognitive presence was at the heart of the educational experience (Garrison et al., 2010). NTs 5, 6, and 7 reported improved comprehension of the CK, with NT 5 specifying that she learned what must be taught. This cognitive shift was enabled by the ability of the NTs to understand and integrate the new knowledge, skills and concepts.

NTs explored various resources such as the WCED FP LS document (2018), the LS CAPS document (2011), WCED ePortal, a Science kit with a teacher guide and suggested activities, and WCED lesson plans (Sen-Akbulut et al., 2022). This helped them to make connections with previous knowledge and to support each other by offering information or encouragement or addressing misconceptions. The misconceptions emerged in the discussion of concepts such as Energy and Change. For instance, NT 4 claimed that learners were not ready for Science learning and did not possess everyday Science knowledge, and NT 5 suggested that the children first needed to learn other skills such as reading and writing. NT 7 stated that NS was not taught in FP and that learners would not be able to understand the concepts dealt with. Yet, as Bosman (2017) notes, young learners have an innate curiosity that gives rise to inquiry and exploration, and the trend emerging from recent research is to teach learners Science in early childhood to foster their ability to think and reason scientifically.

After many iterations of exploration, questioning and discussion, the NTs were able to integrate their newfound knowledge, as reflected in the following extracts from their journal entries:

> NT 1: … *learner results show that what I am doing differently compared to Term 1 is definitely working* ….
>
> NT 4: … *collaborating and discussing … I am making connections … considering and using more of these aspects [in my teaching] ….*
>
> NT 5: … *constructive criticism [from researcher] helped me understand what needed to be done … I reflected … and shifted [my thinking] in my practice ....*
>
> NT 6: *… I'm making changes … learners' involvement [discussion] in experiments … using process skills ….*
>
> NT 7: … *learners [now] come with more questions … learners making their own connections with previous knowledge … I honestly enjoyed it … [the changes].*

Appropriate tasks were planned to afford the NTs time to integrate their new NS knowledge, engage in higher cognitive processes (Rourke & Kanuka, 2009) and develop resolutions. A study conducted by Swan et al. (2009) found that learners did not reach the resolution stage during online discussion. On the contrary, however, in this research project the scaffolded activity with explicit instructions led to the NTs developing possible resolutions. The NTs were strongly encouraged to implement what they had learned during their classroom practice, which led to their beginning to develop their own resolutions. This was achieved through a trial-and-error process. The NTs synthesised the ideas (integration) from the exploration phase to resolve the original problem.

Resolutions were implicit in the following statements: NT 1 claimed that her learners' term performance [reading, writing, and the ability to offer verbal explanations] had improved; NT 7 shared that her learners' involvement and their ability to pose questions and make their own connections had improved. NTs 1 and 7 noted that the difference in their pedagogical practice was improving learner ability. NT 4 revealed that the exploration of the NS policy documents had helped her to integrate the NS CK and apply the knowledge in her teaching practice. NT 5 observed that the 'constructive criticism' received had encouraged her to reflect and shift her thinking [integration], which influenced her way of teaching [resolution]. This supports Bangert's (2008) contention that reflective questioning is a necessary prelude to the resolution phase of the cognitive presence. NT 6 engaged in changed pedagogical practices by incorporating the new knowledge, that is, process skills, which intensified her learners' involvement in their experiments. The exploratory nature of the activity had a high positive correlation with the NTs' integration of the NS CK (Alavi & Taghizadeh, 2013), as indicated in improved pedagogical practices and learner performance.

6.2.4 Session 4

A *teaching presence* was evident in Session 4 in the following three categories: design and organisation, facilitation discourse, and direct instruction (Li, 2022). The designed activity afforded the NTs (1,4, 5, 6, and 7) the opportunity to harness and apply the knowledge gained in Session 3. Session 4 was used primarily to gather all the information needed to develop a comprehensive lesson plan. The first step was to identify one NS topic for their particular grade; secondly, to relate the topic to the appropriate NS concepts; and thirdly, to develop the CK and choose the skills to be taught in the lesson.

During the facilitation of this activity, the researcher encouraged the NTs to engage in dialogic reflection by sharing their topic choices and related concepts, as well as the skills and CK developed for their individual lessons. Strampel and Oliver (2007) suggest that dialogic reflection engenders critical thinking and supports understanding and the integration of knowledge. The researcher posed questions for further discussion and to promote peer support. The NTs presented their ideas, after which the researcher provided immediate feedback [direct instruction]. The following responses were offered:

> NT 1: ... *I have been collaborating a lot* ....
>
> NT 4: … *[I am] unpacking [documents] and understanding [making meaning]* …. *I had to explain the concept energy ... it won't be a quick process ….*

NT 4 realised that she had to work through the process to make meaning of the content first. According to Strampel and Oliver (2007) and Bloom (1956), the NTs' enhanced meaning-making and understanding of their acquired knowledge enabled deeper reflection and the progressive development of higher-order thinking.

The activity was operationalised by using the practical inquiry model (PIM) (Garrison & Arbaugh, 2007) to realise deep and meaningful learning outcomes (Garrison, 2017). Garrison et al. (2010) and Sen-Akbulut et al. (2022) describe the critical discourse of collaborative inquiry as the first step towards developing conceptual knowledge and making meaning. A *cognitive presence* was evident during the process of exploring, listening and expressing thoughts during the activity (Garrison, 2017). The collaborative environment, as noted by Tachie (2022), encouraged NTs to explore the research reading-related material, reflect, ask questions and make informed contributions. The way the exploration unfolded can be illustrated by two of the NTs' responses. NT 5's response – "[I need to] tap into my own potential" – exhibited her use of her prior knowledge and learning experiences as a resource in the process of acquiring new knowledge. NT 6's comment – "now I have to think about this more" – suggests that when understanding is achieved through reflection, inquiry and communication, one can observe one's own learning and build further understanding. Personal reflection and shared collaborative learning together enabled an intersubjective metacognitive construct (Garrison & Akyol, 2013). According to Garrison (2017), this was a measure of the growth of the NTs' critical thinking skills as they became more competent and confident.

The researcher noted that the collaborative nature of the activity enabled NTs to develop new CK through the integration and connecting of ideas. According to NT 1: "there is now a greater understanding of NS … I am now easily able to identify [NS] themes [topics] … and link them to the concept of NS ... I now have a different perspective". Garrison (2017) contends that when individuals learn through educationally-driven engagements with peers involving exploration and integration, their cognition can be reconstructed, extended and confirmed. Increased self-directedness during the activity is recognised by Knowles (1984) as answering individuals' need to satisfy their inquiring minds by building on their educational experiences. NT 7 observed: "the support feels great especially when it comes to planning and the interrogation of Science knowledge … I gained much-needed insight … I can see how it fits in". The responses of both NT 1 and 7 corroborate Beck's (2015) view of how planned activities can demonstrate learners' progress online through the construction and co-production of knowledge. During this collaboration, the NTs collectively applied their knowledge and skills (Kanuka & Garrison, 2004) by co-producing a lesson template as a possible guide for their lesson plans. There was evidence of exploration, integration, and evaluation of their new content and pedagogical knowledge at this juncture. According to Shea et al. (2010), meaning making, the acquisition of new knowledges and deeper thinking create strong links with what is fundamental to cognitive realisation.

6.2.5 Session 5

In this session, a *teaching presence* was realised through discussion of the appropriate pedagogy and strategies to be used for teaching NS in FP. Inquiry-based teaching (structured and guided) as the preferred pedagogy in CAPS was explored as a 'hands-on' way of doing Science. Three strategies embedded in this pedagogy were introduced: i) the question-and-answer technique, ii) group work and iii) the K-W-L strategy. At this juncture, exposure to the pedagogy and different ways of teaching a lesson was essential. The NTs (1, 4, 5, 6 and 7) had already chosen their topics, concepts, skills and the CK for their lessons. The final element in the development of the lesson was to choose the appropriate strategy or strategies to teach the lesson. The following statements were made by NTs 1, 4, 6 and 7:

> NT 1: *… I tried more of the strategies (questioning, discussion, learner-centered classroom, and lesson) and integrated my lesson* ….
>
> NT 4: *…challenging … but I feel so encouraged …. I am trying slowly to include strategies in my lesson … questioning [technique] … to get learners to respond ….*
>
> NT 6: *... I made an effort for the lesson. Learners must collaborate (group work) and talk and be hands-on. Very useful ....*
>
> NT 7: *… I love the collaborative learning (group work) … I am navigating the best way of doing this ….*

After the acquisition and development of their strategies to teach NS the NTs' temporal perspective changed from one of postponing application of their new knowledge because of their ignorance of appropriate strategies to a desire to implement their learning immediately (Kearsley, 2010; Knowles et al., 2020).

During the *cognitive presence*, the NTs were tasked to demonstrate their NS topics, suitable activities and strategies, and to show evidence of how they had developed and used their lesson plans in their classrooms. The following responses demonstrate the cognitive development in their connecting and application of new ideas and knowledge processes (Garrison, 2007). These were communicated in the post-Session 5 discussion, after their first attempt at implementation.

NT 1: … *I am becoming more comfortable to use the strategies ….*

NT 4: … *out of my comfort zone, but I am becoming more comfortable to use the strategies … I am practising the strategies ….*

NT 5: … *challenging … out of my comfort zone … getting learners to respond [learner agency] … I am making a change in my teaching practice*….

NT 6: … *I don't think I am comfortable … it was difficult to teach using the strategies… I made an effort to teach the lesson ….*

NTs 1, 4 and 5 indicated that although they were experiencing discomfort, they were more relaxed and had made a concerted effort to change, using the strategies of K-W-L, the question-and-answer technique and group work. Processes of reconceptualisation and critical thinking were manifested in their development of the lesson plan and attempts to teach the lesson. Their confidence and self-belief became more evident as they moved towards a new equilibrium (Strampel & Oliver, 2007). NT 6, even though in a distressed state of disequilibrium and confessing that she had found it difficult to use the strategies in her lesson, nevertheless displayed some movement in her cognition and teaching practice. She went on to explain which of the strategies she tried to use she had found most valuable.

In sum, the NTs – with the exception of NT 6 – demonstrated their movement towards a higher level of cognitive reflection and, with increased confidence in their use of these unfamiliar strategies, applied their newly-gained knowledge in their classrooms (Garrison, 2010). Their self-belief grew as their trust in their ability to learn and direct themselves deepened. They became steadily more aware of the necessity of reconceptualisation (Kearsley, 2010). For instance, after listening to her peers' responses in the focus group discussions, NT 7 responded: "… *I have the opposite opinion … [at first] I was overcomplicating things for my learners … [but now] I am getting them to talk [agency] … I am navigating a better way of doing [using the strategies]* …."

A cognitive presence was evidenced as the NTs started creating their own lessons (Bloom, 1956) and comparing modifications made to their way of teaching. Resolution became apparent during their practice of the lesson. This resolution was made possible by the NTs' advanced self-directedness, by meaningful online interaction as well as by the immediacy of the application of what they had learned and experienced in their classrooms (Kearsley, 2010; Knowles et al., 2020).

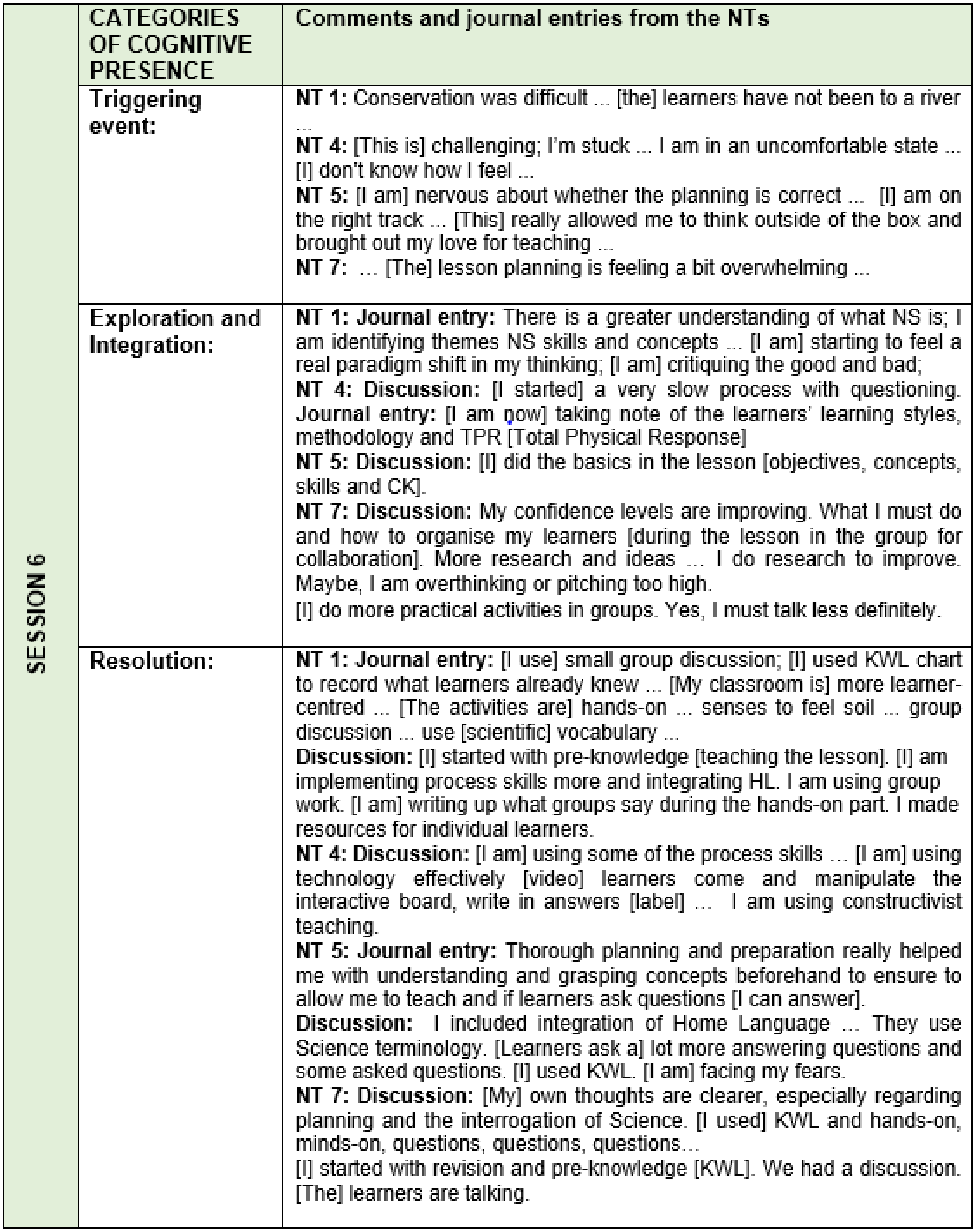
6.2.6 Session 6

In Session 6 of the IP, the primary objective was to provide support and guidance to the NTs as they worked towards the completion of their final lesson plan. At this stage of the IP, NT 6, who suffered a bereavement during COVID-19, travelled to the Eastern Cape and opted to leave the research study. The remaining NTs were encouraged to explore the relevant CK and NS concepts and skills required for their new lesson plan, integrate this information into their existing NS knowledge and incorporate the new pedagogy of inquiry-based teaching. The strategies included the question-and-answer technique, hands-on and minds-on, K-W-L (what I **K**now, what I **W**ant to know, what I **L**earned) and technologies learned over the five weeks of the IP.

The learning process began with the development of the lesson plan, an event that triggered a state of cognitive dissonance among the NTs (Garrison, 2017). According to Garrison et al. (2000; 2003), this initiates a multifaceted process stimulating deliberation, conception and action. The stimulation produces a reflective sequence in which teachers identify where they can improve their knowledge of teaching NS and work towards improving their pedagogical practices and skills (Hammerness et al., 2005).

The following data, set out in Table 6.2, was gathered after Session 6, from the NTs' discussions and journal entries. The discussions took place during the session and the journal entries were written by the NTs after the session. The journal entries provided valuable insight into the **triggering event** and its impact on the teaching process.

Table 6.2 NTs' experiences in Session 6



SESSION 6	CATEGORIES OF COGNITIVE PRESENCE	Comments and journal entries from the NTs
	Triggering event:	**NT 1:** Conservation was difficult ... [the] learners have not been to a river ... **NT 4:** [This is] challenging; I'm stuck ... I am in an uncomfortable state ... [I] don't know how I feel ... **NT 5:** [I am] nervous about whether the planning is correct ... [I] am on the right track ... [This] really allowed me to think outside of the box and brought out my love for teaching ... **NT 7:** … [The] lesson planning is feeling a bit overwhelming ...
	Exploration and Integration:	**NT 1: Journal entry:** There is a greater understanding of what NS is; I am identifying themes NS skills and concepts ... [I am] starting to feel a real paradigm shift in my thinking; [I am] critiquing the good and bad; **NT 4: Discussion:** [I started] a very slow process with questioning. **Journal entry:** [I am now] taking note of the learners' learning styles, methodology and TPR [Total Physical Response] **NT 5: Discussion:** [I] did the basics in the lesson [objectives, concepts, skills and CK]. **NT 7: Discussion:** My confidence levels are improving. What I must do and how to organise my learners [during the lesson in the group for collaboration]. More research and ideas … I do research to improve. Maybe, I am overthinking or pitching too high. [I] do more practical activities in groups. Yes, I must talk less definitely.
	Resolution:	**NT 1: Journal entry:** [I use] small group discussion; [I] used KWL chart to record what learners already knew ... [My classroom is] more learner-centred ... [The activities are] hands-on ... senses to feel soil ... group discussion ... use [scientific] vocabulary ... **Discussion:** [I] started with pre-knowledge [teaching the lesson]. [I] am implementing process skills more and integrating HL. I am using group work. [I am] writing up what groups say during the hands-on part. I made resources for individual learners. **NT 4: Discussion:** [I am] using some of the process skills … [I am] using technology effectively [video] learners come and manipulate the interactive board, write in answers [label] … I am using constructivist teaching. **NT 5: Journal entry:** Thorough planning and preparation really helped me with understanding and grasping concepts beforehand to ensure to allow me to teach and if learners ask questions [I can answer]. **Discussion:** I included integration of Home Language … They use Science terminology. [Learners ask a] lot more answering questions and some asked questions. [I] used KWL. [I am] facing my fears. **NT 7: Discussion:** [My] own thoughts are clearer, especially regarding planning and the interrogation of Science. [I used] KWL and hands-on, minds-on, questions, questions, questions… [I] started with revision and pre-knowledge [KWL]. We had a discussion. [The] learners are talking.

During the **triggering event** NTs 1, 4 and 7 experienced cognitive dissonance, evidenced in their choice of vocabulary: "difficult", "challenging", "overwhelming" (Strampel & Oliver, 2007). This doubting and pre-reflective state was vital to the whole inquiry process (Garrison, 2017).

The NTs' process of cognitive development, which includes both conceptual understanding and skills development, did not comprise a fluid transition from one session to the next because cognitive development is not a linear process. While Garrison and Arbaugh (2007) suggest that cognitive development follows a cyclical process of exploration, integration, resolution and confirmation, it is important to keep in mind that this process is not uniform nor consistent, as NTs often develop at different intervals and paces reflecting the non-linear nature of their development and adaptation.

NT 5, despite experiencing some cognitive dissonance and discomfort about the accuracy of the development of her lesson plan, demonstrated cognitive growth during this process. The triggering event afforded her the opportunity to engage in critical and creative thinking as she expressed her confidence in her planning skills. She cited the opportunities to "think outside of the box" and discover "her love for teaching". This implies that the difficulty she encountered led to the emergence of inspiration and motivation (Li, 2022). Others have noted that the motivation to learn can facilitate teacher growth and lead to a more stable cognitive state, tending toward equilibrium (Strampel & Oliver, 2007; Kearsley, 2010).

It is noteworthy that in Session 5, NTs 1, 4 and 7 demonstrated their ability to engage in higher-order cognitive processes such as reconceptualisation and critical thinking, while in Session 6 they seemed to be grappling with lesson development. This seems to underline the fact that cognitive development does not follow a linear transition from one stage to the next. Although NTs 1, 4 and 7 had made progress in their thinking, there were aspects still in need of development. In contrast, NT 5 seemed to have moved beyond this stage to a higher level of cognition, approaching equilibrium, as evidenced by her ability to think creatively and critically about her lesson plan.

The **exploration phase** revealed a range of cognitive development levels among the NTs. NT 1, for example, exhibited some discomfort, indicating ongoing cognitive processing and the need for stimulated reflection (Strampel & Oliver, 2017). This discomfort stemmed from her sense of uneasiness about teaching a topic unfamiliar to both herself and her learners (conservation of a river environment). While NT 1 demonstrated a basic understanding of NS and science skills, she also reported experiencing a shift in her thinking, though the exact nature remained unclear, making it difficult to pinpoint her precise cognitive development level according to Forehand (2010). Conversely, NT 5 demonstrated a high level of active reflection, rendering her able to reconceptualise and comprehend new concepts and acquired knowledge to guide learning effectively.

NT 4 evinced slow progress with questioning, possibly indicating a lower level of cognitive development. Yet she displayed an awareness of diverse learner styles, hands-on and minds-on teaching, NS process skills and the use of technology. Brooks and Brooks (2021) suggest that technology can be effective in creating an interactive and collaborative learning experience with active hands-on engagement. NT 5 also demonstrated a high level of cognitive development (Forehand, 2010) since she ensured that her learners used scientific language to deepen their understanding of the CK, as advocated by the National Research Council (NRC) (2012) and Kim and Kim (2021).

In comparison, NT 7 exhibited a high level of cognitive development, displaying confidence in her lesson plan research and development, which suggests that she engaged more deeply in self-directed learning (Kearsley, 2010; Merriam & Bierema, 2014). Her understanding of constructivist theories was evident in her teaching practice. By implementing inquiry-based teaching methods which emphasise the construction of knowledge through hands-on inquiry, dialogue, questioning, critical thinking and problem-solving, the teacher demonstrated her comprehension of the complex concepts associated with constructivist theories (Darling-Hammond et al., 2017). NT 7 continued to reflect on her practice to find better ways of organising her learners during a lesson and was cognisant that she should “talk less”. She embarked on more research to improve her teaching practice. The findings thus suggest that NT 7 was more advanced in lesson planning (Kim & Kim, 2021) and cognitive development than NTs 1 and 4. This was demonstrated by her more effective application of complex concepts and teaching strategies.

In the **resolution phase** of the activity, the NTs again manifested varying levels of cognitive development (Garrison et al., 2010). NT 1's use of learner-centred pedagogies, such as small group discussion and hands-on activities to provide a sensory experience, reflects a commitment to having learners actively engage in their learning to acquire a deeper understanding. The use of the K-W-L strategy promoted and enhanced the learners' 'voice', thoughts and ideas (Alsalhi, 2020). Moreover, by incorporating the use of scientific vocabulary and learner-led discussion NT 1 aligned her teaching with best practices in Science Education (NRC, 2012), aimed at developing learners' scientific literacy and critical thinking (Sutiani et al., 2021). Overall, as witnessed in her pedagogical choices and methods of implementation, NT 1's cognitive development was "high" on the conceptual scales advanced by Forehand (2010) and Strampel and Oliver (2007).

NT 4 demonstrated the use of constructivist teaching methods and used technology effectively to encourage learner agency and active participation, which included hands-on and sensory learning. The use of an interactive whiteboard was in keeping with 21st-century pedagogies (Brooks & Brooks, 2021). The introduction of NS process skills such as observation, comparing, classifying, measuring, and experimenting encouraged deep learning and critical thinking, as learners learned to approach problems and challenges in a systematic and analytical way. This all points to higher cognitive levels and a drive toward self-directed learning on the part of NT 4 (Kearsley, 2010). The use of constructivist teaching and technology suggests a good understanding and appropriate application of complex concepts to facilitate learning. Moreover, NT 4 recognised the importance of learners' use of technology.

NT 5 demonstrated her recognition of the importance of prioritising thorough planning and preparation to ensure absorption of the requisite CK and related concepts (Darling-Hammond & Bransford, 2005). The integration in NS teaching of HL and the utilisation of the K-W-L strategy (Ogle, 1986; Alsalhi, 2020) served to activate the learners' prior knowledge and promote learner engagement in the learning process. The question-and-answer method helped to engage learners and incorporate different levels of questioning (Bloom, 1956).

NT 5 encouraged the use of scientific terminology to facilitate a more complex understanding of concepts (NRC, 2012). NT 7 exhibited confidence by adopting the new, reconceptualised pedagogy in her lesson planning, emphasising hands-on, minds-on, inquiry-based learning to encourage learner agency. She stressed the question-and-answer technique to facilitate critical thinking and a deeper understanding of the relevant CK (Bloom, 1956).

In conclusion, the NTs exhibited the development of a more advanced understanding of science teaching and strong pedagogical skills even though demonstrating varying levels of cognitive development. This is evident in their turn towards hands-on and minds-on teaching practice, using NS process skills, integrating technology and exhibiting an awareness of diverse learning styles. All the NTs, although on differing levels of cognitive skill, were able to demonstrate the ability to implement effective strategies and tools (Qablan & DeBaz, 2015). It was gratifying that every NT reached the resolution stage in this activity, even though Kaczko and Ostendorf (2023) suggest that online participants typically do not reach it.

6.2.7 Session 7

In Session 7, the NTs were given the opportunity to meet informally, giving each other mutual support and learning from each other. They discussed the individual lesson plans that they were developing and shared their experiences of classroom teaching using the different strategies they had been exposed to since Session 3 of the IP.

The researcher acted as a non-participant observer to remain unbiased and neutral (Morrison & Lim, 2017) while collecting data – in the form of field notes based on observation – on the NTs’ social interaction. The data generated during Session 7, as presented in Table 6.3, below, focuses on the NTs’ cognitive growth.

Table 6.3 NTs' cognitive experiences in Session 7

SESSION 7	CATEGORIES OF COGNITIVE PRESENCE	Comments from the NTs
	Triggering event	**NT 1: Journal entry:** I dealt with my multiple misconceptions about teaching NS CK – many misconceptions... **NT 4: Journal entry:** I took all the positives that the teachers shared – what changed for me? [a question she asked herself] **NT 5: Journal entry:** I figured out how to plan smarter, not harder LOL; integrate HL ... **NT 7**: **Journal entry:** I can't wait to grow and develop ... Lesson planning is feeling a bit overwhelming ...
	Exploration and Integration	**NT 1: Discussion:** I feel like I am understanding how to be this constructivist teacher. You are lucky to have interaction boards. I use my laptops. **NT 4: Discussion:** I never thought of being a constructivist teacher. We can ask learners to bring something too. **NT 5: Discussion:** I must focus on talking less. I ask many questions. Maybe give them more time to answer. My preparation is good. Go onto the ePortal for the lessons. I can send it. The practical side like what you said. My learners talk and understand a lot more. Tell me about that concept. I normally just do everything. A good idea is to ask [the learners] to involve them to bring items. **NT 7: Discussion:** Have a look at the resources. I will share what I have. Do more practical activities in groups. Yes, I must talk less definitely. Started with revision and pre-knowledge [KWL]. We had a discussion. Learners are talking but not too much.
	Resolution	**NT 1: Discussion:** [Use of] turn to your partner to discuss and give feedback. Quick, quick 2 minutes. They focus because they must give feedback. I used videos... I will send you the links. Small groups. I have changed how I use technology – as we discussed. I have added hands-on minds-on. Add the interactive table in my lesson … as a reminder. **NT 4: Discussion:** I focus more on learner development and involvement. What will the learner do… add that. To know what they understand. I let them explore a lot more and tell me about [their exploration]. Write it in so that I remember. The learners enjoy the hands-on experience. They definitely know more and use the [Science] language. I use technology a lot more and differently. Write it in. My interactive board and getting learners to use the board too. They love it. YouTube has good videos but watch it first. Write down everything. I sometimes bring everything [tools, items]. Get them involved. **NT 5: Discussion:** I will write it [questions] down. I must do more hands-on experiences [include more experiential learning opportunities]. Have everything ready for them. Group work [will add]. Technology is progressing. I do not just play a video now. We discuss and they can ask questions. Questions - Writing it down [in planning], especially the levels [cognitive levels]. **NT 7: Discussion:** I use the ePortal. Yes, we must write down the questions. Definitely more group work. Learners are talking but not too much. Use my new interactive board and get involvement. Ok, what learners must do? [write it] Exploring outside and they love it. Questioning - write it down. Enough time to answer.

The **triggering event**, as experienced by NTs 1, 4, 5 and 7, was their realisation of the scale of the challenges they faced in effective lesson planning when teaching NS. However, the cognitive dissonance felt by NT 1 and revealed in the comment – "I dealt with my multiple misconceptions about teaching NS CK … many misconceptions…" – provided an opportunity for her to develop higher cognitive skills, resulting in the improvement of her NS teaching practice. While misconceptions can impede the effective teaching of NS (Kendeou & Johnson, 2024), NT 1 expressed awareness of her misconceptions and a willingness to learn and improve. Because of their limited CK and pedagogical skills, newly qualified Science teachers faced challenges in identifying and addressing their own misconceptions, let alone the misconceptions of learners in their classrooms (Kendeou & Johnson, 2024). It is for this reason that the NTs needed to enhance their competencies and skills by exploring new knowledge through reflection, discourse and inquiry-based learning (Garrison et al., 2000). The online platform provided a space for the NTs to engage in dialogue with their peers, fostering social presence and buoying their motivation to learn (Kearsley, 2010). This underscored the importance of collaboration and social interaction in promoting professional development as well as cognitive growth among NTs.

The NTs were exposed to the effective practices of their peers in a COI IP (Ingersoll & Strong, 2011). This type of learning shaped the NTs' beliefs and attitudes towards teaching, leading to personal and professional growth. Their comprehension of the importance of learner involvement, which emerged following the discussion about constructivist teaching and related concepts, provided significant evidence of cognitive shift (especially in the case of NT 4).

NT 5 emphasised the importance of planning "smarter", indicating the need for sharper higher-cognitive skills such as analysis, synthesis and evaluation to design an effective lesson plan (Bloom, 1956). NT 7 expressed her eagerness for growth and development, despite feeling temporarily overwhelmed by the demands of lesson planning. These challenges and difficulties, and the demand for cognitive processing, were the triggers for reflective practice and critical thinking among the NTs (Strampel & Oliver, 2007).

After the triggering event, the NTs demonstrated a higher level of **exploration and integration** of their newly acquired knowledge with their existing previous knowledge. They applied their cognitive processes to analyse, evaluate and implement the new information to make connections and solve problems. This integration and application of higher-order thinking skills allowed the NTs to demonstrate a deeper level of understanding, both theoretical and practical, of the new information (Strampel & Oliver, 2007). Further observable evidence of the constructivist shift was apparent in NT 1's use of multi-media teaching and recognition of the importance of interactive learning experiences. NT 4 emphasised learner engagement and co-responsibility, while both NT 1 and NT 5 explored and integrated the use of online platforms and multimedia approaches. Opportunities were thereby created for discussion and reflection, encouraging learners to think critically and make connections between different concepts. The fact that learners were receiving information from different viewpoints helped them to develop a more comprehensive understanding of a particular concept or topic.

During the informal group discussions, NTs 1, 4, 5 and 7 talked about their experience with using the strategies they were exposed to in their lessons. NT 1 demonstrated her active engagement in the reflective process by sharing possible resources and ideas with her peers – "I used videos... I will send you the links ... add the interactive table ...". NT 7 shared her experience of employing the K-W-L strategy in her lessons, which indicated a high degree of integration (Garrison et al., 2000): "I started with revision and pre-knowledge [K-W-L] … we had a discussion… I did more practical activities in groups". The K-W-L strategy, a constructivist teaching practice, emphasises active participation and learner-centeredness (Schunk, 2012). NT 7 noted that as a result of the strategy of "practical activities in groups", her learners' engagement had increased ("learners are talking").

The NTs were engaged in the hands-on and minds-on pedagogy of inquiry-based teaching and reflecting on their practice to promote learner engagement and learning outcomes. The individual and collective search for meaning and understanding demonstrated the close relationship between the NTs' personal construction of knowledge and the influence of their peers on the online platform (Cleveland–Innes et al., 2007).

During the **resolution phase,** the NTs demonstrated increased proficiency in their implementation of Strampel and Oliver's (2007) cognitive development model. The NTs' reflective and collaborative commitment helped them to recognise the importance of engaging in hands-on and mind-on activities to construct knowledge. This is in line with constructivist teaching philosophy and the recommendations of the NRC (2000) regarding inquiry-based learning.

NTs 5 and 7 acknowledged the significance of designing learning experiences that promoted critical thinking, problem-solving and creativity. Acknowledging the importance of these experiences, NT 5 stated that she would "do more hands-on experiences" and use group work strategies. Similarly, NT 7 used a range of strategies to promote learner interest and involvement such as outdoor exploration, learner questioning and group work (Schunk, 2012). In the resolution phase, NT 7 gave full acknowledgment to the utility of the K-W-L strategy in encouraging learners to generate questions, stimulating their curiosity and getting them to engage in active and reflective thinking. She emphasised the importance of writing down questions and allowing enough time for the learners to answer. These findings resonate with the recommendations of the NRC (2000) that teachers design inquiry-based learning experiences, using diverse strategies that encourage learners to take an active role in their learning and thereby promote critical thinking, problem-solving and creativity.

6.2.8 Session 8

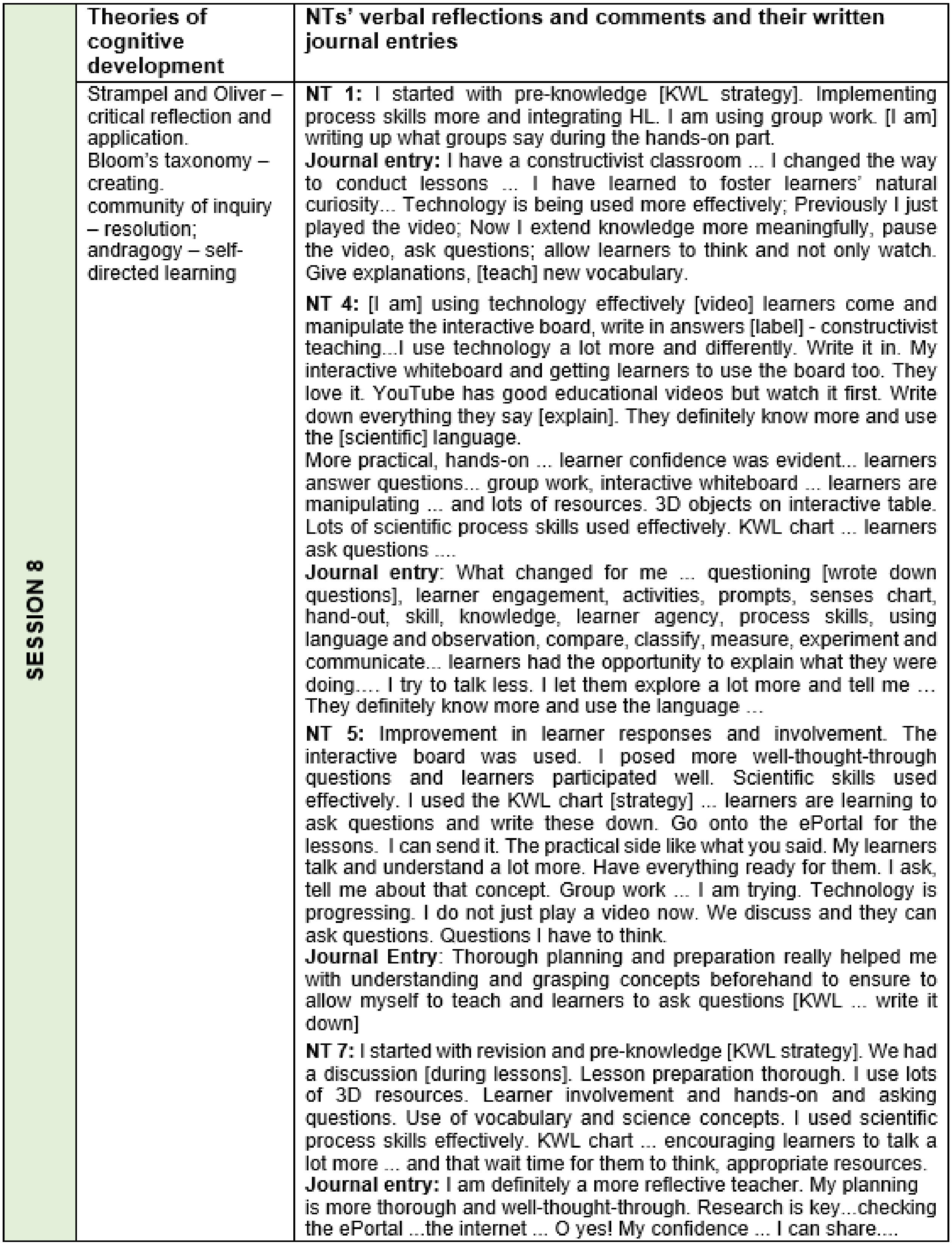
The purpose of Session 8 was to reflect critically on the whole IP. The researcher will analyse the data while referring to the four theoretical constructs underlying the study as a whole:

- Strampel and Oliver (2007): with a focus on the levels of reflection and cognitive development;
- Bloom's taxonomy (1956): with a focus on the highest level of development;

- the community of inquiry (Garrison et al., 2010): with a focus on resolution;
- the theory of andragogy (Kearsley, 2010): with a focus on self-directed learning.

To answer RQ 2 and describe the NTs' cognitive development **during** the IP, the final session proved crucial: it was here that the NTs shared their experiences of and reflections on the IP in its entirety. The data for this section comes from their verbal reflections and written journal entries, as presented in Table 6.4, below.

Table 6.4 NTs' experiences, verbal reflections and written journal entries in Session 8



	Theories of cognitive development	**NTs' verbal reflections and comments and their written journal entries**
SESSION 8	Strampel and Oliver – critical reflection and application. Bloom's taxonomy – creating. community of inquiry – resolution; andragogy – self-directed learning	**NT 1:** I started with pre-knowledge [KWL strategy]. Implementing process skills more and integrating HL. I am using group work. [I am] writing up what groups say during the hands-on part. **Journal entry:** I have a constructivist classroom ... I changed the way to conduct lessons ... I have learned to foster learners' natural curiosity... Technology is being used more effectively; Previously I just played the video; Now I extend knowledge more meaningfully, pause the video, ask questions; allow learners to think and not only watch. Give explanations, [teach] new vocabulary.
		NT 4: [I am] using technology effectively [video] learners come and manipulate the interactive board, write in answers [label] - constructivist teaching...I use technology a lot more and differently. Write it in. My interactive whiteboard and getting learners to use the board too. They love it. YouTube has good educational videos but watch it first. Write down everything they say [explain]. They definitely know more and use the [scientific] language. More practical, hands-on ... learner confidence was evident... learners answer questions... group work, interactive whiteboard ... learners are manipulating ... and lots of resources. 3D objects on interactive table. Lots of scientific process skills used effectively. KWL chart ... learners ask questions .... **Journal entry**: What changed for me ... questioning [wrote down questions], learner engagement, activities, prompts, senses chart, hand-out, skill, knowledge, learner agency, process skills, using language and observation, compare, classify, measure, experiment and communicate... learners had the opportunity to explain what they were doing.... I try to talk less. I let them explore a lot more and tell me ... They definitely know more and use the language ...
		NT 5: Improvement in learner responses and involvement. The interactive board was used. I posed more well-thought-through questions and learners participated well. Scientific skills used effectively. I used the KWL chart [strategy] ... learners are learning to ask questions and write these down. Go onto the ePortal for the lessons. I can send it. The practical side like what you said. My learners talk and understand a lot more. Have everything ready for them. I ask, tell me about that concept. Group work ... I am trying. Technology is progressing. I do not just play a video now. We discuss and they can ask questions. Questions I have to think. **Journal Entry**: Thorough planning and preparation really helped me with understanding and grasping concepts beforehand to ensure to allow myself to teach and learners to ask questions [KWL ... write it down]
		NT 7: I started with revision and pre-knowledge [KWL strategy]. We had a discussion [during lessons]. Lesson preparation thorough. I use lots of 3D resources. Learner involvement and hands-on and asking questions. Use of vocabulary and science concepts. I used scientific process skills effectively. KWL chart ... encouraging learners to talk a lot more ... and that wait time for them to think, appropriate resources. **Journal entry:** I am definitely a more reflective teacher. My planning is more thorough and well-thought-through. Research is key...checking the ePortal ...the internet ... O yes! My confidence ... I can share....

Following a rigorous process of transcription, coding and analysis, an examination of the data collected from the NTs' written journals and verbal reflections and the researchers' notes revealed the emergence of five themes. These themes were derived from a thorough coding process, which involved systematically categorising and organising the raw data to identify emerging patterns and trends:

i) Reflective teacher;
ii) Language and communication;
iii) Questioning technique;
iv) The integration of technology and online platforms; and
v) Learner-centred practices

i) Reflective teacher

Reflective teaching is the ability to self-reflect on teaching practices and beliefs to improve learner outcomes (Moon, 2013; Porntaweekul et al., 2016). Not all the NTs explicitly announced that they had become reflective, but the practice was evident in their written journal entries and remarks. For instance, NT 1 highlighted her shift from a traditional teacher-led practice to a more learner-centred one (Harris, 2018). She "learned [how] to foster learners' natural curiosity …". Reflective practice is a key aspect of developing teacher efficacy and identity (Harris, 2018). NT 4 reflected on her instructional practice, and decided on the need for "more practical, hands-on ... group work". A stronger sense of self-reflection, professional identity and efficacy was observed (Knowles et al., 2015). NT 5 reflected that "thorough planning and preparation really helped me with understanding", aligning her approach with the andragogy's emphasis on self-reflection (Helyer, 2015; Edge, 2020; Knowles et al., 2020). NT 5 continuously improved her practice by identifying her needs, setting goals and taking responsibility for her own learning (Knowles et al., 2020). NT 7 declared that she was "definitely a more reflective teacher". She had come to believe in research practice and thorough lesson planning, as revealed by her statement that "my planning is more thorough and well-thought-through.... Research is key ... checking the ePortal ... the internet ...". Her statements demonstrated her commitment to evidence-based practice in teaching. Her self-belief, self-confidence, positive sense of efficacy and strong teacher identity were clear in her assertion that she was “confident” enough to share her teaching practice with others (Suphasri & Chinokul, 2021). NTs 1, 4 and 5 also displayed a strong sense of self-efficacy and shared their experiences freely with each other. NT 7 appeared additionally motivated by intrinsic factors such as the need for self-direction, relevance to her personal needs and finding practical applications to advance her teaching practice – which would in turn lead to improved learning outcomes for her learners (Kearsley, 2010; Strampel & Oliver, 2017; Suphasri & Chinokul, 2021).

ii) Language and communication

In the improvement of their teaching practice, the NTs identified language and communication as critical components. The NTs described how language acquisition and the introduction of science vocabulary during lessons promoted learning. NT 1 noted that she “integrated Home Language” into her NS lesson, while NT 4 emphasised that “learners had the opportunity to explain”, Articulating what they had learned strengthened their command of the relevant vocabulary and developed their understanding and metacognition. NT 5 focused on “thorough planning and preparation [to] help with the understanding and grasping of concepts”, also supported by the acquisition of the CK vocabulary. NT 7 stated that learners “had a discussion ... used [science] vocabulary ... [while she] encouraged learners to talk” during lessons. This development in language and communication skills enhanced the learners’ confidence, cognitive development and understanding of scientific concepts. Anderson and Krathwohl (2001) regard language and communication as high-level cognitive processes that involve learners in effectively and accurately communicating concepts and ideas. The NTs sought to create a language-rich environment, encouraging communication and discussion and providing opportunities for collaborative learning activities in a social setting (Vygotsky, 1978). Explicit instruction in science terminology and concepts further accelerated learners’ cognitive development and understanding of the natural world (Shi, 2021). NTs 1, 4, 5 and 7 taught the learners [scientific] *process skills* (observation, comparison, classification, measurement, experimentation and communication) and used the process skills *effectively* to inculcate science concepts. The learners were encouraged to express their thoughts and feelings, communicate with others, and thereby develop higher-level thinking skills and scientific literacy (Galay-Burgos, 2018).

It is important to note that Anderson and Krathwohl's (2001) model accentuates the importance of cognitive skills but moreover, the emotional dimensions of learning, highlighting how emotions influence motivation, engagement, and overall learning outcomes. The interaction between cognitive and emotional learning creates a holistic educational experience that supports both intellectual growth and emotional development.

iii) Questioning technique

Questioning has the power to enhance learning outcomes by fostering true understanding (Hattie & Timperley, 2007; McGough & Nyberg, 2017). For example, NT 1 mentioned that she "posed questions [and] allowed [her] learners to think". By incorporating questioning strategies that required understanding, she aimed to "extend knowledge more meaningfully" through an experience that went beyond acquiring information and skills to include deep engagement, reflection and personal growth. By posing questions and encouraging independent thought and reflection, NT 1 encouraged a higher level of cognitive activity beyond simple question answering (she gave her learners time to think before answering the more complex questions).

NT 4 expected her learners to create their own questions, thereby promoting active engagement, curiosity and critical thinking (Bloom, 1956), while NT 5 employed "more well-thought-through questions" to stimulate critical thinking among her learners. Both NTs thus utilised questioning to promote higher-order thinking skills (HOTS) (Bloom, 1956; Hattie & Timperley, 2007). Like NT 1, NT 7 revealed that she gave her learners "wait time" following the posing of a question, in order to create an environment conducive to independent thought and reflection.

It is noteworthy that learners in the classes of NTs 1, 4, 5 and 7 were taught to ask questions, which indicates their understanding of the importance of developing higher cognitive skills among learners to improve their problem-solving abilities.

iv) The integration of technology and online learning

Throughout the IP, the NTs engaged in self-regulated learning and reflective practices by effectively incorporating digital platforms, tools and materials such as YouTube and WCED ePortal, fostering active cognitive engagement in their teaching and learning. The following examples indicate these improvements.

NT 1 observed that "technology is being used more effectively ...". Reflecting on her experience, she recalled that "previously I just played the video". She acknowledged the need to use technology more meaningfully and therefore designed new learning experiences to promote higher cognitive engagement (Strampel & Oliver, 2007). This was evidenced by her intentional shift in practice to make strategic use of video pauses to "ask questions … [and] … allow learners to think … [and] … give explanations …", while facilitating "vocabulary development". Her reflection and critical analysis indicate her willingness to adapt in order to enhance the instructional use of technology to attain her educational goals (Bloom, 1956; Strampel & Oliver, 2007; Kearsley, 2010).

NT 4 revealed that she used an interactive whiteboard: "learners come and manipulate the interactive board [and] write in answers". She emphasised the importance of previewing YouTube educational videos to ensure the appropriateness of the content for the lesson. Her capacity to critically review and evaluate the content to make informed decisions highlights her cognitive ability. She also alluded to her adoption of new practices by describing how she wrote down questions to ask learners and allowed them the opportunity to give explanations and to ask questions themselves. She also wrote down points raised by learners during their interaction. NT 4's self-reflection informed her decisions to strategise and improve her instructional practice (Strampel & Oliver, 2007). Her cognitive growth is exemplified in her review, evaluation, and integration of previewed YouTube videos (Strampel & Oliver, 2007). She developed questioning techniques during this integration of technology to encourage learner engagement (Bloom, 1956; Kearsley, 2010). A cognitive shift is evident in her evaluative thinking and instructional design.

NT 5 exhibited her cognitive development through the effective utilisation of technology, explaining that she no longer "just play[ed] a video" but engaged in discussion and encouraged learners to ask questions. By incorporating the interactive whiteboard as a visual aid, she enhanced learners' comprehension of concepts and ideas (Batcher & Lee, 2009). This highlighted NT 5's ability to use technology for improved learning outcomes. She noted the impact of her revised instructional practice, noting that her "learners are learning to ask questions". They "posed more well-thought-through questions and … participated well …". There was an overall "improvement in learner responses and involvement". The integration of technology in NT 5's teaching practice not only exemplifies her learner-centred orientation and commitment to andragogical principles (Guzey & Roehrig, 2009; Strampel & Oliver, 2007; Kearsley, 2010) but also highlights her cognitive growth

NT 7 acknowledged the importance of technology and the internet as invaluable resources for preparing "more thorough and well-thought-through" lessons and ongoing professional development (Guzey & Roehrig, 2009). Through research and resource utilisation, NT 7 demonstrated a self-directed, proactive approach to ongoing professional development, driven by the specific needs arising from her teaching practice, subject CK and interests (Knowles et al., 2020). Her cognitive development is evident in her use of the WCED ePortal for her NS lessons and resources, as well as her increased confidence in being prepared to share her newly acquired knowledge (Bandura, 1997). By actively engaging with technology, NT 7 accessed relevant information and critically evaluated its applicability to her teaching practice. This reflective process deepened her understanding of the pedagogical possibilities offered by the different technologies, enabling her effectively to integrate them into her instructional practices (Strampel & Oliver, 2007).

Analysis of the data has revealed that NTs 1, 4, 5 and 7 evidenced cognitive development in their deepened understanding of the pedagogical possibilities offered by various technologies, which in turn enhanced their capacity to utilise them more effectively. Their ability to share their experiences also testified to their cognitive growth (Strampel & Oliver, 2007; Kearsley, 2010).

v) Learner-centred practices

Learner-centred practices have been widely recognised as pivotal in the teaching of NS to FP learners, as they promote active engagement, hands-on, minds-on learning and learner agency (Bosman, 2017). Aligning to this concept of learner-centred practices, NT 1 stated that she integrated “scientific process skills ...[and]… group work ... [to] foster learners’ natural curiosity”. Her use of active engagement strategies, such as promoting collaborative learning and nurturing learners’ “natural curiosity” and cognitive engagement, served as evidence of her commitment to learner-centred practices and her own cognitive development in understanding and implementing these (Strampel & Oliver, 2007). She embraced constructivist practice, stimulating learners “to think and give explanations” to attain higher-order thinking (Bloom, 1956; Anderson & Krathwohl, 2001).

NT 4 reported that she had implemented “more practical and hands-on” learning opportunities. She reflected that “what changed for me … [was that] using language and observation, [to] compare, classify, measure, experiment and communicate ... learners had the opportunity to explain what they were doing”. She attempted “to talk less. I let them explore a lot more and tell me …. They definitely know more and use the language [of Science]”. She facilitated her learners’ articulation of their thoughts, which developed their confidence. The use of group work and various tools and resources, including the “K-W-L chart … [and] … 3-Dimensional [3-D] objects on an interactive table”, provided collaborative, hands-on opportunities. Learners were encouraged to ask questions. Through reflection and the integration of new knowledge, NT 4 consciously promoted learner-centred practices, increasing learner participation and fostering metacognition. The result was that learners enjoyed learning and gained in confidence (Strampel & Oliver, 2007).

NT 5 explained that she incorporated group work in her NS lessons, effectively employing the recognised “scientific skills” in her teaching practice. The use of the K-W-L chart strategy afforded the learners an opportunity to pose questions and actively participate in the NS lessons. She became cognisant of posing “more well-thought-through questions”, with the result that “learners participated well”. This practice resulted in increased learner talk – questions and explanations – and more understanding. NT 5’s cognitive shift was evident in her new recognition of learner agency, which changed her instructional practices (Kearsley, 2010).

NT 7 described her utilisation of inquiry-based teaching, emphasising the use of “scientific process skills” in fostering the development of “vocabulary and science concepts”. She incorporated “lots of 3D resources” to provide experiential and “hands-on” learning opportunities. She implemented the K-W-L chart strategy, ascertaining learners’ “pre-knowledge” and “encouraging [them] to talk a lot more”. She adopted the “wait time for them to think” tactic and made use of appropriate resources. NT 7 reflected upon and implemented these practices (Strampel & Oliver, 2007; Kearsley, 2010). She placed a strong emphasis on research and ensured that her lesson “planning [was] more thorough and well-thought-through”.

In summary, the cognitive, affective and professional development of NTs 1, 4, 5 and 7 during the intervention programme was evident in their reflective practices and progressive application of new pedagogic strategies. The adoption of learner-centred, hands-on approaches played a pivotal role in enhancing teaching and learning outcomes. The NTs’ critical self-reflection, decision-making and self-directedness demonstrate their ownership of the teaching and learning process and their growing confidence in their possession and application of knowledge (Bloom, 1956; Strampel & Oliver, 2007; Kearsley, 2010).

6.3 CHAPTER SUMMARY

The cognitive and affective development of NTs 1, 4, 5, and 7 during sessions 1 to 8 of the IP, has been described and discussed in terms of the theoretical frameworks associated with Strampel and Oliver’s reflection, Bloom’s taxonomy, the notion of the community of inquiry and the principles of andragogy. These frameworks have provided insights into the NTs’ cognitive growth, learning progression, collaboration and self-directed learning abilities. It is important to note that the development of the NTs did not follow a smooth and linear trajectory from one session to the next. Instead, they experienced fluctuations in the rate and success of their attempts to implement the strategies learned. The NTs experienced both advances and setbacks in the course of the IP.

NT 1 was able to transition from disequilibrium to equilibrium easily. She quickly assimilated new knowledge and confidently applied it in her teaching practice, seemingly demonstrating continuous cognitive development. She showed a deep understanding of the intricate ideas, concepts and strategies and was driven to explore further. This reflected her motivation and her willingness to take responsibility for and assume ownership of her own learning journey. However, for the other NTs (4, 5 and 7), the learning journey was different as they encountered challenges that took additional time and practice to overcome, before they could reach equilibrium. They gradually made progress and became more self-directed, creating lessons and making modifications to their teaching practice. These NTs demonstrated resilience and determination as they persistently engaged in reflective practices. They surpassed surface-level knowledge and achieved a more comprehensive and detailed grasp of both CK and PK. They registered progress in their ability to analyse, synthesise and apply their knowledge creatively. This highlights the importance of tailored support and guidance in their professional development.

The NTs recognised the importance of critical thinking, problem-solving and creativity in designing effective learning experiences. Overall, the IP fostered cognitive growth and professional development among the NTs, leading to confidence and competence in the application of newly-learned strategies for teaching NS. Notably, these strategies encompassed the implementation of more effective questioning techniques, the provision of learner-centred learning experiences, the utilisation of the K-W-L chart as a learning tool, the integration of technology and the promotion of inquiry-based practices. Such advances indicate the positive impact of the IP on the NTs' instructional abilities and overall professional development.

CHAPTER 7

RESULTS AND DISCUSSION – RESEARCH SUB-QUESTION 3

7.1 INTRODUCTION

This chapter presents the findings relating to how NTs experienced and understood teaching NS after participating in an eight-week IP. This chapter specifically addresses Research Sub-Question 3 (RQ 3): What were the NTs' experiences and understandings of the teaching of NS **after** the programme (IP)?

7.2 RESEARCH SUB-QUESTION 3

What were the NTs' experiences and understandings of the teaching of NS **after** the intervention programme (IP)?

One month after the implementation of the IP, four individually developed NS lesson plans were collected. Four months later, the researcher followed up with four individual semi-structured interviews to accommodate time-frames for WCED data generation. Ten months on, a follow-up focus group interview was conducted with the four NTs to gain deeper insights into the sustained and evolving understanding of teaching NS. All sets of data were analysed inductively, and the following three themes emerged.

- Content knowledge
- Pedagogical practices
- Confidence and self-efficacy

7.3 CONTENT KNOWLEDGE (CK)

This section examines the impact of IP on the CK of the four NTs (NTs 1, 4, 5 and 7). To answer RQ 3, the following discussion presents two sets of data for each NT: excerpts of the individual interviews, discussions, journal entries (Tables 7.1, 7.3, 7.5 and 7.7) and the post-group discussion and excerpts of the individual lesson plans (Tables 7.2, 7.4, 7.6 and 7.8).

7.3.1 NT 1's teaching experiences and understandings of NS CK after the IP

a. Narrative data from the interviews, journal entry, and focus group interview:

Table 7.1 presents excerpts from NT 1's interviews before, during and after intervention, and one journal entry and one focus group interview:

BEFORE IP	DURING IP	AFTER IP
Individual interview: *I wouldn't say I am very familiar with it …* *I wouldn't say I am very familiar with it …Earth and Beyond, I think …*	Feedback sessions Session 2 … *I really did not know all of this* [information] *… this really helped me, but it is scary …* Session 3 … *I did not know any of these concepts and skills …* Journal Entry *… learner results show that what I am doing differently compared to Term 1 is definitely working …*	Individual interview: *I have learned so much about the content [CK] or subject I must teach. I understand the scientific process skills and the concepts …* Focus group interview*:* *There is now a greater understanding of what NS is… skills and concepts. I am now easily able to identify themes in Life Skills and link them to the concept of Natural Science ... I'm using the process skills and concepts in my classroom …*

In this section, core statements from Table 6.1 are used to illustrate the teaching experience and understanding of NT 1. A discussion of her learning trajectory follows.

Before: *I wouldn't say I am very familiar with it …Earth and Beyond*

During: *… learner results show that what I am doing differently compared to Term 1 is definitely working*

After: *I understand the scientific process skills and the concepts … I'm using the process skills and concepts in my classroom*

Before the IP, NT 1 expressed a sense of unfamiliarity, indicating a lack of confidence in her foundational knowledge of NS CK (scientific process skills and concepts). During the IP, after initially lacking exposure, the data suggests a progression in NT 1's journey from remembering to understanding (Level 2) of Bloom's taxonomy (1956). This progression is evidenced in her realisation, where she experimented with the application of the newly acquired scientific skills and concepts, leading to observable changes in her learners' acquisition and retention of content knowledge. The process of reflection, as highlighted by Strampel and Oliver (2007), played an important role in her learning process as is indicated by the data. NT 1's willingness to teach the newly acquired knowledge, scientific skills and concepts portrays a shift towards self-directed learning (Kearsley, 2010; Leong, 2020). This transition from limited familiarity with science concepts and skills to a deeper understanding shows the importance of her increased learning.

After the IP, a transformation from understanding to implementation (Level 3) of Bloom's taxonomy (Bloom, 1956) is evidenced in NT 1's NS learning journey. This growth signified NT 1's transition to self-confidence as evidenced in her ability to integrate CK (scientific process skills and concepts) into her teaching. This progression aligns with Bloom's taxonomy (1956) where NT 1 moved from having basic CK of NS to being able to apply this knowledge in her classroom (Level 3 – Applying). This active use of CK in the classroom demonstrated NT1's higher cognitive engagement and practical implementation of learning.

b. Discussion of the lesson plans

Before the IP, NT1 was unable to write a satisfactory NS lesson plan. During the IP, Table 6.2 illustrates how she increased the amount of information that she included in her lesson plans. Four weeks after the last IP session, NT 1 refined her lesson plan and emailed it to the researcher. This lesson plan provided in Table 7.2 represents what she planned; the actual execution of the lesson, however, may not have followed the exact scientific process skills as recorded, due to the non-linear nature of these skills during inquiry.

Table 7.2 NT1’s lesson plans

LESSON PLANS	
TOPIC: SOIL **SCIENCE CONCEPTS**	
DURING	**AFTER**
Life and Living	**Main: Life and Living** [soil good conditions]; The type of soil: sandy, clay, loamy, soil and sunlight with the correct conditions can bring forth life with sun providing energy and heat.
SCIENTIFIC PROCESS SKILLS	
Observing: colours and textures; sorting different soils: observing creatures that live in soil. **Measuring**: pouring water over soil- which is heavier or lighter **Discussion:** about observations recorded on the chart and to *compare* them to the information.	**Observation:** examining soil samples, describe the properties of soil using senses. **Observe soil:** with magnifying glasses, living things/ creatures /animals in the soil. **Compare:** soil types [colour, texture] **Classify:** the soil types [Sandy, loamy, clay] **Describe:** the soil types [colour texture] **Evaluate:** HOT: what is good soil to plant in- why? **Measure:** introduce basic scientific inquiry**:** Planting seeds in different types of soil, observe and record data, (scientific method) **Communicate:** recorded; types of soil; explain, best for planting, animals that live in the soil, why are earthworms helpful? DBE books

During the IP, despite mentioning the concept of ‘Life and Living’, NT 1 omitted any detail or contextual relevance of the science concept, within the topic of Soil. On the other hand, she demonstrated an understanding of some of the scientific process skills such as: observing and measuring. She planned to conduct an experiment comparing the different colours and textures of soil. The experiment explored water retention by pouring water over various soil samples and discussing which one retained water best. This approach utilised everyday knowledge to build scientific understanding, using simple tools such as magnifying glasses to observe soil properties and living organisms within the soil.

After four weeks, NT 1’s final lesson plan included scientific process skills such as: observing (the properties of soil using senses), comparing, classifying and describing (soil types – sandy, loamy and clay) which included NS subject knowledge. For example, learners were tasked with classifying soils based on their texture and colour, and describing these properties using specific scientific terminology. Although NT 1 wrote these skills in a linear order, in her actual lesson they occurred concurrently or separately. For example, learners were expected to observe, compare, classify, evaluate and measure while doing the experiment, which was structured as an inquiry lesson. During this process of planting seeds, NT 1 planned to ask a higher-order question: 'What is good soil to plant in? Why? Her intention was to ask, 'What kind of soil is best for planting seeds in?' After the experiment, she planned more activities from their DBE books which included a level of inquiry (application of knowledge) and a few where learners merely filled in answers.

NT 1's journey through the eight-week IP, signified more than knowledge acquisition; it represented a transition from understanding to application (Strampel & Oliver, 2007) of NS CK and subject knowledge. For instance, she incorporated a proper scientific method by having learners plant seeds in different soil types, observing their growth and recording the data. The presence of scientific inquiry and experiments in her lesson plan highlighted a shift towards IBT, HOTS and a constructivist, learner-centered approach (Ramnarain, 2024). Her progress from uncertainty to understanding and the self-assuredness to apply the teaching of NS demonstrated her cognitive growth; moving from simple observations to more complex tasks such as classifying and evaluating soil types.

7.3.2 NT 4's teaching experiences and understandings of NS CK after the IP

a. Narrative data from the interviews, journal entry, and focus group interview:

Table 7.3 presents excerpts from NT 4's pre, during and post interviews, one journal entry and one focus group interview:

BEFORE IP	DURING IP	AFTER IP
Individual interview *Not that great, to be honest …* *Sorry, this is a tricky question.*	Feedback sessions Session 2 *I was not exposed to this. I did not know any of this …* Session 3 *… an eye-opener. Throughout all the aspects and concepts …* *I am there but not there yet! [I am growing in confidence]* Journal Entries… *I am feeling confused with all these concepts and information*	Individual interview *… with the knowledge and skills learnt from this programme … science process skills to name them, use them and could tell which concepts it is (Life and Living, Energy and change etc.). I have a better understanding of implementing the skills ... I have learned so much about the content [CK] or subject I must teach …* Focus group interview *… knowing the content … just putting every together [the lesson planning] …*

Core statements from Table 7.3 provide insight into NT 4's learning trajectory.

Before:	*Not that great, to be honest*
During:	*I was not exposed to this. I did not know any of this … I am there but not there yet!*
After:	*I have a better understanding of implementing the [scientific process skills … knowing the content … just putting everything together [the lesson plan]*

Initially, NT 4 revealed limited exposure to, and understanding of, both science concepts and process skills in the NS CK. According to Shulman (1987) such a significant gap in CK hinders a teacher's ability to grasp and retain new information.

During the IP, despite initial difficulties with concepts and skills, NT 4 confidently acknowledged some progress in her reflections, while striving for further development. This comment aligns with Strampel and Oliver's (2007) emphasis on reflection as a key component of professional development which allows for internalising of new knowledge. This shift in perspective indicated a growing confidence, a willingness to learn and an emerging understanding of her foundational knowledge (Kearsley, 2010). Her cognitive level, according to Bloom's taxonomy (1986) could be described as Level 1, (Remembering) progressing to Level 2 (Understanding).

Following the IP, NT 4 demonstrated a significant enhancement in her understanding of the NS science concepts and scientific process skills. This advancement was evidenced by her ability to move from merely remembering and understanding the concepts and skills (Bloom's levels 1 and 2) to effectively applying the CK to various NS topics, aligning with Bloom's level 3, application (Bloom, 1956). Her ability to integrate knowledge and practical application in an educational setting was crucial for effective teaching. As Shulman (1986) asserts, CK is the very foundation of effective teaching. Moreover, NT 4's increased confidence and willingness to engage in further learning signified a shift towards self-direction (Kearsley, 2010). Her reflection on her learning journey showcases the iterative cycle of concrete experience, reflective observation, abstract conceptualisation and active experimentation (Kolb, 1984).

b. Discussion of lesson plans

Prior to the IP, NT 4 did not plan NS lesson plans. The enhanced CK is evident in the refined lesson that she emailed four weeks later, as seen in Table 7.4. It is important to note that the scientific process skills listed in the refined lesson plan represents an unintended structure, since inquiry-based teaching (IBT) is inherently a non-linear process.

Table 7.4 NT 4’s lesson plans

<table>
<tr><th colspan="2">LESSON PLANS</th></tr>
<tr><th colspan="2">TOPIC: SOIL</th></tr>
<tr><th colspan="2">SCIENCE CONCEPTS</th></tr>
<tr><th>DURING</th><th>AFTER</th></tr>
<tr><td>Matter and Materials</td><td>Life and Living: The type of soil; sandy, clay, loamy; planting; seeds grow in good soil, sunlight and water</td></tr>
<tr><th colspan="2">SCIENTIFIC PROCESS SKILLS</th></tr>
<tr><td>Compare and classify - sort different - particles size, and colour.
Observing - Pour water over all the soil to observe which soil holds water.
Measure – pouring water over soil heavy or light.</td><td>Observe: types of soil [sandy, loamy and clay]
Observe texture and colour. Which soil holds water?
Observe the bean – the different parts-use the magnifying glass
Compare and classify sort different soils by properties - particles size, and colour.
seeds - chilli, bean, lentils, etc. describe and compare them…colour, size - big, small shape -flat, round etc.
Measure: measure the weight [weigh] of soil which is heavy or light.
Seeds- size-big, small, flat round etc.
Communicate: Group communicate their findings of the soil experiment … which soil similar or different properties.
Explain about the different seeds…Bean and lentil seed… One part, two parts, shape size etc. Describe differences and similarities. Group experiment. Plant the seeds. Predict which seed [lentil, bean, chilli] will germinate quicker, grow quicker? Poster</td></tr>
</table>

During the IP, NT 4 chose the topic ‘Soil’. CAPS includes three aspects to be focused on under this topic: different soils, creatures that live in soil, soil for growth of plants and the value of growing vegetables primarily aligning with the concept ‘Life and Living’. In NT 4’s initial lesson plan, she classified the topic ‘Soil’ under the concept of ‘Matter and materials’ reflecting basic understanding of soil as a physical substance. Her selection of the science concept was the result of her choice to focus on the first part of the CAPS requirement. While aspects of ‘Matter and Materials’, were important (e.g., exploring soil types), the topic of ‘Soil’ aligned more with ‘Life and living’: soil is a living ecosystem (habitat for living creatures) supporting plants and organisms.

During the IP, NT 4 incorporated scientific process skills into her lesson plan – observe, compare, classify, measure and communicate – to develop her learners' NS knowledge (DoBE, 2011; NRC, 2012). Learners observed water absorption in different soils, measured (weighed) which soil held water, and compared and classified soil samples based on their observations.

After the IP, her revised lesson plan included scientific process skills such as: observing soil types (sandy, loamy and clay), using specific terminology to classify soil, observing seeds (parts, colour, shape and size), comparing and classifying them based on the colour and texture. Activities included: water absorption experiments (measuring weight changes), planting different seeds (bean, lentil and chilli), observing germination, recording observations, and predicting which seeds will grow first. These activities encouraged communication throughout the different processes, explaining what learners observed, what they recorded in their observations in drawings and written descriptions, and explained their predictions for the germination rate. This real-world application enhanced understanding of soil as a living organism and the process involved in plant growth (NRC, 2012). By bridging everyday knowledge with science concepts, learners gained experiences that reinforced scientific principles and stimulated curiosity about the natural world. These activities encouraged active participation and critical thinking, facilitating effective science education.

The eight-week IP journey demonstrated NT 4's comprehensive lesson plan development, showcasing her growth in understanding and application of NS content and subject knowledge. She included scientific inquiry as a constructivist, learner-centred approach, incorporating hands-on activities in a process that straddled cognitive levels 3 (application) and 4 (analysis) (Bloom, 1956; Korthagen, 2016; Ramnarain, 2024). The transition from having no lesson plan to a comprehensive one signifies NT 4's grasp and effective application of science concepts, process skills and subject knowledge

7.3.3 NT 5's teaching experiences and understandings of NS CK after the IP

a. Narrative data from the interviews, journal entry, and focus group interview:

Table 7.5 presents excerpts from NT 5's pre-, during and post-interviews, one journal entry and one focus group interview.

BEFORE IP	DURING IP	AFTER IP
Interview *Do I know … don't I know … I just know enough …* *Very complicated…[laughs]so I am not even going to bother …* *It's foreign to me … it's literally all foreign…*	Feedback sessions Session 2 *Really now, I am shocked … this is the first time I hear this …* Session 3 Journal Entries *Still unsure and apprehensive but slowly starting to enjoy …* *… still need lots of practice but trying my best to be more receptive to the NS concept …*	Individual interview *…scientific process skills like I know… observation, comparing using the abbreviation OCCMEC …there's a major improvement in my confidence and use of skills …*

To understand NT 5's educational journey, learning development and teaching experiences, it is important to examine the key statements from Table 7.5. A thorough analysis of these statements sheds light on her learning trajectory and offers insights.

Before: *It's foreign to me … it's literally all foreign… so I am not even going to bother …*

During: *… still unsure and apprehensive but slowly starting to enjoy… Still need lots of practice*

After: *… there's a major improvement in my confidence and use of skills …*

Before commencement of the IP, NT 5's statements revealed an uncertainty, self-doubt and a lack of exposure to science concepts and process skills, creating a gap in her foundational knowledge. During the IP, NT 5 continued to express uncertainty but showed a growing willingness to engage in the learning process and the CK, despite her apprehension. A shift was noted in her attitude as her willingness to engage increased (Kearsley, 2010). Her acknowledgement of the need for multiple opportunities to practice, highlights her conscious effort to overcome initial challenges and embrace the IP's authentic learning opportunities (Kearsley, 2010).

Following the IP, NT 5 exhibited improved self-confidence resulting from a greater understanding of CK. Her reflections highlighted the progress in her CK and understanding of scientific process skills that brought her thinking up to Bloom's cognitive Level 2, understanding (Bloom, 1956). Shulman (1986) emphasises CK as a foundational element of effective teaching. NT 5's development resonates with Darling-Hammond et al. (2020), who highlight the importance of targeted professional development in deepening teachers' CK. NT 5 expressed appreciation for the CK and skills acquisition (Anderson & Krathwohl, 2001), as well as the access of confidence this afforded her. In this her example endorsed the andragogic principle that adults are motivated to learn when they perceive the direct applicability of the knowledge concerned to their professional practice (Knowles, 1984).

b. Discussion of lesson plans

Prior to the IP, NT 5 was not involved in the formulation of lesson plans. Her improved CK became apparent, however, through submission of a refined NS lesson plan via email four weeks later as showcased in Table 7.6.

Table 7.6 NT 5's lesson plans

<table>
<tr><th colspan="2">LESSON PLANS</th></tr>
<tr><th colspan="2">TOPIC: PLANTS AND SEEDS</th></tr>
<tr><th colspan="2">SCIENCE CONCEPTS</th></tr>
<tr><th>DURING</th><th>AFTER</th></tr>
<tr><td>Life and Living
Know the different parts of a plant.
What plants look like - roots, stem.
What plants need to grow.</td><td>Life and Living: Primary:
A plant is a living thing, it grows. It starts from a seed- Parts of the seed - seedcoat.
Grow a plant from a seed.
What does seed need to grow; sunlight, soil and water; different parts of the plant – roots, stem and leaves.</td></tr>
<tr><th colspan="2">SCIENTIFIC PROCESS SKILLS</th></tr>
<tr><td>Scientific process skills: <i>Observe, compare, classify, experiment, measure and communicate.</i>
Prediction and hypothesis may be used.</td><td>Observe: Use a magnifying glass to observe the outer appearance and texture of different types of seeds
Compare: Compare the sizes, shapes and colours of different seeds
Experiment: plant the seed and watch it grow - windowsill
Measure: the growth with string.
Communicate: record the growth. Draw what you see. Talk about what you see.
Discussion parts of the plant [roots, stem, leaves]</td></tr>
</table>

During the IP, NT 5 aligned the topic 'Plants and seeds' with the concept 'Life and Living', thereby demonstrating her understanding and application of the science concept. Her foundational knowledge focused on the different plant parts, their appearances and basic growth requirements. Although NT 5 listed all the scientific process skills, no explanations were offered. She added the terms 'prediction and hypothesis', but offered no further discussion or strategy for their inclusion. While predictions and hypotheses were present, their explicit application in the lesson plan was not evident, potentially limiting opportunities to encourage critical thinking and scientific inquiry.

After the IP, the focus shifted towards a more detailed explanation of the 'Life and Living' concept, including the life cycle of a plant, from a seed to mature plant (roots, stem and leaves) and the requirements for seed growth (sunlight, soil and water). This understanding and utilisation of scientific knowledge included a basic grasp of subject knowledge.

NT 5 demonstrated her familiarity with scientific process skills such as observation, comparison, experimentation, measurement and communication. Planned activities included observing and comparing different types of seeds using a magnifying glass (size, shape, colour), planting seeds to observe growth, measuring seed size, recording growth and discussing plant parts (roots, stem and leaves). This hands-on approach indicated a form of inquiry-based learning (IBL), encouraging learners actively

NT 5 demonstrated scientific process skills such as observation, comparison, experimentation, measurement and communication, indicating understanding. Planned activities included observing and comparing different types of seeds (size, shape, colour) using a magnifying a glass, planting seeds to observe growth, measuring seed size and growth, recording growth progress and discussing plant parts (roots, stem and leaves).This hands-on approach aligned with the current emphasis on inquiry-based learning (IBL), encouraging learners actively to engage with the scientific process for a deeper understanding of concepts (NRC, 2012).

After the eight-week IP, NT 5 had travelled from feeling overwhelmed and disengaged to experiencing increased confidence in her knowledge and skills. Taking advantage of opportunities for reflection and practice, as advocated by Hattie (2012), facilitated meaningful growth and development. While NT 5 applied science concepts and scientific process skills effectively in her practice, there was perhaps insufficient emphasis on breaking down information into components (scientific knowledge) or examining relations (e.g. seeds and appropriate soil for growth). NT 5 demonstrated progress to Bloom’s cognitive Levels 2 (understanding) and 3 (application) (Bloom, 1956).

7.3.4 NT 7's teaching experiences and understandings of NS CK after the IP

a. Narrative data from the interviews, journal entry, and focus group interview:

Table 7.7 presents excerpts from interviews with NT 7 before, during and after the intervention: one journal entry and one focus group interview:

BEFORE IP	DURING IP	AFTER IP
I would say not say very familiar … *I haven't been taught about those … terminologies … I just don't have sufficient knowledge or training*	Session 2 *Ok, I definitely did not know this …* Session 3 Journal Entries… *I enjoyed this …I have more insight …*	Individual interview *I can say that I feel relatively confident in natural science, giving [teaching] it as lessons and bringing it up in different topics. I've developed more content, knowledge and scientific process skills ... my awareness of doing research to develop my content knowledge …*

Before the IP, NT 7 had had limited experience in creating detailed NS lesson plans. To comprehend NT 7's learning trajectory and experiences will require an examination of the core statements from this Table.

Before: *I would say not say very familiar… I have knowledge or training …*
During: *I enjoyed this …I have more insight …*
After: *I developed more content, knowledge … giving [teaching] it as lessons …doing research*

NT 7's statement prior to the IP revealed that she recognised significant gaps in her knowledge of and training in NS science concepts and scientific process skills. She conveyed an awareness of her own limitations and the need for further learning and development (Kearsley, 2010).

During the IP, NT 7 expressed enjoyment and demonstrated an increased understanding of science concepts. After the IP, NT 7 evinced an awareness that engaging in research had developed her CK and subject knowledge. Her recognition of the value of research to develop her content knowledge is in line with the principles of andragogy, that is, that adult learners are motivated when they can directly apply knowledge gained to their professional contexts. Moreover, NT 7's engagement with research to enhance her CK reflects self-directed learning and reveals her autonomy and initiative in pursuing understanding and skill development (Merriam et al., 2007). NT 7 manifested progress towards a higher level of cognitive skills (Bloom, 1956), particularly in the domains of application and synthesis (levels 3 and 4). She demonstrated an elevated level of skills acquisition and utilisation (Anderson & Krathwohl, 2001).

b. Discussion of lesson plans

Before participating in the IP, NT 7 did not prepare NS lesson plans. Four weeks later, however, her improved CK was evident in a revised lesson plan which she emailed, as depicted in Table 7.8.

Table 7.8 NT 7's lesson plans

LESSON PLANS	
TOPIC: RECYCLING	
SCIENCE CONCEPTS LINKED TO THE TOPICS	
DURING	**AFTER**
Life and living	**MAIN CONCEPT - Matter and material** - making new things from old things [different material]. An old newspaper into a cereal box- tin into a desk tidy (desk organiser for stationery) **Planet, Earth and beyond**-recycling helps keep our planet [the earth] clean by reducing trash in landfills [where it goes after the municipality collects -Environmental awareness and responsibility].
SCIENTIFIC PROCESS SKILLS	
Observing Comparing Classifying Measuring Experimenting Communicating	**Observation** – collection of waste materials. Conduct waste audit: sort and count recyclable items. **Discuss** findings in groups. [nature walk] **Compare** -recycling sorting game; pictures of recyclable and non-recyclable items into 2 groups, compare [sorting]. Count / compare… **Classify** - sorting into different categories e.g., paper, plastic, metal- name the group. Sort a pile of recyclable and non-recyclable material in bins. **Measuring** – waste reduction challenge. Track the amount of waste for the week [especially paper] Which group reduced their waste? The waste is weighed. Brainstorm ways to reduce paper usage. Measure the difference in paper usage the following week. Use tallying to count what was collected. **Experiment-** Making compost. Fill jars with compost leaves, fruit peels etc. Making posters

During the IP, NT 7 identified the topic of 'Recycling' as falling under the concept of 'Life and Living', but without any specific details as to what was entailed. The topic of 'Recycling' actually falls within the science concept of 'Matter and Materials'. This mismatch between the topic and the science concept indicated a lack of CK, suggesting that while NT 7 understood the general idea of recycling, she lacked a deeper understanding of the specific concepts and processes involved (scientific knowledge).

During the IP, NT 7 listed the scientific process skills, without elaborating on how these skills would be applied in her classroom, again suggesting a gap in her CK.

Following the IP, NT 7 correctly identified ‘Matter and Materials’ as the primary science concept for the topic of recycling. Additionally, she connected recycling to ‘Planet Earth and Beyond’ as a secondary science concept, emphasising how recycling helped to keep the planet clean by reducing landfill waste, thus fostering environmental awareness and responsibility and encouraging learners to become agents of change (Forbes et al., 2020).

After the IP, NT 7 was able to incorporate scientific process skills such as observing, comparing classifying and measuring with comprehensive explanations of how she would apply these skills in her teaching practice. She planned learner-centred activities, for example, observation (nature walk); measuring (collection of waste materials which would be audited using a tally system); classifying (sorting material into recyclable and non-recyclable materials); comparing and classifying (glass, paper, metal) and experimentation (making compost). She also attempted to encourage critical thinking among her learners by encouraging them to articulate their understanding of the topic (discussions, brainstorming sessions and posters). NT 7 further demonstrated her newly-acquired scientific knowledge in a waste reduction challenge: tracking, weighing, counting waste items and brainstorming solutions. These activities necessitated higher-order thinking skills. By applying IBL practices, NT 7 empowered learners to use their everyday knowledge to develop scientific insights, thereby fostering a deeper understanding of the concepts involved.

Overall, NT 7’s journey through the IP transcended mere acquisition of CK (remembering – level 1) to encompass the application (level 3) (Bloom, 1956) of CK and subject knowledge through hands-on activities and critical thinking (NRC, 2010). This shift signified a move towards the kind of self-efficacy and self-directed learning associated with adult education theory (Knowles et al., 2020).

Summary

NTs 1, 4, 5 and 7 revealed cognitive shifts in their acquisition and use of CK. Their learning did not proceed in a linear path and the shifts varied in pace, as is evident from the results presented. Despite differences in their learning trajectories, all the NTs in the research study exhibited a measure of growth in their CK over time.

Each NT came into the research project with different experiences and levels of training in NS, which influenced their learning path. Their willingness to learn, increased confidence, and a tendency to experiment, impacted the extent of their CK acquisition. Initially, it became evident that all the NTs had minimal exposure to and comprehension of science concepts and process skills within NS CK. NT 1, with some foundational understanding, transitioned from knowledge acquisition to its application in learner-centred activities. Similarly, NT 4 overcame initial gaps and achieved the application stage (level 3). While NT 5 focused on understanding (level 2), resulting in the effective application of scientific process skills and concepts (level 3 in Bloom's taxonomy, 1956), NT 7 demonstrated the most significant growth, seemingly reaching cognitive levels 3 and 4 by using self-directed strategies.

The NTs transitioned from no knowledge of science concepts and process skills to the simple recall of facts (level 1) and then on to improved understanding (level 2). Through regular attendance at the IP, guidance, practice, reflection and collaboration, the NTs acquired the ability to apply their CK to design learner-centred activities (level 3).

7.4 PEDAGOGICAL PRACTICES

This section investigates how NTs 1, 4, 5, and 7 employed their pedagogical knowledge and skills to integrate inquiry-based teaching (IBT) into their classroom practice, as advocated by the CAPS document (DoBE: 2011:8). Data for the analysis was extracted from the four lesson plans submitted four weeks after the IP and individual interviews conducted five weeks after the IP. One of the main themes emanating from the data was that of inquiry-based teaching as a central pedagogical practice. The teaching strategies aligned with IBT that feature prominently in the data from all the NTs included:

7.4.1 inquiry-based teaching
7.4.2 question-and-answer technique
7.4.3 the K-W-L strategy
7.4.4 group work
7.4.5 the use of technology.

The researcher first uses the narrative data from the interviews to discuss how the NTs understood and implemented IBT in their daily teaching practice. Thereafter, the teachers' implementation of each pedagogical strategy is discussed separately.

7.4.1 Inquiry-based teaching

This section analyses interview excerpts from NT 1, 4, 5 and 7, focusing on their interpretations and application of IBT in their teaching practice.

> NT 1: … using inquiry-based teaching and learning … process of inquiry… process skills … activate curiosity making real-world connections through exploration… experiential learning … engaging hands-on experiences and reflection … use of scientific attitudes … respect for living things…
>
> NT 4: the science process skills … exploring or whatever is needed for the lesson to make it learner-centered … used a magnifying glass … comparing, measuring and recording observations …. skills …. learners to discover …
>
> NT 5: … that went into an inquiry lesson … and make it more learner centered than teacher-centered … I am facilitating teaching in the classroom … used a form of experimenting … came to the correct conclusion …
>
> NT 7: … different types of scientific inquiry … compare the experiences with the investigation … their specific learning styles … use of vocabulary and terminology to explain … space to engage.

The NTs' commitment to the implementation of IBT was evident in their use of exploration, experiential learning, learner-centred classrooms, investigations and reflections, showcasing their understanding of inquiry as a pedagogical practice (Ramnarain, 2024).

Notably, NT 1 recognised the importance of scientific attitudes and values embedded in IBT, such as respecting living creatures. Prachagool and Arsaiboon (2022) emphasise the crucial role of teachers in cultivating these attitudes among young learners as they form the foundation for scientific exploration.

NTs 1 and 4 drew attention to the use of scientific process skills to engage learners in scientific inquiry. They highlighted the importance of hands-on experience, where learners had agency, space for experimentation and the opportunity to co-create knowledge with the NTs acting as facilitators (Garrison & Arbaugh, 2007; Akyol & Garrison, 2010). The learner-centred approach shares the principles of andragogy, which is orientated towards self-directed education (Knowles et al., 2020).

NT 5 referred to her role as a facilitator during the teaching process, further underscoring her transition from a teacher-centred pedagogy to a more collaborative and learner-centred environment. This shift echoes Schneider et al. (2013), who describe IBT as a framework in which science knowledge construction becomes a social and cooperative experience. NT 7 accentuated the accommodation of learners' learning styles and using accurate scientific terminology, again features of IBT. These collective efforts highlighted the NTs' commitment to fostering a classroom environment that values learner inquiry, collaboration and active learning (Schneider et al., 2013).

The adoption of IBT facilitated a transition in teaching philosophy. The NTs' proficiency in designing engaging IBT lessons demonstrated their understanding of scientific inquiry and the nature of science (NOS), both of which are fundamental in acquiring scientific knowledge (Ødegaard et al., 2014). Progression in IBT instructional practice reflected the NTs' increasing ability to operate at a high cognitive level which included problem-solving, critical thinking, metacognitive abilities and self-awareness of the learning strategies (Anderson & Krathwohl, 2001; Kearsley, 2010). Their self-directedness was showcased in their ability to synthesise knowledge to design and implement instructional practices promoting cognitive engagement and critical thinking. Among the key elements in their incorporation of IBT principles were making real-world connections and adopting a learner-centred approach with hands-on learning.

7.4.2 Question-and-answer strategy (Q&A)

This section examines NTs' implementation of the Q&A strategy in their teaching, including a discussion:

> NT 1: I pose questions … high-level questioning [wait] time ...more [probing] … they are answering … [learners] also asking inquiry questions … what if the sun didn't come out, would the plant grow?
>
> NT 4: … to ask open-ended questions … asking learners to think critically and not only answer with a yes or no answer. I have to get them to really think about what I am asking. Which soil would you choose for planting seeds? Why? Asking more [probing] questions to support them. I am writing down some of the questions I will ask …
>
> NT 5: I'm grooming and training learners to always ask questions and to give their opinions **…**
>
> NT 7: I pose questions … they can self-reflect and self-evaluate … allowed [learners] to pose their own questions. In doing so it also helps with the collaborative group learning, learners discuss what they've observed during the investigation as well… encourage and support learners to write their own questions for scientific investigations … encouraging them to, in a sense, beef up their vocabulary and also their language structure – helps inform the questions better ….

The NTs (1, 4, 5 & 7) recognised the importance of posing relevant questions because of the role they play in enhancing classroom interaction and fostering cognitive engagement (Salmon & Barrera, 2021). The NTs' approach to asking questions differed, however, suggesting their evolving understanding of questioning techniques.

NT 1 emphasised higher-order questioning through probing questions, encouraging learners to explore their responses or consider alternative perspectives (Anderson & Krathwohl, 2000). She incorporated 'wait time' to allow learners to process complex questions and formulate thoughtful responses (Rumohr, 2013).

NT 1 encouraged learners to generate their own questions, a practice that conduces to deeper understanding, critical thinking and active learning, all key components of IBT (Almeida, 2012; Agustini et al., 2024). It also resonates with Pelo's (2014) call for teachers to cultivate curiosity and value questions from learners, thereby enriching classroom discussion (Strampel & Oliver, 2007). NT 1's use of higher-order thinking and reflection encouraged learner cognitive engagement and the development of HOT skills (Salmon & Barrera, 2021).

NT 4 focused on open-ended questions to stimulate critical thinking, in line with established higher-order questioning strategies (Anderson & Krathwohl, 2000). There was no evidence, however, of learners posing questions in NT 4's approach.

While NT 5's response did not explicitly discuss the levels or purpose of Q&A strategies (Anderson & Krathwohl, 2000), her approach focused on fostering a culture of inquiry by encouraging learners to consistently ask questions and share opinions. This created a pedagogical environment that lent itself to deeper learning (Kawalkar & Vijapurkar, 2015).

NT 7 used questions to prompt self-reflection and self-evaluation (Strampel & Oliver, 2007). In addition to using the Q&A strategy to encourage HOT skills such as analysis, synthesis and evaluation (Kawalkar & Vijapurkar, 2013), NT 7 allowed her learners to record questions relating to their scientific investigations. These questions were consonant with the principles of higher-order questioning (Anderson & Krathwohl, 2000).

By employing various Q&A techniques, the NTs all contributed to fashioning a learning environment that encouraged learner inquiry and curiosity. This shift underscored the fundamental role of IBT in nurturing critical thinking skills and promoting deeper engagement in the learning process. NTs' application of the Q&A strategy indicated increasing autonomy (Knowles et al., 2020) and developing competence.

7.4.3 The K-W-L strategy: What I Know – what I Want to know – what I have Learned strategy

This discussion is structured into three sections corresponding to the K-W-L chart: 'K' (Know), 'W'' (Want to know), and 'L' (Learned). Each section outlines how NTs utilised the strategy.

> NT 1: The K-W-L strategy … before a new topic … organise their previous information … transcribe… [what] they would like to know …teach learners to pose a question … rephrase if needed. Write down – L… learners write ... show … tell … what they have learned … they see their own growth at the end topic [lesson]… write down misconceptions…deal with misconceptions …
>
> NT 4: …implementing the K-W-L [strategy] …pre-knowledge or skills … what knowledge learners know … before content or concept introduced… tell me what they [learners] … would like to know …. then what they learned… L chart …. after teaching the topic…
>
> NT 5: … use the K-W-L strategy … what they know before… figure out before what would you like to know… helps with questioning… information… to start the practical lesson … moved to what they would like to know… write it down… then what we have learned [L] in the [learning] process …
>
> NT 7: … the K-W-L chart… beginning of lesson … what they know [K] write on the board … '… why people pollute our oceans…' [learner question] … giving free reign where the lesson would go… very learner-centred … at end …. what we have learned [L] during that lesson … [learners' questions] … why people pollute our oceans … what causes pollution in oceans… what are the effects of pollution... both in my recap lesson and learner follow-up … different intervention methods …

All the NTs implemented the K-W-L strategy to activate prior knowledge [K] (Alsahi, 2020) before introducing a new topic. They asked probing questions to assess, recall and facilitate collaborative idea sharing, in line with the K-W-L core strategy of building on existing knowledge (Alsahi, 2020). All the NTs recorded their learners' responses. Notably, NT 1 organised the learners' ideas on a 'K' chart that included their misconceptions. This reflects a constructivist approach (Vygotsky, 1978) that emphasises the importance of prior knowledge and active learning, central to the K-W-L strategy.

During the 'W' stage, learners were encouraged to articulate any questions they had to help promote reflection and set learning goals (Strampel & Oliver, 2007). All the NTs used this stage to stimulate curiosity and engagement. NT 1 implemented a scaffolded approach, guiding learners in refining their questions before recording them. In contrast, NT 7 emphasised learner agency, allowing questions to guide the lesson. While this method strengthened self-regulation and ownership as recommended by IBL (Garrison & Arbaugh, 2007), it risked diverging from essential topics. Depending on learner prior knowledge and the difficulty of the topic being explored, finding the correct balance between teacher guidance and learner experience is crucial. In Grades 1 to 3, the process of recording should transition from teacher-facilitated discussions, drawings and writing to learner-centred writing in Grades 2 and 3, with continued scaffolding as needed.

All the NTs implemented the K-W-L strategy, albeit with variations. While activating prior knowledge and promoting reflection were common themes, NT 1’s approach distinguished itself by incorporating misconceptions into the ‘K’ chart and addressing them during teaching and assessment. These variations highlight the NTs’ understanding and application of the K-W-L strategy’s flexibility and adaptability in fostering a strong learning environment.

7.4.4 Group work

This section explores how the NTs implemented group work as a strategy in IBT through insights gathered from the interview excerpts.

> NT 1: … using small group work and discussion … opportunity to share ideas with each other, give opinions … helped them prompting with questions… get them to talk and be involved, learned how to collaborate and discuss the inquiry questions … assign roles … scribe, report back, collection.
>
> NT 4: … divided learners into groups … explored by touching … compared and smelled the seeds … use observation, comparing, measuring and recording skills… communicated what they observed … after discussions in their pairs [think- pair-share], groups and drawing or writing down important information… more and more learner-centred and the children love it … when I use the collaboration group discussion and developing their answering skills….
>
> NT 5: I am working on group work. I divided them into groups. Each group had to plant the bean in a see-through glass, and we revised what they observed. It is collaborative, working together, … it’s about experimenting… my third lesson … my practical lesson … the investigation and the comparing of the bean in that lesson….
>
> NT 7: … facilitate collaborative learning in the classroom … gets learners thinking … scientific investigations … facilitate learner-based and evidence-based discussions which we do as a class, also in group work … learner-centred… big part in collaborative skills ….

All the NTs implemented group work in their IBT lessons, demonstrating a commitment to fostering collaboration, a key component of IBT (Ahn, 2023). NTs 1, 4, 5 and 7 emphasised the value of stimulating discussion to encourage peer interaction and collaborative knowledge co-construction (Garrison & Arbaugh, 2007; OECD, 2019). They acted as facilitators of the discussion, using different approaches.

NT 1 focused on developing essential social and communication skills through group work. She used probing questions to trigger the sharing of ideas, the co-creation of knowledge and sharpening the group's focus on inquiry-relevant issues. This approach honed skills like explaining ideas, listening actively and negotiating meaning (Slavin, 2021; Ahn, 2023). She implemented a structured approach by assigning roles within groups such as those of scribe, reporter and collector (of materials) to enhance organisation and participation.

NT 4 utilised a learner-centred approach, supporting learners in articulating answers and creating an enjoyable learning experience. Notably, her use of the TPS strategy showcased her versatility in teaching IBT. By encouraging learners to think, pair and share their thoughts, observations and findings, she promoted understanding (OECD, 2019).

NT 5 focused on revision and collaboration, emphasising the value of working together, while NT 7 facilitated collaborative and evidence-based learning to stimulate group thinking and experimentation (Garrison & Arbaugh, 2007). Cooperative learning theories that stress communication, active listening and negotiation were promoted through the identification of clear goals during the inquiry process (Johnson et al., 2021; Slavin, 2021).

By incorporating group work, all the NTs supported IBT's principles of inquiry, critical thinking and communication skills development (Kaçar et al., 2021). While collaboration and knowledge creation were common themes, NT 1's structured approach with assigned roles revealed sound pedagogic practice. All the NTs reported progress in this area, although little detail was made known about the specific activities and structures used by NT 4 and NT 5.

7.4.5 Think-pair-share (TPS)

By analysing interview excerpts, this section explores how NTs deployed the TPS strategy in their teaching practice.

> NT 1: … doing think-pair- share asking each other questions … deeper understanding from each other … questioning each other … allow themselves to think deeper about the question… critical thinking…I use it whenever needed for understanding, discussion and feedback [share information before feedback] During the lesson or at the end [What you have learned] … think-pair-share when needed ….
>
> NT 4: … after discussions in their pairs [think- pair-share], during group [work]
>
> NT 5: … we use the technology …… in our think-pair and share activities …
>
> NT 7: No mention

NT 1 effectively utilised the think-pair-share (TPS) strategy to promote a sound understanding of the content. By encouraging questioning and discussion during the pair phase, she built up her learners' exploratory and critical thinking, confirming the findings of research on TPS's effectiveness in moving beyond surface-level knowledge (Kaddoura, 2013; Mundelsee & Jurkowski, 2021). The wait time included in the 'think' phase in NT 1's approach is likely to have boosted learner confidence (Rumohr, 2013). During the 'pair' phase, NT 1 allowed learners to collaborate and articulate their thoughts. Finally, in the 'share' phase, she created opportunities for learners to extend their ideas, entrenching understanding and promoting deeper comprehension. Notably, her adaptability in using TPS throughout the lesson suggests its potential to enhance comprehension at various stages.

NTs 4 and 5 provide limited information about their implementation of TPS as a strategy. NT 4 indicates that she used utilised TPS during group activities, while NT 5 incorporated technology, but no details of the implementation are provided. NT 7's failure to mention the use of TPS suggests a potential area for future growth.

Research supports TPS's alignment with IBT environments in promoting active learning and collaborative interaction, and developing critical thinking skills (Johnson et al., 2021;

Slavin, 2022). NT1 highlighted TPS's versatility and potential to support various educational goals and improve learner outcomes (Mundelsee & Jurkowski, 2021).

7.4.6 Use of technology

This section analyses excerpts from interview data to determine the NTs' technology integration during their NS lessons.

> NT 1: It's been very difficult … we don't have white boards… make use of laptop … videos to enhance lessons and pausing them [video] … now I ask questions … discussions they learn better, remember process of something ... real life experiences … teaching a topic like sea animals, we can't go into the sea [COVID]… we've got our technology internet, play video, sea animals… technology… process skills… … sea animals, different animals. We compare, classify… e Portal… NS lessons… always checking sites now ...
>
> NT 4: … also a mind shift to use technology… I used the white board [to play a video] earlier due to COVID protocol the learners could not interact… manipulate white board… Questions we say we going to get back to them [learners] … they have a question… pop your question on the interactive whiteboard [Google] have facts, answer for them right there… read together… have the knowledge … the e portal is your next best friend … researching… what I need… lessons, LTSM…
>
> NT 5: It's a new thing … now I use technology often to enhance the lessons… pique learners' interests … question ... important for me to expose them…[like] using the drop and drag on the interactive activities … they learners] learning with technology… [they can use the smartboard to interact with information...having e portal [for a] new teacher …
>
> NT 7: …technology a big lack … use my laptop … video resources... topics we are discussing … use the video as a point of discussion, linking previously discussed… new discussion points … we use the videos to help with our critical thinking and problem-solving skills… lessons, Use e-Portal LTSM, so many resources… and research….

Careful analysis of the NTs' responses identified concerns regarding technology integration. NT 1 felt that integrating technology was difficult at first and NT 5 regarded it as a new thing that required a mind shift, indicating their lack of technological pedagogical knowledge (TPK) (Suchita et al., 2023). Despite this, all the NTs displayed a positive attitude towards technology, evidenced by comments such as "learners learn better" and "videos help with…." This is in line with the view of Knowles et al. (2020) that acceptance of technology reveals progress towards self-resolution.

Two of the NTs (4 and 5) had classrooms equipped with a smartboard and interactive whiteboard. The other two NTs had limited access to technological resources, relying on personal laptops. Despite these limitations, these NTs (1 and 7) effectively utilised technology to enhance learning activities. NT 1 used videos, stopping at strategic places for discussion, in line with the segmentation principle (Clark & Mayer, 2011), which suggests that bite-size learning improves retention (Hasler et al., 2007; Kulgemeyer & Riese, 2018). NT1 used videos to substitute for real-life experience, helping learners to develop scientific process skills such as comparing and classifying (there are, of course, limitations associated with the use of videos to replace real-life experiences in IBL) (Suchita et al., 2023).

NT 7 expanded beyond simple presentations, using videos as a catalyst for interactive discussion, linking them to previous topics and in this way promoting problem-solving skills (Brooks & Brooks, 2017). By introducing new discussion points she bridged visual content with interactive discourse, supporting learners in information synthesis and developing critical thinking skills (Anderson & Krathwohl, 2001). NT 4 also employed videos to facilitate discussion and encourage active participation, though there was no detail about how she went about it. She also enriched the pedagogical environment by using internet searches and virtual platforms.

NT 5 demonstrated a significant shift from traditional resistance to technology, embracing its potential for interactive learning and 21st-century skills development (Brooks & Brooks, 2017). This shift was evident in her use of the smartboard for interactive activities such as drag-and-drop exercises, promoting engagement and knowledge retention (Knowles et al., 2020).

All the NTs, as early adopters of technology in NS lessons, demonstrated a commitment to recognising and exploiting technology's potential to develop critical thinking skills, essential for 21st-century learners (Saravanakumar et al., 2023). The NTs progressed towards self-directed learning in technology use at different paces (Knowles et al., 2020). Their integration of various tools enhanced NS IBT delivery through the creation of a technology-rich environment. Their frequent use of the WCED e-portal and other platforms underscores their dedication to improving educational outcomes and equipping learners with skills for the future.

Summary

Thorough analysis of how NTs implemented teaching strategies revealed a clear transition towards the pedagogy of IBT. This is evident in how they integrated the CK and subject matter knowledge with pedagogical knowledge to design engaging experiences consistent with IBT principles. All the NTs (NTs 1, 4, 5 and 7) highlighted the utilisation of scientific process skills to facilitate scientific inquiry. They prioritised promoting curiosity, hands-on learning, learner agency and real-world connections in their lessons. This resulted in an authentic learning environment that encouraged exploration, experimentation, and collaborative knowledge creation through scientific processes.

All the NTs recognised the value of the Q&A strategy in promoting critical thinking and learner reflection. Techniques such as open-ended and probing questions were used. Notably, NT 1 used wait time after posing a question, encouraging more considered thought on the part of learners. Varying degrees of learner autonomy in question-posing were also observed. The NTs implemented a variety of approaches, including facilitating inquiry questions, recording learners' questions, encouraging opinion sharing and providing opportunities for self-evaluation. All of these are in line with a core aspect of Science pedagogy, fostering scientific curiosity. The lesson plans indicate some of the questions that the NTs prepared for their lessons (see Appendices 8 to 11).

The NTs exhibited competence in implementing the KWL strategy in order to ascertain the state of learners' knowledge before teaching a Science topic. They provided opportunities for learners to articulate their formulated questions (W) and set learning outcomes, although the distinction between the "W" and the "L" was not clearly articulated. NT 1's implementation of the K-W-L stood out for its focus on addressing misconceptions and augmenting knowledge acquisition through oral, written and practical demonstrations. NT 7's use of the K-W-L strategy demonstrated her PCK, using learners' questions to adapt her lesson and address individual learner needs.

Similarly, TPS proved to be a valuable strategy, though the evidence suggests that NTs 4, 5 and 7 might require further support and practice. NT 1 effectively utilised TPS to promote discussion, critical thinking and collaboration, key objectives of active learning. The collaboration was evident in the learners' interaction during the "pair" and "share" phases. The versatility of TPS was highlighted by NT1 as a strategy that could be used to support various educational goals and improve learner outcomes.

While not all the NTs had full access to technology, they nonetheless embraced its potential for enhancing learning. A transition in their attitudes towards the use of technology was evident in their IBT. NTs 1 and 7 demonstrated a strong understanding of technology integration, using it to stimulate discussion and broaden thinking. NT 4 made real-time use of the internet to answer learners' questions, while NT 5 taught learners drag-and-drop exercises. Notably, all the NTs utilised online platforms for research for lesson plan development.

Despite variations in their pedagogical practice, all the NTs demonstrated growth in the execution of their IBT. They manifested self-directed learning in advancing to a higher cognitive level. This is exemplified by their successful integration of pedagogical knowledge (PK) with CK to create stimulating, authentic IBT experiences.

7.5 CONFIDENCE AND SELF-EFFICACY

This section investigates how the NTs (1, 4, 5, and 7) developed confidence and self-efficacy in their knowledge acquisition and teaching of NS. Individual interviews conducted four weeks after the IP provided insights into this development.
Extracts from the interviews:

> NT 1: … confident teaching … deep plan [ing] …efficient preparation content [knowledge] success … 100% more confident in comparison… growing in [teaching] practice grown as teacher and leader…lead colleagues at school… all the different strategies… a mentor.

> NT 4: … very confident … learned content knowledge and skills… improved teaching … I'm open to science… believing in myself… I am not afraid… willing to share… I can teach Science is so great ...do my own research … implementing strategies….
>
> NT 5: … my confidence … major improvement… my teaching …. a shift in my mind set ... I've grown to love the subject ... you unlocked and you tapped into my potential that I thought I never had… a major improvement in my teaching … make use of lots of methods [strategies], and resources … I'm open to learning ... find out more [research] …. open to constructive criticism … a driving force to want to do better for my learners … improve … excited to teach my learners …. enthusiastic about science….
>
> NT 7: …I feel very confident …I have learned … confident in natural science teaching... more confident to develop learners' collaborative, critical and creative thinking … communicative skills...developed a constructivist classroom... awareness of doing research… continue to develop different ways of teaching to engage learners….

7.5.1 Confidence and self-efficacy

Insights from the interview data indicate that all four of the NTs experienced significant gains in confidence and self-efficacy as they transitioned towards a more learner-centred and constructivist teaching approach. NT 1 expressed "100% confidence", while NT 4 and 7 reported feeling "very confident" and NT 5 noted a "major improvement' (Knowles et al., 2020). This shift in mindset was attributed to the knowledge, skills and strategies acquired through the IP.

NT 1's experience extended beyond classroom confidence to leadership, as evidenced by her mentorship of colleagues (Zhou et al., 2022). This mentoring role underscored her belief in her teaching and leadership abilities, stretching Bandura's (1997) concept of self-efficacy to include effective leadership (Knowles et al., 2020).

NT 4's willingness to share knowledge with colleagues indicated confidence in her newfound capacity to teach NS effectively. Her transformation from initial doubt to confidence was evident in her statement "just knowing I can teach Science is so great". Her comments such as "I believe in myself", "I am not afraid" and "willing to share" demonstrated her competence and a growing sense of self-efficacy.

NT 5's journey showcased a remarkable transformation in self-belief and the emergence of a passion for teaching NS: "I've grown to love the subject". Her declaration, "I'm open to learning", reflected a growth-oriented mindset, a key component of self-efficacy. She viewed the IP as a mechanism that had served to unlock her teaching potential, boosting her enthusiasm and faith in herself (Knowles et al., 2020). NT 5 noted that constructive critique had become the impetus for improving her teaching practice. Her commitment to improvement disclosed her dedication to refining her teaching practices for the benefit of the learners, in sharp contrast with her earlier apprehension.

NT 7's self-efficacy extended beyond content delivery to facilitating complex learning processes. Her improved confidence in fostering critical thinking and collaboration was consonant with Abd-El-Khalick's (2012) concept of self-efficacy (Knowles et al., 2020). Her conviction that learners now enjoyed their lessons highlighted the positive impact of her self-efficacy on the learning environment. NT 7's commitment to developing a constructivist classroom and continuous research to engage her learners demonstrated a long-term dedication to improvement, a characteristic of self-efficacy (Knowles et al., 2020).

Variations among the NTs were evident. NT 1 demonstrated the most significant increase in confidence, crediting thorough CK, pedagogical skills and careful planning and preparation. NT 4 highlighted ongoing self-improvement, in line with Bandura's (1977) assertion that practice improves performance. NT 5's journey showcased a transformation, as she treated constructive criticism as a catalyst for improvement. The IP seemed to unlock her teaching potential, enhancing self-belief and genuine enthusiasm. NT 7's self-efficacy facilitated critical thinking and collaboration, positively impacting the learning environment (Bandura, 1997). Overall, the NTs reported feeling more confident, enthusiastic and better equipped to deliver effective NS education.

Summary

The NTs experienced a heightened sense of confidence and self-efficacy that were directly attributable to the intervention programme's design. The feelings of empowerment bespoke more than a motivational enhancement; they were rooted in a strong foundation in NS CK, subject knowledge and pedagogical knowledge, specifically regarding IBT. Acquisition of this knowledge translated into increased confidence.

The gain in self-efficacy is particularly evident in NT 1. Her comprehensive grasp of CK and meticulous planning strategies (see Appendix 8) fuelled her sense of confidence. Well-equipped with scientific knowledge, she was fully prepared to answer learners' questions and guide their learning effectively.

For NTs 4 and 5, the IP challenged their initial anxieties and engendered a growth-orientated mindset. Statements like "just knowing I can teach Science is so great" (NT 4) illustrated a clear shift from self-doubt to self-belief. Not only did the programme provide knowledge, it also instilled confidence in the teachers' ability to teach NS effectively.

The IP balanced theoretical knowledge with hands-on experience, equipping the NTs with the capacity to implement IBT strategies in their classrooms. The programme also emphasised the value of constructive criticism, a concept embraced by NT 5. Her willingness to use feedback as a tool for improvement demonstrated a desire for continuing growth and commitment to a long-term cycle of self-efficacy development.

Lastly, the intervention programme appears to have resulted in a supportive learning community among the NTs. Their shared experience and collaboration contributed to their self-belief, which even extended beyond the classroom (as is evident in the leadership role assumed by NT 1).

7.6 CHAPTER SUMMARY

This section summarises the impact of the IP on the NTs' PCK.

Among the significant findings was the substantial cognitive development undergone by the NTs. The data revealed that the NTs acquired a multifaceted understanding of the NS curriculum and CK, encompassing science concepts (knowledge strands), scientific process skills and the ability to apply the methods of scientific inquiry to topics identified as relevant to science education. In sum, the NTs experienced significant development in how they thought about and approached science education. Their enlarged knowledge base was further strengthened by their being equipped with effective teaching strategies specifically designed for science education. The NTs were able to create comprehensive NS lesson plans reflecting this newly gained content and subject knowledge. The lessons ensured that their learners were exposed to structured and meaningful Science experiences.

Another significant finding that emerged from the data was the transition in the NTs' application of inquiry-based teaching practices following the IP. More interactive strategies such as Q&A and K-W-L were employed. These strategies enabled the NTs to uncover learners' prior knowledge and effectively mediate the learning process. They also employed learner-centred strategies like TPS, group work and the integration of technology, which facilitated learner agency, collaboration and the co-creation of knowledge. Moreover, the NTs demonstrated an awareness of learner curiosity and interest by adapting lessons to cater to individual needs, knowledge and prior experiences. Insights into the learning landscape empowered them to tailor instruction and facilitate knowledge construction rather than simply disseminate information. This signalled a successful shift from their previous teacher-centred teaching practice to one promoting greater cognitive engagement on the part of learners.

Another significant finding was the surge in confidence and self-efficacy among the NTs. Exposure to regular iterations in the application of CK and employment of pedagogical strategies led to a sense of accomplishment and a growing sense of self-belief among the NTs. These positive emotions significantly influenced the teachers' openness to new learning, paving the way for successful pedagogical development. The IP nurtured a transformative shift in the NTs' confidence and self-efficacy, empowering them to embrace and implement IBT practices. This, in turn, led to the creation of more engaging Science classes that promoted deep learning and critical thinking, ultimately improving learner outcomes. The interconnectedness of the cognitive and affective aspects of teaching was manifest.

The NTs' participation, collaboration and desire to grow played a crucial role in shaping their professional identities. Through exposure to theories, pedagogies, professional standards and positive values and attitudes, their classroom practice was transformed. The IP equipped teachers with the tools and confidence to become lifelong learners. This transformation has the potential to create a ripple effect, positively impacting not only participating teachers but also future generations of learners.

CHAPTER 8

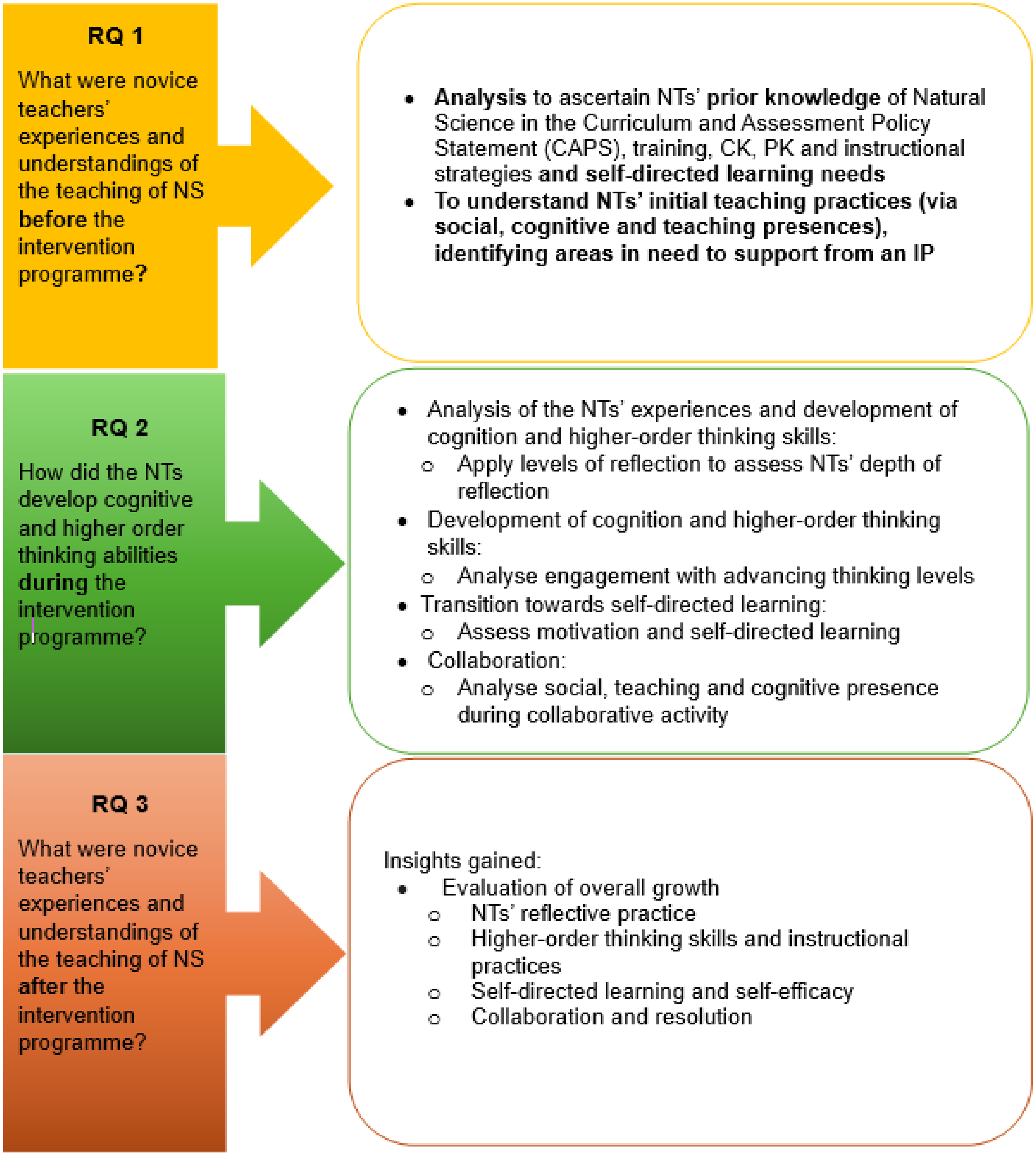
OVERVIEW OF FINDINGS AND INTRODUCTION TO THE COLLABORATIVE, REFLECTIVE AND COGNITIVE DEVELOPMENT CONCEPTUAL FRAMEWORK

8.1 INTRODUCTION

8.1.1 Background and purpose of the chapter

This chapter provides a comprehensive synthesis of the research, answering the research questions formulated to support the overarching research inquiry: “What framework can be developed to support novice teachers’ instruction competencies in Natural Science (NS) in the Foundation Phase (FP)?”

The chapter presents an overview of the findings derived from exploration of the three research questions in Chapters 5, 6 and 7. The research questions (RQ 1 to 3) and the trajectory of the study are outlined in Figure 8.1, below. Drawing on the detailed analysis in Chapters 5, 6 and 7, this section elucidates change and progress in the NTs’ discourse on the teaching of NS as observed throughout the IP.



RQ 1

What were novice teachers' experiences and understandings of the teaching of NS **before** the intervention programme?

- **Analysis** to ascertain NTs' **prior knowledge** of Natural Science in the Curriculum and Assessment Policy Statement (CAPS), training, CK, PK and instructional strategies and **self-directed learning needs**
- **To understand NTs' initial teaching practices (via social, cognitive and teaching presences), identifying areas in need to support from an IP**

RQ 2

How did the NTs develop cognitive and higher order thinking abilities **during** the intervention programme?

- Analysis of the NTs' experiences and development of cognition and higher-order thinking skills:
  - Apply levels of reflection to assess NTs' depth of reflection
- Development of cognition and higher-order thinking skills:
  - Analyse engagement with advancing thinking levels
- Transition towards self-directed learning:
  - Assess motivation and self-directed learning
- Collaboration:
  - Analyse social, teaching and cognitive presence during collaborative activity

RQ 3

What were novice teachers' experiences and understandings of the teaching of NS **after** the intervention programme?

Insights gained:

- Evaluation of overall growth
  - NTs' reflective practice
  - Higher-order thinking skills and instructional practices
  - Self-directed learning and self-efficacy
  - Collaboration and resolution

Figure 8.1: Research questions and the trajectory of the study

RQ 1-3 can be regarded as sub-questions formulated to add range and depth to its primary goal of answering the main research question: "What framework can be developed to support novice teachers' instruction competencies in Natural Science (NS) in the Foundation Phase (FP)?" The three sub-questions acted as a collective compass directing the research process, enabling detailed exploration and thorough analysis. Validity and reliability were enhanced by triangulating the findings of the study through an amalgam of five theoretical or organisational frameworks (four in the case of RQ 2 and 3).

8.2 SYNOPSIS OF THE FINDINGS FOR RESEARCH QUESTIONS 1 TO 3

8.2.1 Summation of research question 1

The researcher used three theoretical perspectives to examine the experience, understanding and initial professional discourse regarding the teaching of NS among NTs before the eight-week IP. A summary of the results gathered in Chapter 5 to answer RQ 1 – "What were the novice teachers' experiences and understandings of the teaching of NS **before** the intervention programme (IP)?" – is presented in Table 8.1.

A brief description of the NTs' initial discourse ensues. The information is presented via different colour codes to indicate how the various aspects link with the themes generated in the course of the study:

Natural Science Curriculum	Pedagogical Practices	Related affective information

The next section will discuss the NTs' initial thoughts, beliefs, understandings and practices as inferred from the interview and observation data.

Table 8.1 Novice teachers’ preliminary experiences and discourse (adapted from Maree, 2022)

NATURAL SCIENCE CURRICULUM KNOWLEDGE
There was a clear lack of familiarity with the NS FP CAPS curriculum knowledge with all NTs. NTs 4, 5 and 7 complained about surface-level or no training at all. They expressed that did not feel qualified to teach NS and were unaware that NS was included in the Life Skills curriculum within the CAPS. NT 1 was aware that NS was a part of Life Skills curriculum, but still communicated that she did not feel confident to teach NS and would not take risks.
NATURAL SCIENCE CONTENT KNOWLEDGE
All the NTs articulated that they had limited knowledge of the four scientific concepts in NS which forms the foundation upon which knowledge about the natural world is built. All NTs expressed limited exposure and understanding of the scientific process skills in NS which represents scientific thinking skills. They had a limited experience with NS terminology and subject knowledge was also mentioned as a deficit. There was a mismatch between the NTs' claimed use of inquiry-based teaching and their limited knowledge of scientific process skills and concepts in their actual teaching.
PEDAGOGICAL PRACTICES USED IN THE TEACHING OF NS
NT 1’s pedagogy of choice was IBT to teach NS which she mentioned during the interview. During the classroom observation she used question-and-answer, direct instruction, group work and collaborative learning. She used some process skills which included observation, comparison, practical activities and provided feedback (communication). NTs 4 and NT 5 used question-and-answer and direct instruction. NT 6 used question-and-answer and direct instruction, scientific process skills (predict, observe compared) and IBT. NT 7 used question-and-answer and direct instruction as well as observation. Despite these positive attempts in NTs 1, 4, 5 and 7, the frequent use of question-and-answer approaches suggests a potential reliance on traditional teacher-centered teaching methods. While varying in depth and breadth, all participants incorporated some inquiry-based elements in their teaching. The NTs expressed that they needed various strategies to address their limited NS CK. They highlighted the need for background knowledge and research on NS content before teaching. All the NTs expressed that they had limited resources.
RELATED AFFECTIVE INFORMATION: WILLINGNESS TO LEARN
During the initial interview NT 5 indicated that NS was very complicated, communicating her disinterest. NT 7's reliance on internet resources, implied a willingness to seek additional information. She mentioned a need to learn almost immediately.

RELATED AFFECTIVE INFORMATION: SELF-EFFICACY
Collectively, the NTs suggested a lack of self-motivation, low confidence resulting in low self-efficacy. NT 7 expressed a need to learn about FP NS and expressed confidence that her high school science knowledge acquired would be beneficial. This knowledge increased her self-belief. NTs 1, 4 and 5 displayed low self-efficacy, doubted their teaching abilities and were fearful, avoiding challenging tasks.

The initial discourse of the NTs revealed a deficit in their knowledge of the CAPS Life Skills NS curriculum. They were unfamiliar with the concepts of CK, PK and PCK in NS. This lack of knowledge conduced to low self-confidence, resulting in self-doubt regarding their teaching abilities. NTs communicated their disappointment in their respective HEIs, where they were not exposed or trained to teach NS, a situation that had resulted in feelings of apprehension and frustration. In addition, the NTs experienced anxieties and constraints during the COVID-19 pandemic, caused by multiple factors, both personal and systemic. These constraints and anxieties included social distancing, the exclusion of hands-on process skills training because of the prohibition on handling the same objects, the introduction of the streamlined annual teaching plans (ATPs), reduced teaching time (from 6 hours to 3 hours per day), and the use of the Life Skills topics as the context for teaching Home Language. These all made teaching difficult for NTs.

Acknowledged deficits became the basis of the IP, which aimed to address knowledge and skills gaps. Time was built into the IP for applying knowledge in real classroom contexts, discussions, shared information and practices. NTs needed to be encouraged to participate in collaborative activities to mitigate feelings of being overwhelmed and frustrated. Reflective practices were built into the IP to encourage NTs to share their thoughts, views and feelings about the teaching of NS and identify areas that needed modification in their practice.

8.2.2 Summation of research question 2

In the analysis in Chapter 6 of RQ 2, “How did the novice teachers develop cognitive and higher-order thinking abilities **during** the intervention programme?”, a blend of four key theoretical frameworks informed the research process and the analysis of the data. The

NTs' critical thinking abilities and professional development in NS teaching during the eight-week IP were analysed. Specific concepts and goals within the four integrated theoretical frameworks were utilised to analyse the teachers' progress. Table 8.2, below, displays the changing discourse of the NTs, from their initial comments before the start of the IP and during the IP.

Table 8.2 Development in NTs' preliminary discourse (adapted from Maree, 2023)

NATURAL SCIENCE CURRICULUM KNOWLEDGE	
PRELIMINARY DISCOURSE	**INCREASED COMPETENCE**
NTs showed a clear lack of familiarity with the NS FP CAPS curriculum.	The NTs indicated that the collaborative explorations and discussions allowed them to make connections and integrate their new knowledge about the NS FP CAPS curriculum. Their understanding was evident in the questions posed to each other, the ideas shared and the explanations given. The higher cognitive level of the exploratory activity allowed the NTs to recognise the value and utility of the CAPS document, making connections with teaching and learning. All the NTs claimed to understand the CAPS document and to have had their misconceptions dispelled. The NTs mentioned their growing understanding of NS concepts and skills, in other words, their growth in scientific literacy. They also communicated their realisation that learning was an ongoing process which needed commitment
NTs 1, 4, 5 and 7 complained about surface-level or no training at all.	The NTs indicated that the purposeful collaboration and sustained reflection to construct new knowledge during the eight-week IP narrowed the gap identified in their training. They showcased their willingness to learn and apply their new knowledge during their NS lessons. Even though they experienced many systemic challenges, they wanted to use the new knowledge to appreciate the impact it would have on their teaching. NTs recognised the growth in their SMK and its application.
NATURAL SCIENCE CONTENT KNOWLEDGE	
PRELIMINARY DISCOURSE	**INCREASED COMPETENCE**
All the NTs acknowledged that they had limited knowledge of the four scientific concepts in NS forming the foundation upon which knowledge about the natural world is built. They also all claimed to have had limited exposure to	A deeper exploration of the LS CAPS documents gave the NTs more in-depth insights into NS concepts, scientific process skills and scientific knowledge. Initially, two NTs requested a recap of coverage of scientific process skills and concepts. They indicated that they needed to go and read more about the topic. The NTs however gained in confidence, sharing their understanding and then individually applying the knowledge gained by matching concepts and skills to topics and explaining the rationale for their choice. They applied their

scientific process skills and therefore had a limited understanding of these.	newly acquired knowledge in the development of individual lesson plans.
PEDAGOGICAL PRACTICES USED IN THE TEACHING OF NS	
PRELIMINARY DISCOURSE	**INCREASED COMPETENCE**
NTs 1, 4, 5 and 7 employed direct teaching and question-and-answer approaches with an emphasis on teacher-centred learning.	NTs realised the value that their changed discourse added to their learners' learning, development and self-belief. They shared the different strategies they were using, which were now more learner-centred. Discussions took place about the constraints they faced, including reduced time, classroom management and the need for more practice. The NTs shared how learner-centred strategies such as the K-W-L strategy and practical activities allowed learners to engage, give explanations and pose questions. Variations in the implementation of strategies included the use of Q&A, with a focus on asking open-ended higher-order questions, encouraging learners to pose questions and using 'wait time' to give learners time to think. All the NTs showcased the new strategies they had added to their teaching repertoire since the onset of the IP.
While it varied in depth and breadth, all the participants incorporated some inquiry-based elements in their teaching.	All the NTs claimed that they were using and improving IBT. They explained how they used the strategies learned to strengthen the learner-centred aspect of their teaching approach. At various intervals during the eight-week IP, they voiced their need for more time to practise these strategies. They complained about the time constraints imposed on Life Skills by the WCED and, more generally, COVID-19. They described how they incorporated experiential learning into their daily practice, including hands-on activities, group work and experimentation, think-pair-share and technology-based activities. Since these strategies were all new to them, they shared their learning and discussed how they could improve so that learners' various learning styles and needs could be addressed. The NTs engaged in continuous self-reflection to improve their practice. Through many iterations of learning, collaboration, discussion and application, and moving towards implementation at their own pace, they achieved varying degrees of success.
RELATED AFFECTIVE INFORMATION: WILLINGNESS TO LEARN	
PRELIMINARY DISCOURSE	**INCREASED COMPETENCE**
Collectively, the NTs evinced a lack of self-motivation and a low level of confidence, resulting in low self-efficacy. NTs 1, 4 and 5, in particular, displayed low self-efficacy. They doubted their teaching	The COVID-19 factor presented multiple challenges resulting in fear and anxiety. One NT was negative at the beginning of the IP and low self-efficacy was evident. Through continuous collaboration and reflection, the NTs realised that they had a common goal. The knowledge that each of them was experiencing anxieties about NS teaching and COVID-related issues set them at ease. A shift was noted in their attitude as

abilities and were fearful, avoiding challenging tasks.	they eagerly embraced the learning during each session, communicating their growth. They verbalised the importance of believing that they were capable of teaching NS. The NTs' enthusiasm was ignited because of the change in their learners' attitudes and enthusiasm, manifested in improved question posing, thoughtful answering of questions and a willingness to share information.
RELATED AFFECTIVE INFORMATION: SELF-EFFICACY	
PRELIMINARY DISCOURSE	**INCREASED COMPETENCE**
NTs displayed low self-efficacy, doubted their teaching abilities and were fearful, avoiding challenging tasks.	A noticeable additional challenge loomed in the form of the effects of COVID-19 precautionary measures. The teachers had to deal with systemic issues, external and personal pressures, emotional stress and professional setbacks. They showed great resilience in the face of the pandemic, remaining eager to do the best for their learners. They exhibited courage in continuing with the IP. The NTs worked on the gaps in their knowledge that had been identified. Through regular checking-in, collaboration and discussion their practice and beliefs changed. The NTs were committed to learning and improving their practice. They embarked on doing their own research, gravitating toward self-direction. The NTs realised that ongoing self-reflection would maintain and build self-belief, improving their professional identity.
Collectively, the NTs displayed a lack of self-motivation and a low level of confidence, resulting in low self-efficacy.	The NTs newly acquired knowledge of CK, PK and PCK provided them with the foundational knowledge required for teaching NS. This knowledge enhanced their confidence, motivating them to implement new pedagogical practices in the classroom. They became self-motivated to freely share their experiences with each other and pursue new knowledge. Self-belief, a positive sense of efficacy and a developing teacher identity became evident. Their intrinsic motivation and self-direction were related to their personal sense of advancing their teaching practice. The development in their self-belief and self-motivation led to professional development.

The progress made by the NTs differed in a variety of ways throughout the eight-week IP. Their pace was determined by several factors, including their previous knowledge and their willingness to learn with and from each other. They had to negotiate numerous challenges, including systemic factors – the time constraint of reduced teaching time, which impacted their teaching practice; personal factors – family illness during COVID-19, and feelings of anxiety and apprehension whilst grappling with the new knowledge; and difficulties with knowledge acquisition – some NTs needed additional time for study and practice at different stages of the IP. As they navigated their way through the IP, the

NTs became more resilient in coping with the emotional stress caused by internal and external pressures and professional setbacks. The NTs adapted to the challenges, assuming responsibility for their own learning and constantly pursuing further understanding and growth. Their inhibitions and low self-efficacy were gradually replaced by self-motivation, self-belief and an openness to sharing what they still needed to improve in their NS teaching practice. The steady progress in their professional development, each at their own pace, yielded greater self-directedness, more criticality and modifications in their NS teaching practice and teacher identity (Suphasri & Chinokul, 2021).

8.2.3 Summation of research question 3

Table 8.3, below, presents a summary of the findings about changes in the NTs' professional discourse, the subject of RQ 3 as presented in Chapter 7: "What were the novice teachers' experiences and understandings of the teaching of NS **after** the IP?".

Table 8.3 Changes in and development of NTs' discourse (adapted from Maree, 2023)

NATURAL SCIENCE CURRICULUM	
PRELIMINARY DISCOURSE	**CHANGED CONCEPTUAL KNOWLEDGE**
There was a clear lack of familiarity with the NS FP CAPS curriculum among all the NTs.	The NTs displayed significantly enhanced understanding and knowledge of the NS CAPS requirements. Their revised conceptualisation of the NS curriculum was manifest in their understanding of relevant concepts and scientific process skills. The NTs understood the Life Skills curriculum, and that NS was a part of BK. They were able to classify NS topics, align the opposite concepts with the NS topic and identify appropriate scientific process skills. Their ability to explain the concepts, skills and SMK was evident during their collaborative sessions. Their in-depth knowledge of the NS curriculum was revealed in their development of individual NS lesson plans. They were also able to integrate the LS NS topic into HL and Mathematics (e.g., write a story about the bean plant and measure and record the bean plant).

NTs 4, 5 and 7 complained about having received surface-level training or no training at all.	The NTs moved beyond surface-level understanding. This was evidenced in their application of the science process skills and concepts. They explained that the eight-week IP exposed them to a higher level of comprehension which enhanced their understanding, application, synthesis, and evaluation of content, resulting in the capacity to create content. They included these skills in their NS lesson plans. Deeper knowledge allowed them to address learner misconceptions and create opportunities for learners to make connections with everyday life (examining plants, soil, bugs). Their growing confidence and independence in curriculum implementation showcased their autonomy in responding to classroom dynamics.
NATURAL SCIENCE CONTENT KNOWLEDGE	
PRELIMINARY DISCOURSE	**CHANGED CONCEPTUAL KNOWLEDGE**
The NTs admitted that they did not feel qualified to teach NS and were unaware that NS was included in the Life Skills curriculum within the CAPS. They all confessed that they had limited knowledge of the four scientific concepts in NS that form the foundation upon which knowledge about the natural world is built.	After the IP, all the NTs described their extensive acquisition of NS CK within the LS curriculum. Their greater and more critical understanding of scientific literacy was evident in their growing knowledge of scientific process skills, concepts and the nature of science. This was manifest in their flexible support for their learners, in some cases exploring beyond the prescribed curriculum. The CK acquired was evident in the NTs' clear explanations of concepts, how they would teach them and how to address misconceptions. NTs repeatedly emphasised the importance of developing CK to provide learning opportunities, developing and encouraging learners to generate knowledge through the HOT skills. Evidence of the use of everyday knowledge and transition to scientific knowledge was evident in their activities (e.g. from the known term for a seed to dicotyledon). The application of knowledge in their lesson plans demonstrated a higher cognitive level of engagement with the CK and SMK. Their ability to scaffold learning increased as they guided their learners' questioning and understanding. The NTs integrated the CK into practical real-life experiences, enabling them to teach the SMK.
Despite these positive aspects, the frequent use of question-and-answer approaches suggests a continuing reliance on traditional pedagogical practices.	Their use of different pedagogies is further evidenced in the types of activities the NTs included in their lesson plans. Although the NTs felt that they were not proficient in technology use, their progress was discernible in that their learners were encouraged to manipulate, use the drop and drag function and add answers to diagrams and drawings. Teaching proficiency increased as they facilitated inquiry lessons, presentations and research about SMK, lesson plans and ideas for hands-on activities. They noted that learning to use technology effectively in NS lessons was an ongoing process.

All the NTs reported limited experience and understanding of scientific process (thinking) skills.	NTs described the transformation in their approach to scientific inquiry. They realised that scientific process skills are the foundational skills in scientific inquiry and could be integrated across the curriculum. The NTs' cognitive growth was evidenced in the types of activities they developed to expose learners to inquiry.
They had limited exposure to NS terminology and subject knowledge (SMK) was also mentioned as a deficit.	The use of scientific vocabulary was emphasised by the NTs as they realised that it was important for critical thinking and scientific inquiry. All the NTs included scientific terminology in their lesson plans. Some were more vocal than others about the importance of using the appropriate scientific vocabulary, encouraging their learners to articulate their thoughts and explanations in scientific terms. The application of knowledge in their detailed lesson plans demonstrated a deeper understanding and a higher level of cognitive engagement with the CK and SMK.
PEDAGOGICAL PRACTICES	
PRELIMINARY DISCOURSE	**CHANGED CONCEPTUAL KNOWLEDGE**
The NTs, except NT 1, did not have any practical experience during their teacher training.	After their exposure to practical experience, motivated through the 8-week IP, a shift was noted in the NTs' teaching practice from teacher-centred to more learner-centred approaches. Their lesson planning and execution of NS lessons showcased the creation of conducive learning environments. They utilised appropriate LTSM (real plants, soil, etc.), involving using exploration (senses), questioning, discovering and recording during their practical scientific inquiry. Evidence of collecting, analysing, organising, experimenting, recording and communicating was seen in differentiated measures. The NTs became facilitators, guiding learners through the investigations and posing open-ended questions to support connection making. They also had recourse to direct instruction when it was needed.
All the NTs reported limited exposure to and understanding of scientific process skills, which in NS equate to scientific thinking skills.	The NTs' acquisition of a wider repertoire of strategies included inquiry-based and learner-centred teaching. Teachers executed scientific process skills, emphasising scientific observation, experimentation, prediction and evaluation. Their developing PCK was evident in the inclusion of strategies to teach content through inquiry aimed at understanding the world. What was notable was their growing embrace of questioning, problem-solving and exploration to develop critical thinking skills, rather than direct instruction and the memorisation of facts. Critical thinking skills during the NTs' inquiry process were evident at different levels. Not all the NTs used evaluative questioning.
There was a mismatch between the NTs' claim to be using inquiry-based teaching	The acquired IBT knowledge was transferred to the collaborative development of the lesson plan template. The NTs' understanding of the CK, SMK and PCK necessary for

and their limited knowledge of scientific process skills and concepts in their actual teaching.	a Science lesson was evidenced in their individually developed lesson plans and the execution thereof. All the NTs included learning intentions, the scientific process skills used, scientific vocabulary, inquiry-based teaching strategies such as K-W-L and Q&A, and possible questions to ask to stimulate learner-generated questions. All the NTs included scientific attitudes and values and a measure of environmental awareness an advocacy.
CONFIDENCE AND SELF-EFFICACY	
PRELIMINARY DISCOURSE	**CHANGED MINDSET**
NTs displayed low self-efficacy, doubted their teaching abilities and were fearful, avoiding challenging tasks.	NTs' confidence levels rose with the growth of their CK, PK and PCK. The increase in self-belief was especially evident in their own accounts of how much their ability to teach NS had progressed. Their motivation levels escalated, and their persistence was showcased throughout the IP, enabling them to reach higher levels of confidence and self-esteem. Towards the end of the process, the NTs felt that they had achieved most of their goals, which included: knowledge of the LS curriculum, CK, PK, and PCK to teach NS. Confidence in their acquired knowledge and their constant willingness to share their knowledge with others within the group and outside resulted in three of the NTs assuming the role of Life Skills subject heads in their Grades. They mentioned that they became mentors to other NTs. These NTs' drive and resilience were evident in their accepting the challenge of leading others.

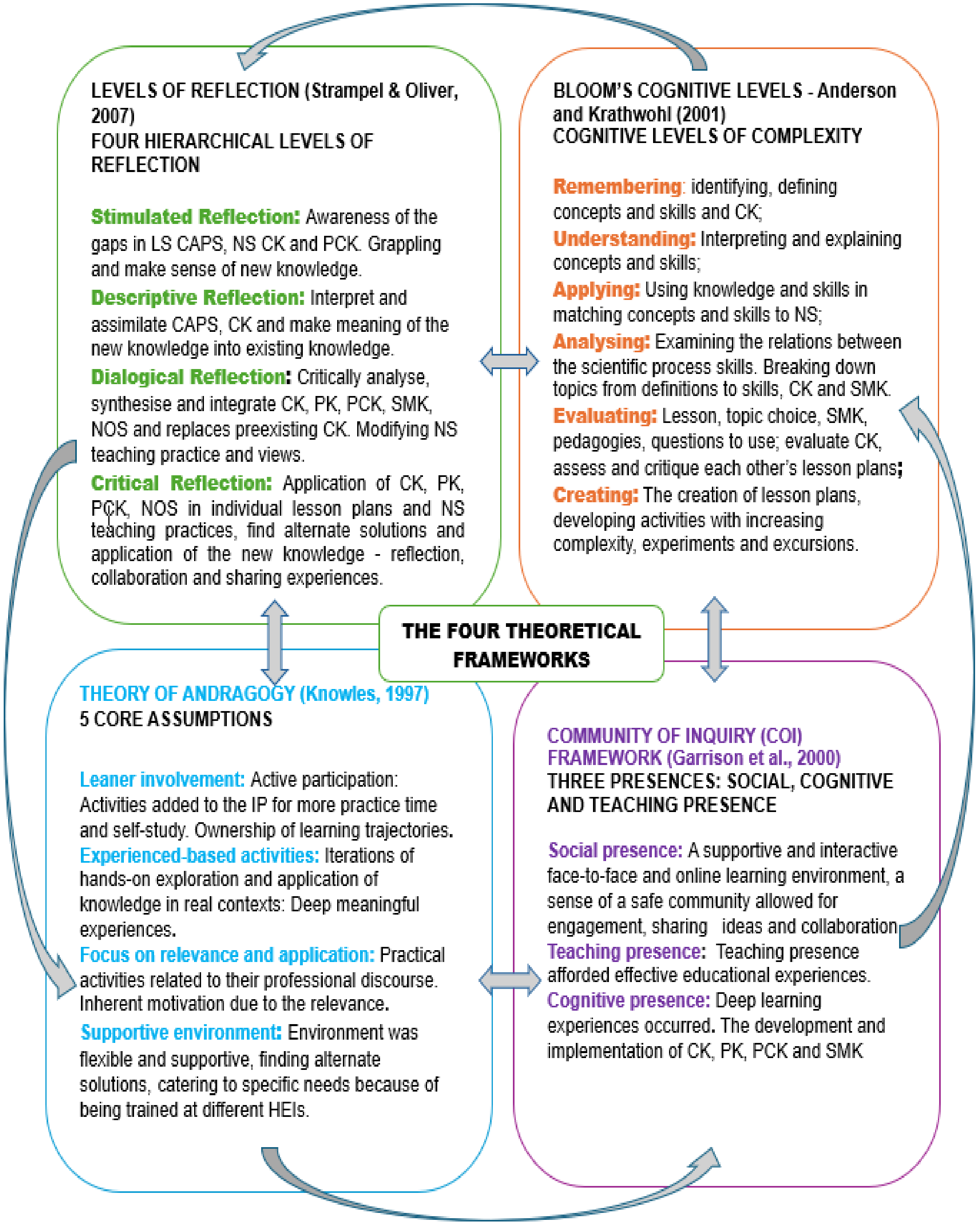
Initially, the NTs intimated that they had been inadequately trained and prepared in terms of their knowledge of NS for FP CAPS. They felt they lacked the knowledge to teach NS and therefore lacked self-confidence. Through the IP, the NTs acquired an in-depth understanding of the Foundation Phase LS NS curriculum, which included the acquisition of CK, NS concepts, scientific process skills and SMK. As a crucial foundation for teaching NS, CK provided a strong platform upon which to build the relevant PCK and NS pedagogical practices. The NTs were thus capacitated with the basics of NS teaching, including the scientific process skills and concepts that they applied to their NS lessons from Session 5 onwards. The NTs were further exposed to a variety of new IBT strategies, substantially extending their limited repertoire of pedagogical practices and strategies. This newly acquired knowledge empowered them to select a NS topic, link the appropriate concepts and skills, develop the SMK and choose the appropriate strategies for the NS lesson. The lesson was taught and improved upon over a period of one month after the completion of the IP. They identified solutions to problems and shortcomings as they amended their NS teaching practice. A shift from a teacher-centred to a more learner-centred approach was noted, along with the development of critical thinking skills. The NTs showed progress in their understanding of the nature of science, scientific values and scientific literacy. They could therefore employ CK and PK in their NS lessons, making the CK accessible to their learners in an engaging, learner-centred manner.

Their shift towards greater autonomy was noted, first, in the creativity of their lesson plan development and implementation, and secondly, in the further research they conducted into inquiry-based pedagogies and how to improve their practice. They sought to make their classroom environments conducive to NS learning, with appropriate LTSM and strategies involving scientific process skills and scientific inquiry. The growth in their CK, PCK and scientific literacy instilled a developing confidence in the NTs' ability to teach NS, which changed their views, attitudes and behaviour. Participation and collaboration during the eight-week IP birthed a growth-oriented mindset in the NTs which shaped their self-belief.

Reflective practice was pivotal in the NTs' development, though not all of them were diligent in recording their reflections since they preferred to verbalise them. Their reflective practice and experience during the IP afforded them an opportunity to engage collaboratively with learning theories, pedagogies and professional standards. This helped to cultivate positive values and attitudes. Nevertheless, although the NTs overcame many challenges and made a leap forward in their NS teaching practice, they noted that they needed "to be life-long learners". They understood that their ability to improve was actualised through continuing practice and learning.

8.3 THE MULTIDIMENSIONAL APPROACH OF THE FOUR FRAMEWORKS IN ANSWERING THE RESEARCH QUESTIONS

The synthesis of the four frameworks in a multidimensional approach was more effective than the application of a single theory. The four frameworks, together with some explication of how they were employed to answer the three research sub-questions, are presented in Figure 8.2, below.



LEVELS OF REFLECTION (Strampel & Oliver, 2007)
FOUR HIERARCHICAL LEVELS OF REFLECTION

Stimulated Reflection: Awareness of the gaps in LS CAPS, NS CK and PCK. Grappling and make sense of new knowledge.
Descriptive Reflection: Interpret and assimilate CAPS, CK and make meaning of the new knowledge into existing knowledge.
Dialogical Reflection: Critically analyse, synthesise and integrate CK, PK, PCK, SMK, NOS and replaces preexisting CK. Modifying NS teaching practice and views.
Critical Reflection: Application of CK, PK, PCK, NOS in individual lesson plans and NS teaching practices, find alternate solutions and application of the new knowledge - reflection, collaboration and sharing experiences.

BLOOM'S COGNITIVE LEVELS - Anderson and Krathwohl (2001)
COGNITIVE LEVELS OF COMPLEXITY

Remembering: identifying, defining concepts and skills and CK;
Understanding: Interpreting and explaining concepts and skills;
Applying: Using knowledge and skills in matching concepts and skills to NS;
Analysing: Examining the relations between the scientific process skills. Breaking down topics from definitions to skills, CK and SMK.
Evaluating: Lesson, topic choice, SMK, pedagogies, questions to use; evaluate CK, assess and critique each other's lesson plans;
Creating: The creation of lesson plans, developing activities with increasing complexity, experiments and excursions.

THE FOUR THEORETICAL FRAMEWORKS

THEORY OF ANDRAGOGY (Knowles, 1997)
5 CORE ASSUMPTIONS

Leaner involvement: Active participation: Activities added to the IP for more practice time and self-study. Ownership of learning trajectories.
Experienced-based activities: Iterations of hands-on exploration and application of knowledge in real contexts: Deep meaningful experiences.
Focus on relevance and application: Practical activities related to their professional discourse. Inherent motivation due to the relevance.
Supportive environment: Environment was flexible and supportive, finding alternate solutions, catering to specific needs because of being trained at different HEIs.

COMMUNITY OF INQUIRY (COI) FRAMEWORK (Garrison et al., 2000)
THREE PRESENCES: SOCIAL, COGNITIVE AND TEACHING PRESENCE

Social presence: A supportive and interactive face-to-face and online learning environment, a sense of a safe community allowed for engagement, sharing ideas and collaboration
Teaching presence: Teaching presence afforded effective educational experiences.
Cognitive presence: Deep learning experiences occurred. The development and implementation of CK, PK, PCK and SMK

Figure 8.2: The four theoretical frameworks

Each of the research frameworks provided a different theoretical perspective that enabled an in-depth understanding of the phenomenon under investigation. The synthesis of the four theories, each reliably grounded in principles well established and widely recognised in education research and practice, formed a strong foundation for the production of a new theoretical framework.

The new amalgamated framework in turn serves as the basis for a comprehensive approach to address educational processes in future teacher professional development. The amalgamated framework is represented in Figure 8.3, below.

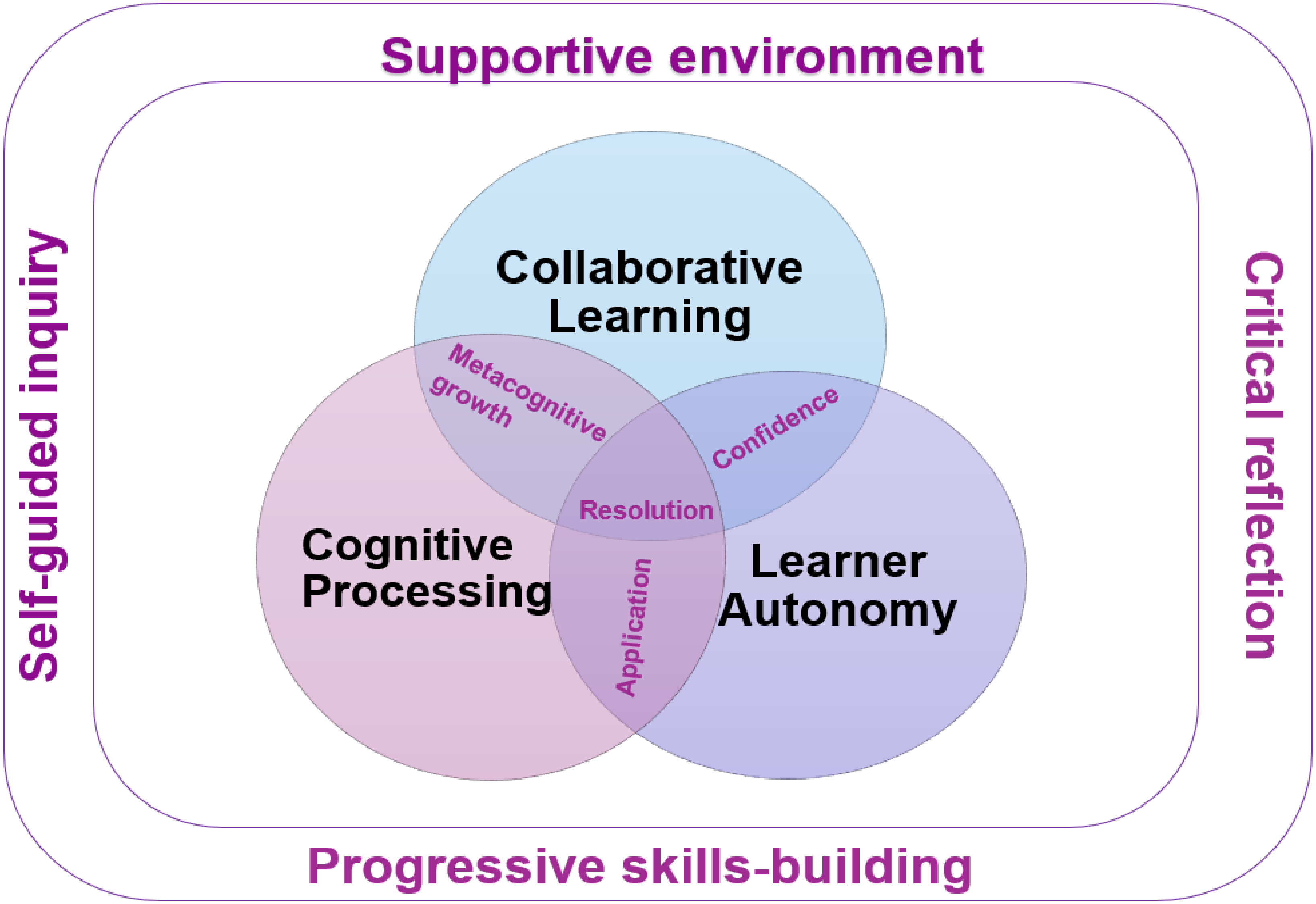


Figure 8.3: The Collaborative, Reflective and Cognitive Development Conceptual Framework

8.4 THE COLLABORATIVE, REFLECTIVE AND COGNITIVE DEVELOPMENT CONCEPTUAL FRAMEWORK (CRCD)

The CRCD presents perspectives that are not apparent if each component theory is considered separately. The new theoretical framework for training NTs in NS focuses on three solidifying main concepts: collaborative learning, cognitive processing, and learner autonomy. In combination, the implementation of these essential concepts can empower teachers to develop optimally.

The collaboration concept in this framework provides for higher cognitive levels of inquiry and continuous development, both personal and professional. NTs practised problem-solving and critical thinking skills, progressing through the higher cognitive levels as they engaged with new material, scenarios, teaching and learning. Collaboration is closely aligned with encouragement and the creation of a secure and supportive environment. Here trust is built, enabling engagement through which NTs can share their insights and learn from and with each other. In this study, it was within this supportive environment the NTs were afforded scaffolded opportunities to co-develop content and strategies and discuss complex concepts. Thereafter, as their self-belief increased, they transitioned through progressive stages of skill building and knowledge acquisition to self-guided inquiry and setting their own learning goals independently.

The development in the NTs' higher cognitive processing provided the impetus for improving their NS teaching, enhancing their confidence, self-efficacy and independence. Awareness of the concept of cognitive processing stimulated metacognitive growth, awareness and control of their own learning and higher-level cognitive thinking leading to evaluation and creativity. Independent activities were added to their existing repertoire as the gradual release model was deployed.

The critical reflection concept introduced in the framework supported the growth of self-awareness. NTs became more confident in their understanding, progress and ability to learn. The IP allowed for deep-level interconnected learning opportunities, in a collaborative supportive setting, with continuous reflection on learning experiences and searching interrogation of the content for in-depth understanding and the application of knowledge. The CRCD framework contributed to the body of knowledge informing the design of the IP, developing practical learning activities and strategies for the professional development of teachers.

8.5 CONCLUDING REMARKS

This chapter concludes with a summary account of the development of the new CRCD conceptual framework, grounded in the theoretical frameworks employed to answer the three research questions in Chapters 5, 6 and 7. The framework is reciprocally embedded in the research findings, which saw the participating NTs progress from cognitive dissonance and disempowerment to self-belief and improved professional discourse. This was achieved through a tailored, comprehensive yet flexible IP, with specific defined objectives. A rigorous systematic approach gave precedence to a needs evaluation, followed by the creation of a supportive and engaging environment to meet those needs by focusing on critical thinking, optimal knowledge, skills, pedagogical strategies and increased confidence.

As a result of the IP, the NTs' initial knowledge gaps, resistance, beliefs and attitudes transitioned to a positive mindset. Their changed perspectives translated into behavioural changes in the form of the adoption of new teaching practices. Through exploration, research and reflective practice NTs developed CK, PK, PCK and SMK. The acquisition of these knowledges accelerated their development as NS teachers.

The findings with respect to research questions 1 to 3 illuminated the cognitive development of the NTs when teaching NS in FP classrooms. This was not a smooth and linear trajectory, but a multi-layered process that needed careful consideration. The progress and setbacks experienced by the NTs as a result of this rigorous intervention emphasised the complexity of a learning process in which they developed both cognitively and affectively. Collaborative guided inquiry, metacognitive processing, progressive skill building and reflective practices together shaped their professional identities as NS teachers. The positive values and attitudes that they acquired transformed their professional discourse. Cognitively, an in-depth understanding of scientific literacy, higher-level critical thinking and effective pedagogical strategies became evident as they developed and implemented NS lessons. Affectively, the NTs gained in confidence and self-efficacy, moving toward a more proactive, learner-centred educational philosophy in their NS teaching. The transformation in classroom practice was impacted by the multi-dimensional movement of their teaching from surface-level instruction to the provision of a more engaging, inquiry-based learning environment. Chapter 9 provides a summary of the thesis, offers a conclusion and makes recommendations.

CHAPTER 9

SUMMARY, RECOMMENDATIONS AND CONCLUDING COMMENTS

9.1 INTRODUCTION

This final chapter concludes this research project with an overview of the study, a summary of the key findings, recommendations for policy, practice and implications for future research.

9.2 OVERVIEW OF THE STUDY

This section offers a comprehensive synthesis of the research conducted and the key findings arising from it, identifying the primary contributions it makes to the existing body of knowledge. The study pursued its objectives by seeking to answer defined research questions within the context of the literature reviewed and a theoretical framework devised for the purpose. After the overview, certain conclusions are reached and recommendations are made for policy, practice and future research.

This research study aimed to develop a framework for supporting and enhancing the development and success of FP NTs’ instruction competencies in NS. To this end, the Collaborative, Reflective and Cognitive Development Conceptual Framework (CRCD) was developed. As a comprehensive conceptual framework, CRDC encompasses collaborative learning, cognitive processing and learner autonomy. It was designed to support NTs in NS curriculum knowledge, skills and practice, to improve their confidence in their teaching and increase its proficiency. The framework foregrounds a supportive responsive environment, self-guided inquiry, critical reflection and iterations of activities and practice for progressive skill building, metacognitive growth, and the development of confidence and resolution.

9.3 SUMMARY OF KEY FINDINGS IN THE STUDY

The findings revealed that through the scaffolded processes and integration of new practices, the NT participants attained resolution, self-efficacy and autonomy. Their stages of development will be described in chronological order – before the IP, during the IP and after the IP – to explain their learning trajectory during the research study process.

The research findings highlighted critical disparities in the FP NTs’ preparedness to provide NS education effectively. The **pre-IP** findings revealed that each NT, regardless of their diverse backgrounds, faced distinct challenges. In response to RQ 1, it emerged from the NTs’ experience and understanding of teaching NS in FP classrooms showed that all of them had limited CK. This resulted from the limited scope and sequence of CK in the CAPS document and the inadequate subject knowledge gained in achieving their qualifications.

The NTs’ repertoire of pedagogical strategies used to teach NS varied considerably and included: using inquiry (NT 1), 3D objects (NTs 1, 2 and 3), ICT (NT 1), group work (NTs 1, 2 and 4), experiential learning (NTs 4 and 7) and experiments (NT 6). These findings revealed that, apart from group work, the question-and-answer technique and direct instruction, the NTs had a limited repertoire of learner-centred practices for teaching NS. This ignorance of instructional strategies adversely affected their commitment and self-esteem, causing a lack of interest or even negative feelings towards the subject.

The NTs’ differing experiences and the discrepant levels of training received at their respective HEIs informed the researcher’s development of an IP. The researcher tailored the intervention to address the specific needs and challenges of each teacher, thereby accommodating a range of perspectives and teaching contexts. This approach underscored the importance of acknowledging divergence to ensure that support strategies were adaptable. The spectrum of initial perspectives among the NTs ranged from complete avoidance, through a sense of discomfort and aversion, to a partial or open interest in the subject. Five out of the original seven NTs were aware of the need to improve their content knowledge and pedagogical skills.

The results reflect that **during the IP**, a relaxed and supportive environment was created as a safe space for exploration and collaboration. NTs’ specific needs determined the pace of the intervention: when to pause, when to provide support or when to accelerate and advance. Tailored guidance allowed for cognitive processing and professional growth. The research revealed that the reflective practices with which the NTs initially struggled soon became routine, internalised pedagogical habits. Evidence of metacognition appeared when NTs were able to identify their strengths and challenges, leading to deeper reflection and a more critical evaluation of their teaching practices. A more comprehensive understanding of their CK, PK and PCK meant that decisions about remedial action became clearer. The acquisition and application of new knowledge were evident in the comprehensive lesson plans that they developed. These featured several learner-centred strategies that involved hands-on participation and required a higher level of cognitive engagement. The NTs' immersion in an inquiry-based learning environment encouraged them to embark on a journey of critical thinking and problem-solving, leading to resolution. The transition from theory to practice was evident in their teaching, which featured practical application of the new pedagogical strategies. Evidence of self-guided inquiry was observed as NTs embarked on research, seeking better ways to conduct their lessons.

After the IP, the NTs continued to gain confidence and independence, crucial for the adoption of IBT and learner-centred strategies. This was evident from their insights into their role, which shifted from requiring the rote learning of NS facts to a more constructivist approach encouraging learner participation, questioning and self-inquiry. Their continued reflection and growing competence were seen in their increased use of technology. Their ability to recognise, address and resolve challenges autonomously reinforced their sense of professional agency. The transformation recorded in the NTs' reflections and journal entries was manifested in their continuous research to refine and extend their teaching strategies. The NTs' new understanding of scientific skills and concepts, scientific processes and IBT advanced their application of the investigative nature of NS.

In sum, reflective practice became pivotal during the IP. In the form of verbal as well as written reflections, it proved to be a key element in augmenting teacherly self-efficacy. The NTs identified their strengths, acknowledged their limitations and recognised areas for improvement. Inclining towards IBT in their teaching practice, and using various strategies and adaptations, the NTs steadily increased their competences. These were reflected in their growing confidence in incorporating the new scientific literacy concepts and pedagogical knowledge into their NS teaching. This is what Garrison and Arbaugh (2007) call “resolution”, which is central to the new conceptual framework, the Collaborative, Reflective and Cognitive Development conceptual framework (CRCD).

9.4 THEORETICAL AND CONCEPTUAL FRAMEWORK

The new CRCD framework was developed from the findings and stipulates the conditions for a supportive learning environment to increase scientific literacy through collaborative learning, critical reflective practice and cognitive processing. These fundamental practices underpinned the IP, fostering deeper learning and creating a pathway towards greater teacherly confidence, self-efficacy, and ultimately resolution in NS teaching practice.

The eight IP sessions were conducted with scaffolding techniques for navigating the CAPS, improving pedagogical practice and scientific literacy, and promoting self-guided inquiry (Vartiainen & Kumpulainen, 2019). The understanding of how science functions in everyday life enabled more vigorous participation in scientific processes. Specific NS activities served as the foundation for teaching NS (Vartiainen & Kumpulainen, 2019). Progressive skills building and confidence development enabled the NTs to plan more effectively, adapt their teaching strategies, and support and develop critical thinking, problem-solving and the application of scientific methods. This was achieved through many iterations of scaffolded activities that resulted in a systematic learning journey of self-reflection and collaboration. This culminated in the NTs’ achieving self-assurance and autonomy. The NTs’ metacognitive growth increased learning awareness and self-assessment, which in turn improved planning, adaptation of teaching practice and goal setting. The NTs’ ability to transition from theory to practice increased through their individual journeys as they achieved the resolution of sophisticated understanding and adept pedagogical practice.

9.5 RECOMMENDATIONS

The following recommendations for policy, practice and future research, are made:

Policy:

It is recommended that:

- NS be afforded the same status as the other subjects in the FP curriculum set out in CAPS. For example, more time should be given to the teaching of NS. After the COVID-19 pandemic and according to the DoBE's Circular S5 of 2023, the time allocated for Beginning Knowledge (BK) was reduced to 30 minutes in Grades 1 and 2 and 30 minutes in Grade 3 – with one of the three subjects being NS. NS is essential for a holistic education and facilitates both cognitive and inquiry skills essential for other subjects, including Mathematics and Home Language;
- Scientific literacy and the Nature of Science (NoS) be explicitly defined in the CAPS, with clear objectives indicating science's role in society;
- a developmentally appropriate progression of the general scientific concepts be included across the Foundation Phase from simple to more complex;
- the Life Skills BK topics, which are mainly focused on everyday knowledge, include a progression from everyday knowledge to scientific knowledge;
- NS foundational skills and competencies be integrated with Home Language and Mathematics to reinforce the application of knowledge in 'real' situations;
- definitions be added in a glossary of scientific terminology, scientific skills and concepts for inclusion in the next revision of the CAPS document.

Practice

The recommendations are that:

- A targeted comprehensive professional development programme (PDP) be developed, using the CRCD, for in-service teacher training, relying upon the expertise and resources of an established training centre such as the Cape Teaching and Leadership Institute (CTLI) in the Western Cape. This centre would play a central role in designing the PDP to address the gaps in teachers' NS CK, PK and PCK. The facilitator should have a sound knowledge of FP NS and be experienced in using IBT.

Collaboration should take place in a safe, secure and supportive environment, conducive to higher cognitive levels of inquiry, problem-solving and critical thinking skills. The progressive skills building should culminate in self-guided inquiry and resolution. The PDP should be implemented according to a cyclical model, whereby teachers attend training sessions on NS and pedagogy, with intervals for implementation and practice. The cycle of the sessions would include collaborative exploration, inquiry, implementation, critical reflection, discussion, refinement, application, and enhancing teacher competence and autonomy. Video recordings can be used for self-assessment. For continuity, the promotion of effective teaching processes and the development of self-efficacy and confidence have to be sustained, so additional training and support (including easily accessible platforms such as WhatsApp) should be made available to address challenges.

- HEIs' curriculum coursework in the pre-service FP teacher education programme include the pedagogy of Inquiry-Based Science Education, hands-on and minds-on experiences suited to real classroom applications. The lecturers should have specialist knowledge of NS and the FP CAPS, introducing learners to the language and the framework for discussing the natural world, promoting curiosity and a sense of inquiry;
- FP lecturers should link the theory of teaching NS with practice in regular practical sessions;
- The teaching of NS lessons should be included as mandatory for FP pre-service teachers during teaching practice;
- Lecturers should model the use of technology in their NS teaching and learning.

Future Research

The recommendations are that:

- The CRCD framework be used across the curriculum subjects and phases. Future research should investigate how CRCD can be employed to facilitate changes in teachers' professional discourse;
- Future research be conducted with FP teachers, perhaps using a larger sample;

- Quantitative research be conducted, with experimental and control groups to measure the impact of the intervention on learner outcomes;
- The inclusion of learner outcomes in a longitudinal study would yield more conclusive evidence of impact.

9.6 CONTRIBUTION OF THIS STUDY TO SCIENTIFIC KNOWLEDGE

The CRCD contributes to the broader discourse of FP NS teacher training and professional development, focusing on collaborative learning, cognitive processing and critical reflection leading to resolution and autonomy.

This framework can, therefore, serve as a ‘roadmap’ for TPD programmes for all subjects, educational contexts and phases, offering a specific pathway to the development of self-guided, reflective practitioners. The framework informs TPD by bridging the gap between generalist teaching and subject-specific pedagogy, promoting higher cognitive levels of inquiry and continuous development, both personal and professional.

9.7 CONCLUDING COMMENTS

The IP made use of the NTs’ past experience with NS, alternative scenarios and solution-driven activities. The aim was to elevate cognitive processing and develop critical thinking. All the activities in the IP thus started with exploration, leading to discussion and reflection. The idea was to expose the NTs to multiple opportunities to engage with unfamiliar content, make meaning, internalise the content by connecting the new knowledge to previous knowledge, and evaluate the result. Carefully constructed activities facilitated a collaborative process of group meaning-making, reflection, the construction of new knowledge and its application in different situations. Time for discussion, reflection and regular feedback was included in the design of the programme. The NTs were gradually taken through these cognitive stages, with the researcher continually checking in to determine who required more time or support. In the course of their journey, the NTs navigated scaffolded processes to enhance higher-order thinking skills, self-guided inquiry and self-efficacy.

Following the identification of lacunae in CK and PK in the NS curriculum, the research aimed to develop a framework to strengthen FP NTs' professional discourse with a strong scientific literacy foundation and effective teaching strategies. During and as a result of the research, several critical gaps in the current literature were addressed. Specifically, the study identified a need for structured support mechanisms to help teachers develop critical reflection skills, and promote cognitive growth and self-efficacy, components that are often neglected in teacher professional development (TPD). The broader significance of CRCD lies in its capacity to serve as a transformative approach for future interventions aimed at sustainable TPD, impacting on teacher effectiveness and autonomy. An indication of sustained practice was evident in the NTs' professional discourse months after the IP.

The CRCD framework transformed the NTs' initial perspective, with its discursive gaps, resistance and negativity, into a positive mindset with concomitant behavioural change. Through inquiry and critical reflection, the NTs developed scientific literacy and SMK, which accelerated their development as NS teachers. NTs developed both cognitively and affectively, gaining the confidence and self-efficacy that enabled them to adopt learner-centred educational philosophy in their NS teaching. The transformation from surface-level instruction to implementing an inquiry-based learning environment was brought about by the multi-dimensional approach of the CRCD.

This CRCD framework gives prominence to higher-order cognitive and affective development, a goal that could inform policy and address challenges in teacher education and TPD. The concepts (cognitive processing, collaborative learning and learner autonomy) encapsulated in the framework, used strategically and collaboratively, position the CRCD framework as a useful structure for the achievement of learning outcomes. The framework includes scaffolding techniques for inquiry, developing critical reflective practices, and refining pedagogical practices by breaking down complex concepts to teach more impactful, learner-centred lessons (Alt & Raichel, 2020). The framework has the capacity to drive sustained improvement in educational quality, bridging current gaps in the curriculum and supporting future growth within the Science field.

9.8 REFLECTIVE ACCOUNT OF THE RESEARCH PROCESS

Reflecting on her research journey, the researcher pondered on both the challenges she faced and the opportunities for growth afforded her. Data generation during COVID-19 was undoubtedly the most challenging and demanding period of the research. The researcher was confronted with many unexpected obstacles and had to dig deep into her resolve, in the process strengthening her resilience and adaptability. One challenge was the adoption of the digital platform, Microsoft TEAMS, as the medium for conducting interviews and the IP, which was mostly practical in nature. This required the researcher to expand and adapt in her preparation and execution of the project.

Three of the participants withdrew from the study for personal reasons and there were times when the researcher thought the remaining teachers would withdraw because of the daily stresses and continual demands made of them. Yet despite the challenges and anxieties they faced, the teachers persevered because they experienced growth in their teaching practice and witnessed a change in their learners' interaction and development. Their cooperation and regular feedback granted the researcher invaluable insights into the daily challenges of delivering the NS curriculum without adequate CK, training or support. The NTs' drive, commitment and willingness to learn amidst uncertainty and apprehension was an inspiration to the researcher. She developed more patience and empathy, and became more determined to overcome hurdles such as frequent schedule changes. She offered support when needed and extended the reflection time so that the participants could share their experiences of teaching during the COVID-19 pandemic.

This doctoral journey was a transformative one as the researcher experienced personal and professional growth as an educator, teacher trainer and developer of curriculum material. Her understanding of the teachers' plight in the time of crisis deepened, as did her appreciation of the challenges they experienced in teaching NS. In the researcher's future work, this invaluable experience will be a reminder of the importance not only of adaptability in research but also of always being flexible and understanding in her encounters with teachers. It became increasingly apparent that her role was more than that of data collector, but rather of someone who needed to understand and support the teachers in their real-world situations. This experience has given her an in-depth perspective on the crucial value of flexible support structures for teachers. The researcher is truly honoured and privileged to have journeyed with these ‘ground breakers’ in their learning trajectory.

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APPENDICES 1 to 17

Appendix 1: Questionnaire for the collection of biographical details before the initial individual interviews and IP

Please provide your full name (first and last name). **…………………………………………………………….**
What is your date of birth? **…………………………………………**
How many years of teaching experience do you have? ………………………………………………………..
Which school are you teaching at? …………………………………………..
At which Higher Education Institution were you trained? …………………………………………………………………
What qualification do you hold? For which phase? ………………………………………………………………
What grade are you currently teaching? ……………………………………………
Please indicate whether you are interested to be a participant in this research project. Yes No
I am looking forward to engaging with you. Thank you for taking the time to complete the questionnaire. A follow-up meeting will be scheduled for introductions and the signing of the consent forms. I thank you kindly! Elizabeth Fredericks

Appendix 2: Example of one of the consent letters

Peninsula
University
of Technology

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Category of Participants (tick as appropriate):

Principals		*Teachers*		*Parents*		*Lecturers*		*Students*	
Other (Subject Advisor)	√								

You are kindly invited to participate in a research study being conducted by ………………………………………… from the Cape Peninsula University of Technology. The findings of this study will contribute towards (tick as appropriate):

An undergraduate project		*A conference paper*	
An Honours project		*A published journal article*	
A Masters/doctoral thesis	√	*A published report*	

Selection criteria
You were selected as a possible participant in this study because (give reason why candidate has been chosen):
you are a qualified novice teacher (0 to 3 years of experience) teaching in an English medium Foundation Phase class in a primary school in the Western Cape;
you are a lecturer at a Higher Education Institution where the novice teachers were trained;
you are a Subject Advisor who supports the school where the novice teacher/s teaches.

The information below gives details about the study to help you decide whether you would want to participate.

Title of the research:

A framework for supporting Foundation Phase novice teachers' instruction competencies in Natural Science

A brief explanation of what the research involves:
National and International research explains that Natural Science in Foundation Phase is hardly taught and that teachers lack the content and pedagogical knowledge because of being ill prepared at Higher Education Institutions. This research study aims to develop a framework which could be used by Higher Education Institutions, DoE, Western Cape Education Department and Districts to adequately prepare and support teachers in content knowledge, pedagogical and pedagogical content knowledge to teach Natural Science.

Procedures
If you volunteer to participate in this study you will be asked to do the following things: (The researcher must complete the section below. For example: 'Each research participant will be interviewed by the researcher or his/her assistants or collaborators [provide names of interviewers]. Briefly explain how many interviews, the duration of the interviews, place, date, etc.)

Each research participant in this study will be interviewed for approximately 45 minutes (depending on the conversation) at a School/ Campus or virtually for convenience during the first term in 2021. The researcher will conduct 2 classroom observation lessons (indoors or outdoors). The classroom observation will include the teachers' documents and learner work. Thereafter the researcher will conduct 10 developmental sessions and requests that each participant attends. Participants are requested to journal their experiences and thoughts. After the sessions the researcher will conduct 1 classroom observation lesson (indoors or outdoors).

Potential risks, discomforts or inconveniences
(Researcher please briefly describe any foreseeable risks, discomforts or inconveniences likely to affect research participants)

There are no known risks and/or discomfort associated with this study.

You are invited to contact the researcher should you have any questions about the research before or during the study. You will be free to withdraw your participation from the study at any time without an explanation.

Kindly complete the table below before participating in the research.

	Tick the appropriate column	
Statement	**Yes**	**No**
1. I understand the purpose of the research.	✓	
2. I understand what the research requires of me.	✓	
3. I volunteer to take part in the research.	✓	
4. I know that I can withdraw at any time.	✓	
5. I understand that there will not be any form of discrimination against me as a result of my participation or non-participation.	✓	
6. Comment:		

Please sign the consent form. You will be given a copy of this form on request.

	2021-01-21
Signature of participant	Date

Researchers

	Name:	Surname:	Contact details:
1.	Elizabeth	Fredericks	0842938791

Contact person: Elizabeth Fredericks
Contact number: 084 293 8791
Email: elizabethjfredericks@gmail.com

Appendix 3: Pre-IP semi-structured individual interview schedule

Name:

Date:

Interview Questions	Aim: To ascertain the NTs' preparedness to teach Natural Science in Foundation Phase: Their classroom set-up, their experiences with NS, their knowledge of the curriculum, their teaching practices and pedagogical practices, thoughts and feelings about the subject. This important and valuable information will be utilised to develop an IP.
25 to 40 minutes	Duration of the interview
Welcome and set the scene	
1	What grade are you currently teaching and how many years of experience do you have in teaching in the Foundation Phase?
2	What qualification(s) do you have in Natural Science?
3	What is your classroom space like? Do you have space for displays and educational corners in your classroom?
4	Can you describe your experience teaching Natural Science?
5	What are your thoughts, beliefs, feelings about Natural Science as a subject in Foundation Phase?
6	Which specific NS concepts in the CAPS of Natural Science present a problem to you to teach? Why do you say so?
7	How would you rate your knowledge of the Natural Science and that you teach, on a rating scale 1 to 5, with 1 having no content and practical NS teaching knowledge and 5, comprehensive content and practical knowledge of teaching NS. Why would you say so?
8	How familiar are you with the Natural Science requirements in the CAPS document? [if necessary, probe with: the content, concepts, skills required from you as the teacher? Skills the learners should acquire?]
9	What do you think about Natural Science to be taught in the FP?
10	What pedagogical practices and strategies do you use to teach Natural Science lessons?
11	(If not mentioned) Do you use the outdoors to teach Natural Science and which lesson/s did you teach?
12	How do you involve your learners during Natural Science lessons? Do you encourage "learner talk"? What happens during learner "talk"?
13	What are your expectations of your learners?
14	How do you organise and manage your class during lessons?
15	How important is scientific literacy and scientific attitudes in your teaching of NS?

16	What kind of resources do you have to teach Natural Science and were you trained to use technology in your teaching practice? If not specific…probe with … Were you trained to use technology in your teaching practice?
17	How do you prepare for the topics you teach in your grade?
18	How do you feel about your training at university?
19	Depending on the response. Follow-up question… What specifically would you like to highlight?
20	Were you trained in any specific teaching methodologies or technues in Natural Science? If not clear, the researcher can specify inquiry which is an instructional practice mentioned in CAPS.
21	Were the characteristics of a good science teacher part of your training? What would you say these character traits should be?
22	Did your training include learning theories?
23	What would you suggest could be changed, or improved, in the training at university?
24	What in your view is omitted in the training but which you think is crucial?
25	What support do you receive for NS or Life Skills integration? Prompt: from either the SMT or the principal or the Subject Advisor or anybody from the Department? When? Describe that support? [did it help you in your teaching in NS?]

Appendix 4: Non-participant classroom observation schedule

Classroom observation schedule	
Date: Topic: Duration: Location: Number of learners: Name:	
Descriptive Notes (Detailed, chronological notes about what the observer sees, hears; what occurred-teacher strategies, the physical setting)	**Reflective Notes** (Concurrent notes about the observer's thoughts, personal reactions, experiences)
Lesson structure and execution:	
Teachers and learners' interaction:	
Classroom management:	
Pedagogical practices:	
Use of learning and teaching material:	
Learner engagement ("learner talk"):	
Use of technologies (ICT integration):	
Teacher demeanour and communication:	
Classroom environment:	
Differentiation, assessment and feedback:	

Appendix 5: NTs reflective journaling points to consider

Points to consider when journaling
What new pedagogical practices did you try? What was challenging? Adaptations made to teach NS during pandemic. What resources were useful? Moments of frustration or satisfaction. Learner engagement What emotions, thoughts and feelings are you experiencing?

Appendix 6: Researcher’s field notes recorded during the IP

Informal field notes recorded during IP		
Session 1 Date: 14 June	Face-to-face	
Before the commencement of the first session		
NTs’ present	Prior to the commencement of Session 1 the NTs’ shared their thoughts, feelings and emotions about the journey they were embarking on and teaching NS during COVID.	Possible theme/pattern Anomaly
NT 1		
NT 2	Withdrew from the study before the video-recorded lesson required, prior to the IP	
NT 3	Withdrew from the study before the video-recorded lesson required, prior to the IP	
NT 4		
NT 5		
NT 6		
NT 7		
Reflections after the session		
NT 1		
NT 4		
NT 5		
NT 6		
NT 7		
Session 2 Date: 21 June	CAPS Life Skills overview, the golden thread, learners age and stage of development and curiosity. Face-to-face session	Possible theme/pattern Anomaly
NT 1		
NT 4		
NT 5		
NT 6		
NT 7		
Session 3 Date: 28 June	CAPS: What does Natural Science entail? Virtual session	Possible theme/pattern Anomaly
NT 1		
NT 4		
NT 5		
NT 6		
NT 7		
Session 4 Date: 5 July	CAPS: Scientific concepts Virtual session	POSSIBLE THEME/PATTERN ANOMALY
Reflection	Comments about their learning, needs, thoughts, feelings and emotions	
NT 1		
NT 4		
NT 5		
NT 6		

NT 7		
Reflection	After Session 4	
NT 1		
NT 4		
NT 5		
NT 6		
NT 7		
Session 5 Date: 12 July	Motivation and reflection, scientific process skills, attitudes, values, inquiry-based science education and pedagogical strategies. Virtual session	Possible theme/pattern anomaly
Reflection	Lesson plan - discussions about the scientific concepts	
NT 1		
NT 4		
NT 5		
NT 6		
NT 7		
Session 6 Date: 23 July	NS lesson planning session Classroom practice: curriculum knowledge, subject knowledge, pedagogical content knowledge, instructional approaches, uses of senses Virtual session	Possible theme/pattern Anomaly
NT 1		
NT 4		
NT 5		
NT 6	Withdrew from the study before Session 6	
NT 7		
Session 7 Date: 3 August	Online informal conversation and support: Sharing of their lessons and resources Virtual session	Possible theme/pattern Anomaly
NT 1		
NT 4		
NT 5		
NT 7		
Session 8 Date: 16 August	Lesson: Open discussion: lesson plan, classroom practice and use of strategies Virtual session	Possible theme/pattern Anomaly
NT 1		
NT 4		
NT 5		
NT 7		

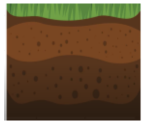
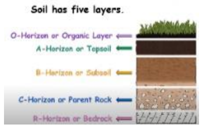
Appendix 7: The collaboratively developed NS lesson plan template used for the NTs' individual lesson plans submitted

<table>
<tr><th colspan="2">NATURAL SCIENCE LESSON PLAN</th></tr>
<tr><td colspan="2">Topic: Core Concept:</td></tr>
<tr><td colspan="2">Term: Week: Date:</td></tr>
<tr><td>Learning intention</td><td></td></tr>
<tr><td>Personal and social well-being</td><td></td></tr>
<tr><td>Beginning knowledge Scientific process skills development</td><td></td></tr>
<tr><td>Scientific concept</td><td></td></tr>
<tr><td>Value and attitudes</td><td></td></tr>
<tr><td>Lesson format:
REMEMBER to always be aware of activities to promote Executive Functioning: Working memory, Inhibitory control and Self-regulation **Learner talk, discussion, exploration, INQUIRY 'find-out", problem solving, thinking and reasoning is of utmost importance**</td><td>Introduction:
Main:</td></tr>
<tr><td>What will teacher do?</td><td></td></tr>
<tr><td>Which strategies?</td><td></td></tr>
<tr><td>What will the learners do?
Hands-on and minds-on Inquiry-based learning</td><td>
<table>
<tr><th colspan="3">Classroom management [when and what]</th></tr>
<tr><td>Whole class discussion</td><td>Think-pair -share [two's]</td><td>Small Group activity</td></tr>
<tr><td>KWLS chart</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="3">I see, I think, I wonder can also be used when appropriate</td></tr>
</table>
</td></tr>
<tr><td>QUESTIONING Possible questions Blooms:
Remembering
Understanding
Applying</td><td>
<table>
<tr><th>Bloom's Level</th><th>Possible questions</th><th>Possible answer</th></tr>
<tr><td>Remembering</td><td></td><td></td></tr>
<tr><td>Understanding</td><td></td><td></td></tr>
<tr><td>Applying</td><td></td><td></td></tr>
<tr><td>Synthesis</td><td></td><td></td></tr>
<tr><td>Evaluation</td><td></td><td></td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td>Evaluating
Creating
Analysing
Creating</td><td><table><tr><td>Creativity</td><td></td><td></td></tr></table></td></tr>
<tr><td>Possible misconceptions</td><td></td></tr>
<tr><td>DBE BOOK activities page numbers:</td><td>Page numbers
Content
Activity</td></tr>
<tr><td>LTSM:
Flashcards:
Scientific vocabulary</td><td><table><tr><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>E – resources
Use of technology</td><td></td></tr>
<tr><td>Learner activities</td><td></td></tr>
<tr><td>Integration:
Show and tell
Oral</td><td></td></tr>
<tr><td>Learners demonstrate: what they can do? explain? mastered?

What are the success criteria? AFL/ AOL</td><td><table><tr><td>Learner demonstrates learning</td><td>What should/do they demonstrate?</td></tr><tr><td>Observe</td><td></td></tr><tr><td>Compare</td><td></td></tr><tr><td>Communicate / HOT</td><td></td></tr><tr><td></td><td></td></tr></table></td></tr>
<tr><td>Lesson reflection</td><td>*Remember to write down reflections daily* What worked well. What can I improve?</td></tr>
</table>

Appendix 8: NT 1's individually developed, comprehensive lesson plan

Term: 3	Week: 6 Topic: SOIL Core Concept: Life and living Date: AUGUST
	SCIENCE LESSON
PERSONAL AND SOCIAL WELL-BEING	• Taking care of our environment – My responsibility
OBJECTIVE / AIM / LEARNING INTENTION 	**Facilitate learner understanding of the basic components of soil:** This includes explaining that soil is a mixture of broken-down rocks, organic matter (dead plants and animals), air, and water. • **Introduce learners to different types of soil:** Learners can learn about how soil texture (sandy, clay, loamy) and colour can vary depending on its composition. • **Introduce the concept of soil life:** Learners can learn about some of the creatures that live in soil, such as earthworms and insects, and their role in keeping the soil healthy.  • **Highlight the importance of soil for plant growth:** Learners can understand that soil provides plants with nutrients, water, and support for their roots.
LEARNING AIMS/ INTENTIONS:	• Use the process skills effectively. Apply the skills to • Identify different soil types based on colour and texture, compare, classify and describe soil types • Explain why soil is important for plants to grow, what is needed for growth and why. • Name some creatures that live in the soil. • Explain what earthworms do for the soil.
SKILLS DEVELOP - MENT 	• **Develop learners' observation skills:** Through activities like examining different soil sample describe the properties of soil using their senses. • **Observe soil** with magnifying glasses, learners check if they find any living things/animals in the soil • **Compare** soil types [colour, texture] • **Classify** the soil types [Sandy, loamy, clay] • **Describe** the soil types [colour texture] • **Evaluate- HOT:** what is good soil to plant in- why? • **Encourage critical thinking and questioning:** By asking probing questions that encourage learners to think beyond basic facts, the teacher can spark curiosity and a desire to learn more about soil. • **Promote collaboration and communication:** Activities like Think-Pair-Share can help learners learn from each other and develop their communication skills.

	• **Introduce basic scientific inquiry:** Planting seeds in different types of soil allows learners to observe and record data, fostering an understanding of the scientific method. • **Communicate** what they have recorded; types of soil; explains which is the best for planting, animals that live in the soil, why are earthworms helpful? • **Recording** information in DBE workbook and can talk about it to their friends.
SCIENTIFIC CONCEPT	• **MAIN CONCEPT: Life and Living** [soil which provides the right conditions is a source of food] • **Energy and change** [soil and sunlight with the correct conditions can bring forth life with sun providing energy and heat] • **Planet, Earth and beyond** [Soil and water- important for human life and sustenance]
VALUE AND ATTITUDES	• **Foster appreciation for the natural world:** Learn about the importance of soil, learners develop a respect for this essential part of our environment. • **Introduce the concept of sustainability:** Discuss ways to protect soil health-composting and reducing pollution, laying the foundation for responsible environmental habits. • **Respect for living things:** o Highlight the importance of soil creatures like earthworms for healthy soil. o Discussion on the role earthworms play to aerate the soil o Discuss how healthy soil helps plants grow, which provides food for animals (including us!). o Handle creature gently. Return any creature back to nature • **Reduce, Reuse, Recycle:** o Introduce the concept of composting kitchen scraps to enrich soil instead of throwing them away. [Learners make compost in a tin] o Discuss how using recycled materials (like pots for planting) helps reduce waste. • **Mindful consumption:** o Briefly touch on the concept of buying less and choosing products with minimal packaging to reduce waste that might end up in landfills and potentially harm soil health. • **Responsibility for our actions:** o Discuss how littering can harm the soil and the creatures that live in it. o Encourage students to think about ways they can keep their environment clean. • **Appreciation for nature:** o Encourage exploration of the outdoors and observing the connection between healthy soil, plants, and a thriving ecosystem. • **Sustainable Garden: Plant our own beans, tomatoes-** fresh produce with no insecticides

BEGINNING KNOWLEDGE

REMEMBER to always be aware of activities to promote Executive Functioning: Working memory, Inhibitory control and Self-regulation **Learner talk, discussion, exploration, INQUIRY 'find-out", problem solving, thinking and reasoning is of utmost importance**

LESSON 1 FORMAT:
Introduction – KWL

SOIL IS AN IMPORTANT NATURAL RESOURCE

Soil is formed by the process of weathering wherein rocks break down by the combined action of wind, water and climate. It is a very slow process where over a period of time large rocks disengage and then get converted into soil [broken down into smaller particles over a long period of time- called weathering]. Soil is loose material that covers the surface of the earth. It is a mixture of mud, minerals, organic matter such as dead leaves and insects and also gas. Water play an important role in soil formation. Wind also helps to wear rocks down into soil.

Soil is where plants grow. Without soil there will be no plants and without plants there will be no life on our planet. It is also home to a number of living organisms, like microorganisms, insects and small animals like earthworms, snails, rats and snakes.

WHAT WILL I / TEACHER DO?

- **Facilitate learner understanding of the basic components of soil:** This includes explaining that soil is a mixture of broken-down rocks, organic matter (dead plants and animals), air, and water.
- **Introduce learners to different types of soil:** Learners can learn about how soil texture (sandy, clay, loamy) and colour can vary depending on its composition.
- **Introduce the concept of soil life:** Learners can learn about some of the creatures that live in soil, such as earthworms and insects, and their role in keeping the soil healthy.
- **Highlight the importance of soil for plant growth:** Learners can understand that soil provides plants with nutrients, water, and support for their roots.

LESSON 2

- **Skills-based:**
  - **I can** differentiate between living and non-living things found in soil (earthworms vs. rocks).
  - **I can** use simple tools like magnifying glasses to observe soil properties.
  - **I can** follow instructions to plant seeds and care for them.
  - **I can** record observations and data about soil and plant growth.
- **Process-based:**

  - **I can** describe the formation of soil through simple explanations (breakdown of rocks and organic matter).
  - **I can** explain the importance of healthy soil for plant growth (nutrients, water retention).
  - **I can** identify the impact of human actions on soil (pollution, erosion).
- **Value-based:**
  - **I can** appreciate the importance of soil as a natural resource.
  - **I can** understand the responsibility of caring for soil for future generations.

STRATEGIES: KWL STRATEGY

What I know	**What I would like to know**	**What I have learned**
Transcribe what the learners would like to know in a simple sentence	Support /Teach learners to pose a question Rephrase if needed Write the question down	Individual learners - Write what they have learned - Demonstrate - Show and tell - Explain growth using their recording sheet

WHAT WILL THE LEARNERS DO?

Hands-on and minds-on INQUIRY-BASED LEARNING

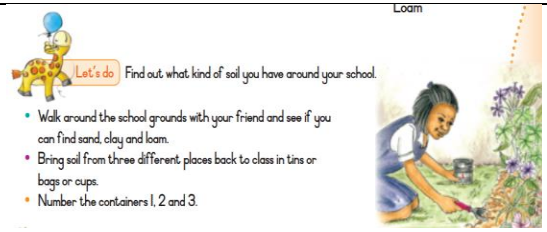
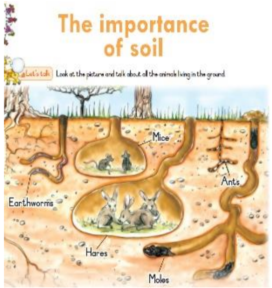
- Questioning / Probing
- Facilitate Discussion - Small group discussions. Why do you think ..? Explain why …. What do you think would happen if …….?
- Think-pair-share activities when needed
- Direct teaching / Small group teaching [SCAFFOLD THE LEARNING] WHAT WILL BE DONE???
- Clearing up misconceptions
- Set activities/ monitor the activities [RECORD OBSERVATIONS OF LEARNERS WHO NEED FURTHER SUPPORT TO WITHDRAW SOONEST]
- Show and tell

CLASSROOM MANAGEMENT [when and what]		
Whole class discussion	**Think-pair -share [two's]**	**Small Group activity**
KWLS CHART Introduction: Beginning of the lesson	Think about the concept ALONE [what do I think] Sharing ideas with my friend about the concept -Small group or whole class	Learners observe 3 different types of soil monitor, discuss and record – soil types [by drawing and labelling what they see]
		Show and tell – group or individual
I SEE, I THINK, I WONDER can also be used when appropriate		

THINK-PAIR-SHARE	Think-pair-share – Use whenever needed; to gauge learners' understanding or for discussion and feedback (share information with friend before feedback) During the lesson or at the end [What you have learned]

QUESTIONING POSSIBLE QUESTIONS BLOOMS:
Remembering
Understanding
Applying
Evaluating
Creating
Analysing
Creating

Bloom's Level	**Question**	**Answer**
Remembering	What colour can soil be?	Brown, black, red, yellow (depending on the type of soil)
Remembering	How does soil feel different from sand at the beach?	Soil can feel crumbly, moist, or sticky, while sand feels loose and dry.
Understanding	Why do we call soil "dirt"?	Soil is made up of tiny broken-down rocks, dead plants, and other things. Dirt can be a loose term for any kind of ground material.
Understanding	We can see worms wiggle on top of the soil sometimes. Do they live there? What do they do?	Yes! Worms live underground in the soil. They help break down dead plants and make the soil healthy.
Applying	If you wanted to build a sandcastle at the beach, would you use soil or sand? Why? [practical]	Sand would be better for building a sandcastle because it's loose and holds its shape. Soil is crumbly and might not hold its shape as well.
Applying	We learned that soil comes in different colours. Why do you think this might be?	The colour of soil might depend on the rocks and plants that were broken down to make it. For example, red soil might have a lot of iron in it.
Synthesis	Imagine you have a plant that's wilting. What could be wrong? How might soil be related to the problem?	The plant might not be getting enough water. Since soil holds water, maybe the soil is too dry, or the type of soil might not hold water well
Evaluation	Why do you think soil is important for our planet?	Because soil helps plants grow, and plants give us food and oxygen to breathe! Healthy soil also helps filter water and provides a home for many creatures
Creativity	Imagine you could create a new kind of soil. What special properties would it have, and how would it help plants grow	My soil would be rainbow-coloured and sparkly! It would hold lots of water and have all the nutrients plants need to grow big and strong!

Hands-on activity	 Let's do Find out what kind of soil you have around your school. • Walk around the school grounds with your friend and see if you can find sand, clay and loam. • Bring soil from three different places back to class in tins or bags or cups. • Number the containers 1, 2 and 3. **Inquiry- based lesson:** In groups learners can collect soil, test textures between fingers, discuss, explain to group, label it, and describe it.  The importance of soil Let's talk Look at the picture and talk about all the animals living in the ground. **Observe:** types of soil [sandy, loamy and clay] Observe texture and colour. Which soil holds water? **Compare and classify**: sort different soils by properties -particles size, and colour. **Measure:** measure the weight [weigh] of soil which is heavy or light. Seeds- size-big, small, flat round etc. **Communicate:** Group communicate their findings of the soil experiment … which soil similar or different properties. They record and share with the rest of the class. Groups: Go and find out- what living creatures do we find in soil [school garden, home] A sample of soil could be harvested for careful inspection. Record and give feedback. **Experiment:** Water absorption experiment: how it holds water-drop one small drop of water and observes with a magnifying class how quickly it absorbs, runs off or dries **Observe:** Observe the bean – the different parts-use the magnifying glass **Compare and classify** seeds - chilli, bean, lentils, etc. describe and compare them…colour, size - big, small shape -flat, round etc. **Measure:** Seeds- size-big, small, flat round etc. **Communicate:** Explain about the different seeds…Bean and lentil seed… One part, two parts, shape size etc. Describe differences and similarities. Group experiment. Plant the seeds. Predict which seed [lentil, bean, chilli] will germinate quicker, grow quicker? Poster **Makes posters:** Learners choose which they want to make
Possible misconceptions Used Google	**Common misconceptions learners may have about soil to address in my lesson:** • **All soil is the same:** Learners might think all soil is the same, regardless of colour or texture. You can explain that soil comes in different types (sandy, clay, loamy) with varying properties that affect plant growth. • **Soil is just dirt:** Dirt is a general term for ground material, soil is a complex ecosystem with living organisms and plays a crucial role in plant growth. • **Plants only need water to grow:** Water is essential, but plants also need nutrients from the soil for healthy development.

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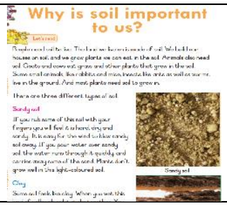
- **Soil never runs out:** Explain the concept of soil erosion and how human activities can deplete this valuable resource.
- **Soil is gross:** Learners might find the idea of dirt dirty, highlight the importance of soil creatures and how healthy soil is vital for our planet.

</td>
</tr>
<tr>
<td>**DBE BOOK ACTIVITIES page numbers:**</td>
<td>Why is soil important to us pg. 2
The importance of soil pg. 4
More about soil pg. 6
Working with soil pg. 8</td>
</tr>
<tr>
<td>**LTSM - Flashcards: Scientific vocabulary**</td>
<td>
<table>
<tr><td>soil</td><td>light</td><td>clay</td><td>vegetables</td><td>weigh</td></tr>
<tr><td>creatures</td><td>texture</td><td>loamy</td><td>plants</td><td>compare</td></tr>
<tr><td>dry</td><td>earthworms</td><td>water</td><td>compost</td><td>sort</td></tr>
<tr><td>wet</td><td>moles</td><td>garden</td><td>observation</td><td>colour</td></tr>
<tr><td>brown</td><td>sandy</td><td>growth</td><td>measure</td><td>heavy</td></tr>
</table>

Different types of soil Spades Magnifying glasses Paper towels of lids of jars Water
</td>
</tr>
<tr>
<td>**E – resources USE OF TECHNOLOGY**</td>
<td>https://youtu.be/5b9o7yM7YGE
Kylee Makes a Worm Farm | Outdoor Play and Learning in Nature for Kids! Create DIY Worm Jar (youtube.com)
Concepts BLOOMS Questions</td>
</tr>
<tr>
<td>**LEARNER ACTIVITIES**
Group activities
Responsibility
Social skills</td>
<td>**Group Work** – Assign roles e.g. scribe, report back, collection
Each group observes the 3 soil samples for particle size - breaking up clumps with a toothpick and using a magnifying glass, texture-rub between fingers
Identify the different types of soil.
Can describe the 3 types of soil.
Water absorption experiment: how it holds water-drop one small drop of water and observes with a magnifying class how quickly it absorbs, runs off or dries.

Is there anything in the soil? Living creatures?
Name the soil which is best for planting.
Name the types of animals that live in soil
Learners plant seeds and record the growth.
Make compost in a jar. Start a compost project at home, Take photos and share with class.
Make a poster
Complete activities</td>
</tr>
</table>

<table>
<tr><td>ASSESSMENT FOR LEARNING</td><td>During the hands-on engagement teacher listens to the learners’ discussions
Periodically checks on the recording and asks questions about it
Presentations and discussions</td></tr>
<tr><td>INTEGRATION:
Show and tell
Oral
HL</td><td>Reading: Shared or individual reading
Teacher sets comprehension questions
Why is soil important to us?</td></tr>
<tr><td><i>Vocabulary</i></td><td>Match the words
Label the bean plan</td></tr>
<tr><td>LEARNERS DEMONSTRATE WHAT THEY CAN DO/ MASTERED OUTCOMES</td><td>
<table>
<tr><td>LEARNER DEMONSTRATE LEARNING</td><td>DEMONSTRATE</td></tr>
<tr><td>Observe</td><td>Use senses (sight, touch) to describe different seeds (size, colour, shape, texture). - Draw an
observations of seeds</td></tr>
<tr><td>Compare/ Classify</td><td>Different types of soil</td></tr>
<tr><td>Communicate /HOT</td><td>The connection between healthy soil and healthy plants</td></tr>
<tr><td></td><td>Name animals that live in soil</td></tr>
</table>
</td></tr>
</table>

Appendix 9: NT 4's individually developed, comprehensive lesson plan

<table>
<tr><td>Term 3</td><td>Date: AUGUST-SEPTEMBER Core Concept: Life and living; Matter and Materials</td></tr>
<tr><td>Week: 6</td><td>SCIENCE LESSON Topic: SOIL</td></tr>
<tr><td>OBJECTIVE / AIM / LEARNING INTENTION</td><td>Learners will be able to
o Identify the different types of soil [sandy, loamy, clay]
o Describe the different types of soil. Colours and textures
o Explain which soil is the most suitable for planting [Growth of vegetables]
o Know what seeds are? Look at the seed parts (seed coat, baby embryo, dicotyledon)
o Why they are important?
o Planting seeds and record how they grow
o Can explain the different parts</td></tr>
<tr><td>SCIENTIFIC PROCESS SKILLS
Technological Process skills

Geographical skills
Inquiry
Interpretation
Values Attitudes</td><td>SCIENTIFIC PROCESS SKILLS
<table>
<tr><th>Scientific Process Skills</th><th>Actions</th></tr>
<tr><td>Observe:</td><td>Look closely at the different types of soil [sandy, loamy and clay] s
Observe texture and colour. Pour water over all the soil to observe which soil holds water
Observe the bean – the different parts-use the magnifying glass. Which will germinate first?</td></tr>
<tr><td>Compare and classify:</td><td>Sort different soils by properties such as particles size, and colour
Seeds-Open it up carefully – 2 parts. Look inside. Use the magnifying glass to see the embryo (baby part)
Discuss what you see. What so you think it is called?
Look at different seeds: chilli, bean, lentils, etc. [describe and compare them…big, small, flat round etc.)</td></tr>
<tr><td>Measure</td><td>Learner's measure the weight [weigh] of soil which is heavy or light.
Size-big, small, flat round etc.</td></tr>
<tr><td>Communicate:</td><td>Each group will communicate back to the class their findings of the soil <i>experiment</i>. What they understand … which soil may be similar or different</td></tr>
<tr><td>Communication</td><td>Explain about the different seeds…Bean and lentil seed… One part, two parts, shape size etc. They describe all the differences and similarities they see in the seeds What happened when planted. Record the growth</td></tr>
<tr><td>Prediction</td><td>Which seed [lentil, bean, chilli] will germinate quicker and grows quicker? Group <i>experiment</i>. Plant the seeds. Predict which seed [lentil, bean, chilli] will germinate quicker, grow quicker? Poster</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>SCIENTIFIC CONCEPT</td><td>Life and Living: The type of soil; sandy, clay, loamy;
What is a seed? Planting the seed; seeds grow in good soil, sunlight and water</td></tr>
<tr><td>VALUE AND ATTITUDES</td><td>Care and Respect – respect the speaker
Life and appreciation for seeds and the ability to growth food to not go hungry
Tolerance, Taking turns</td></tr>
<tr><td>BEGINNING KNOWLEDGE
<u>REMEMBER</u> to always be aware of activities to promote Executive Functioning: Working memory, Inhibitory control and Self-regulation
Learner talk, discussion, exploration, INQUIRY ‘find-out”, problem solving, thinking and reasoning is of utmost importance</td><td>LESSON FORMAT:
WHAT WILL I / TEACHER DO?
STRATEGIES:
Introduction of the lesson -KWL
Main lesson: Discussion, inquiry
Seeds are the small parts produced by plants from which new plants grow. In a flowering plant, three parts work together to help a seed develop and grow into a new plant.
The seed develops into three distinct parts: the seedcoat, the food storage and the embryo
The seed coat surrounds the seed, the food storage feeds the embryo, and the embryo develops into a plant.
The purpose of all seeds is reproduction.
The bean seed has two parts called dicotyledon. (2 parts)
The mealie see one part is called monocotyledon (one part)
How a bean seed germinates

Group work: Activities
Dissect the bean seed – Group work; Observe the bean growing (sprouting), discuss, record.
Plant the bean seed and record the growth-drawing.
Germination of the bean seed; environmental condition; water, sunlight and air. The seed absorb water and seed coat breaks… use video after discussion
Plant 3 types of seeds Bean, lentils and chilli
Consolidation
KWLS STRATEGY
<table>
<tr><th>What I know</th><th>What I would like to know</th><th>What I have learned</th></tr>
<tr><td>Transcribe what the learners would like to know in a simple sentence</td><td>Teaching moment
Throughout the weeks
Support learners to pose a question
Rephrase if needed
Write the question down even</td><td>Individual learners
- Demonstrate
- Show and tell
- Explain growth using their recording sheet</td></tr>
</table></td></tr>
<tr><td>WHAT WILL THE</td><td>• Questioning / Probing
• Facilitate Discussion - Small group discussions. Why do you think ..? Explain why …. What do you think would happen if …….?</td></tr>
</table>

<table>
<tr>
<td>LEARNERS DO?

Hands-on and minds-on INQUIRY-BASED LEARNING
Any misconception discussed after the lesson; Both SOIL and SEED</td>
<td>

Direct teaching / Small group teaching
Clearing up misconceptions
Set activities/ monitor the activities [record
Plant a seed and observe and record the growth; Show and tell – bean seed

<table>
<tr><th colspan="3">CLASSROOM MANAGEMENT [when and what]</th></tr>
<tr>
<td>Whole class discussion
KWL – What do you know
Teacher transcribes simple sentences for learners to ‘read’
‘W’ What would you like to know
** Continue to teach learners how to ask a question if they are struggling.
This may take time

What did you learn [L]
Demonstrate the ‘I know’ but verbalizes and teacher may write, and learners read together.</td>
<td>Think-pair -share [two’s]

Learners turn to their partner to discuss ‘what is soil’

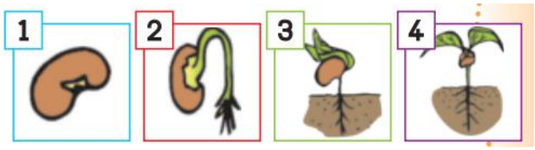
Multiple times during the lesson
Both with soil and seed
Teacher asks a Question [listed but more can be asked for probing deeper]
Think about it
Discuss with your partner
Feedback to small group or whole group</td>
<td>Small Group activity
1.Observing the soil
OCCMEC

2.Prepare the boxes to plant the seeds</td>
</tr>
<tr>
<td>KWLS CHART
Introduction: Beginning of the lesson</td>
<td>Think about the concept ALONE [what do I think]
Sharing ideas with my friend about the concept -Small group or whole class</td>
<td>Learners plant seeds, prepare for planting, monitor, discuss and record growth [by drawing and labelling what they see]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learner will walk around the school to observe soil and put them in containers and label them. Show and tell – group or individual</td>
</tr>
</table>
</td>
</tr>
<tr>
<td>QUESTIONING POSSIBLE QUESTIONS BLOOMS: Remembering Understanding Applying</td>
<td>
<table>
<tr><th>BLOOM'S LEVEL</th><th>SAMPLE QUESTIONS</th><th>POSSIBLE ANSWERS</th></tr>
<tr><td>Remember</td><td>Name the different seeds?</td><td>Sandy, loamy, and clay soil.</td></tr>
<tr><td></td><td>What colour is sandy soil? What are the different types of soil</td><td>Light brown or yellow.</td></tr>
<tr><td>Understand</td><td>Why is loamy soil good for planting?</td><td>Because it holds water and has nutrients for plants to grow.</td></tr>
</table>
</td>
</tr>
</table>

Evaluating **Creating** **Analysing** **Creating**	Understand	How many parts does a bean seed have? Can you tell me their names	
		Why do they need sunlight to grow?	
		How does clay soil feel?	It feels heavy and sticky.
	Apply	Which soil would you choose for planting seeds?	Loamy soil, because it holds water well and has nutrients.
		Can you show me the picture of sandy soil?	Yes, it looks light and gritty.
	Analyse	How are sandy and clay soil different?	Sandy soil is light and gritty, while clay soil is heavy and sticky.
		Why do you think plants grow better in loamy soil than in sandy soil?	Because loamy soil holds water and has nutrients, which plants need to grow.
	Evaluate	Which soil do you think is best for growing flowers?	Answers may vary, but most may choose loamy soil because it's good for plant growth.
	Synthesis	How could we improve clay soil to make it better for planting?	By adding organic matter like compost to make it lighter and more suitable for plants.
	Create	Design a garden using different types of soil.	Learners can draw a garden with labels for sandy, loamy, and clay soil areas.
DIRECT INSTRUCTION WITH QUESTIONING	**Seed coat** -The seed coat is like a tough jacket that protects the baby plant inside the seed. **Embryo - baby plant** -The embryo is like a tiny baby plant waiting to grow big and strong **Radicle -Root -** The radicle is the baby plant's first root that goes down into the ground **Hypocotyl – Middle part** -The hypocotyl helps the **baby plant** push up through the soil to reach the sunlight. **Cotyledons – seed leaves** -The cotyledons are like yummy snacks that give the baby plant energy to grow.		
MAIN LESSON	To lead the learners through the activity of separating the parts of the soaked bean and to pose questions in between, you can follow these steps:		
	Preparation: Soak the bean seeds in water overnight to soften the seed coat. Gather materials such as soaked bean seeds, paper towels, magnifying glasses (optional), and bowls for water		
	Introduction: After the 'K' Show the learners the soaked beans. Explain that you going to 'explore' the bean together [outside and inside]. Each group receives a few beans and a magnifying glass Ask questions interest [curiosity];		

	Let's look at the outside of the bean. What do you see? In some cases, the seedcoat may be evident as it has loosened because of soaking. They talk about what they 'observe'…Loose skin, a piece etc. What do you think the name could be? Why do you think the seed has that part? Let's look inside the bean. Teacher guides them through the process. Then explore the inside. The learners are asked to gently separate the bean. They discover 2 parts. What is that you see? What do you think that part is called? **Questions**: What do you see? What do you think the name could be? Why do you think the seed has that part? Do you think you can open up the bean? What do you think is inside the bean? Are their separate parts to the bean seed? Pose more questions Can you find the baby plant inside? Why do you think the baby plant needs the parts you found? How do you think the baby plant will use the food? **Discussion and conclusion:** After discussing and exploring the parts of the bean seed, I will let them discuss again and then ask 'what have you learned' we will write it on the 'L' part of chart. Learners will discuss in groups and then share. The main parts of the lesson will be emphasized [functions and parts] Critical thinking part
DBE BOOK ACTIVITIES page numbers:	Page 2 to page 9
SHARED READING CONTENT KNOWLEDGE	DBE WORKBOOK READING: More about soil Term 3 – Week 2 Let's read You can make your own compost. Compost provides nutrition for plants. Here is a recipe for making compost. **NB. [After the lesson] Additional information** **More 'inquiry' about the creatures that live in the soil**
CONTENT KNOWLEDGE	Why is soil important to us? Term 3 – We e k 1 33 2 Let's read People need soil to live. The land we live on is made of soil. We build our houses on soil, and we grow plants we can eat in the soil. Animals also need soil. Goats and cows eat grass and other plants that grow in the soil. Some small animals, like rabbits and mice, insects like ants as well as worms, live in the ground. And most plants need soil to grow in. There are three different types of soil. **Sandy soil** If you rub some of this soil with your fingers you will feel it is hard, dry and sandy. It is easy for the wind to blow sandy soil away. If you pour water over sandy soil, the water runs through it quickly, and carries away some of the sand. Plants don't grow well in this light-coloured soil.

<table>
<tr><td></td><td>Clay soil: Some soil feels like clay. When you wet this kind of yellowish soil it sticks together. You can form all sorts of clay, like cups and bowls and clay animals, but it is difficult to grow plants in clay soil. When it rains, clay holds the water for a long time and the plants, that are growing in it, get too we</td></tr>
<tr><td>CONTENT KNOWLEDGE</td><td>Animals that live in soil
Beetles Ants Moles Snakes centipedes
Earthworms Worms Millipedes</td></tr>
<tr><td>LTSM - Flashcards: Scientific vocabulary</td><td>Flashcards: loamy, sandy, clay, soil, seed, seed coat, baby plant cotyledon, two parts
Labels Pictures / real soil
life skills bluebook activities -activity sheets
magnifying glass, sieve, soil [3 types]</td></tr>
<tr><td>E – resources USE OF TECHNOLOGY</td><td>video you tube https://youtu.be/qJ9fJU1X9mA Soil
video about animals that live in soilhttps://youtu.be/q3suM0V7a1g
Oxford reading book https://www.youtube.com/watch?v=42Zp0M0AtEI
Germination https://www.youtube.com/watch?v=ZY6v8UPJGfU</td></tr>
<tr><td>Strategic use of video</td><td>Stop at the Concepts -Ask BLOOMS Questions
Clarity of ... concept / misconception</td></tr>
<tr><td>LEARNER ACTIVITIES</td><td>Learners plant seeds record periodically on their own chart
Compare the soil
Observe and name the parts of the bean
Name animals that live in the soil
Make a poster
Write sentences
Read the story – Shared writing and reading – the bean and soil [2 stories if time allows]</td></tr>
<tr><td>ASSESSMENT FOR LEARNING</td><td>Continuous
Listen to individual learners – what they say. What they understand?
Misconceptions
Another opportunity to observe the bean seed – reinforce scientific terms</td></tr>
<tr><td>LEARNERS DEMONSTRATE WHAT THEY CAN DO/ MASTERED OUTCOMES</td><td>
<table>
<tr><th>LEARNER DEMONSTRATE LEARNING</th><th>DEMONSTRATE</th></tr>
<tr><td>Identify the different types of soil</td><td>“I can point to pictures or samples of sandy, loamy, and clay soil and name them.”</td></tr>
<tr><td>Describe the different types of soil, including colors and textures</td><td>“I can describe sandy soil as light and gritty, loamy soil as dark and crumbly, and clay soil as heavy and sticky.”</td></tr>
<tr><td>Explain which soil is the most suitable for planting vegetables</td><td>“I can say that loamy soil is best for planting because it holds water well and has nutrients for plants to grow.”</td></tr>
</table>
</td></tr>
</table>

	I can show the different parts of the bean I can explain what it is and how it functions/ can do
INTEGRATION:	Home Language: Talk about soil – group activity and feedback to the class Show and tell Oral Poem: I THINK MICE ARE NICE
Vocabulary	Match the words Label the soil types
DISPLAY TABLE	   Add label and sentences Learners can touch, observe Flashcards and cards with picture s to match the process of the growth of a bean plant Label the bean seed on a card with the different parts and words in a container. Read the simple story of a bean created for Shared reading [with a partner] or alone

Appendix 10: NT 5's individually developed, comprehensive lesson plan

Term 3	**Week 6 Date:** August / September **TOPIC: PLANTS AND SEEDS** Concept: Life and Living

<table>
<tr><td></td><td>SCIENCE LESSON</td></tr>
<tr><td>Objective / Aim / Learning Intention</td><td>

What are seeds? identify a seed (Observe)
Where they come from?
What do seeds need to grow?
Identify and name the parts of a seed
Understand how seeds grow into plants and the conditions they need, like water, soil, and sunlight
Different seeds - similarities and differences - compare
PLANT A SEED: Inquiry – active 'hands-on', minds-on – playful learning to inspire young minds

</td></tr>
<tr><td>Scientific Process Skills
Technological Process skills

Geographical skills
Inquiry
Interpretation
Values
Attitudes

Technological process Skills
Inquire/ Find out
Design/ Draw
Make
Evaluate</td><td>
SCIENTIFIC PROCESS SKILLS
<table>
<tr><th>SCIENTIFIC PROCESS SKILLS</th><th>CORRESPONDING ACTIONS FOR SEEDS</th></tr>
<tr><td>OBSERVE</td><td>- Use a magnifying glass to observe the outer appearance and texture of different types of seeds [hard, soft, course, smooth]</td></tr>
<tr><td></td><td>- Watch a time-lapse video showing the germination process of seeds and observe the growth of seedlings. [After how many days do we see some evidence of growth]</td></tr>
<tr><td>COMPARE</td><td>- Compare the sizes, shapes, and colors of different seeds from various plants.</td></tr>
<tr><td></td><td>- Compare the growth rates of seeds planted in different types of soil or exposed to varying amounts of sunlight [varying sunlight not used in this experiment]</td></tr>
<tr><td>CLASSIFY</td><td>- Sort seeds into groups based on their characteristics, such as size, shape, or the type of plant they produce. [lentils, beans, chilli, mealie, paw-paw, apple, sunflower etc.]</td></tr>
<tr><td></td><td>- Classify seeds as edible or non-edible, based on their suitability for consumption by humans or animals.</td></tr>
<tr><td>MEASURE</td><td>- Use a ruler or measuring tape to measure the length and width of seeds. [informal]</td></tr>
<tr><td></td><td>- Measure the growth of a planted seed over time, recording its height at regular intervals. Day 5, Day 8, Day 12, Day 15 , Day 20</td></tr>
<tr><td>EXPERIMENT</td><td>- Conduct an experiment to investigate the effect of different factors (e.g., water, light, temperature) on seed germination.</td></tr>
<tr><td></td><td>- Design and carry out an experiment to determine the best conditions for storing seeds to maintain their viability.</td></tr>
<tr><td>COMMUNICATE</td><td>- Share observations and findings about seeds with classmates through discussions or presentations.</td></tr>
<tr><td></td><td>- Create a poster or multimedia presentation to communicate information about the life cycle of seeds and their importance</td></tr>
<tr><td colspan="2">Prediction may be used for the CLASS experiment. Planting a bean and putting it in a very dark place
What do you think will happen to the bean? Teacher writes down the predictions. [Learners can read together (Shared reading]
After many weeks of observation. Discuss the learner predictions and what did occur.</td></tr>
</table>
</td></tr>
</table>

Scientific concept	Life and Living
Value and attitudes	Respect Honesty Tolerance Care

Beginning Knowledge

REMEMBER to always be aware of activities to promote Executive Functioning: Working memory, Inhibitory control and Self-regulation **Learner talk, discussion, exploration, INQUIRY 'find-out", problem solving, thinking and reasoning is of utmost importance**

LESSON FORMAT:
WHAT WILL I / TEACHER DO?
STRATEGIES:
Introduction of the lesson
Main lesson:
Group work
Activities
Consolidation
KWLS STRATEGY

What I know	**What I would like to know**	**What I have learned**
Transcribe what the learners would like to know in a simple sentence	Teaching moment Throughout the weeks Support learners to pose a question Rephrase if need Write the question down even	Individual learners - Demonstrate - Show and tell - Explain growth using their recording sheet

WHAT WILL THE LEARNERS DO?

Hands-on and minds-on INQUIRY-BASED LEARNING

- Questioning / Probing
- Facilitate Discussion - Small group discussions. Why do you think...? Explain why .... What do you think would happen if ....?
- Direct teaching / Small group teaching [SCAFFOLD THE LEARNING] WHAT WILL BE DONE???
- Clearing up misconceptions
- Set activities/ monitor the activities [RECORD OBSERVATIONS OF LEARNERS WHO NEED FURTHER SUPPORT TO WITHDRAW SOONEST]

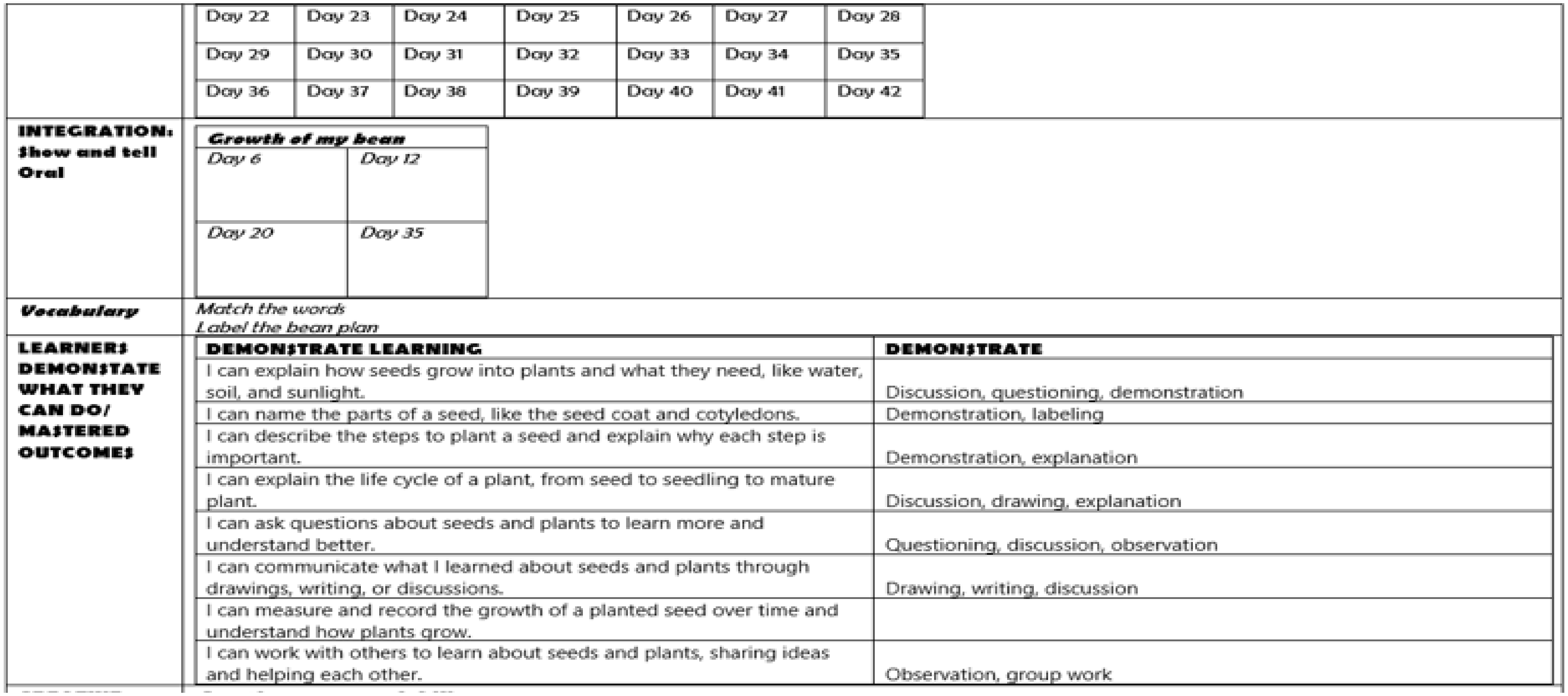
CLASSROOM MANAGEMENT [when and what]		
Whole class discussion	**Think-pair -share [two's]**	**Small Group activity**
KWLS CHART Introduction: Beginning of the lesson	Think about the concept ALONE [what do I think] Sharing ideas with my friend about the concept - Small group or whole class	Learners plant seeds, prepare for planting, monitor, discuss and record growth [by drawing and labelling what they see]
		Show and tell – group or individual

QUESTIONING POSSIBLE QUESTIONS

Bloom's Level	**Question**	**Answer**
Remembering	What is a seed?	A seed is a tiny part of a plant that can grow into a new plant.

<table>
<tr><td>BLOOMS:
Remembering
Understanding
Applying
Evaluating
Creating
Analysing
Creating</td><td>
<table>
<tr><td>Remembering</td><td>Can you name some different types of seeds?</td><td>Examples include sunflower seeds, pumpkin seeds, and apple seeds.</td></tr>
<tr><td>Remembering</td><td>Where do we find seeds in fruits?</td><td>Seeds are found inside fruits, like apples, oranges, and watermelons.</td></tr>
<tr><td>Understanding</td><td>Why do plants need seeds?</td><td>Plants need seeds to grow new plants so they can reproduce.</td></tr>
<tr><td>Understanding</td><td>How do seeds grow into plants?</td><td>Seeds need water, soil, and sunlight to grow into plants.</td></tr>
<tr><td>Understanding</td><td>What do seeds need to grow big and strong?</td><td>Seeds need plenty of water, good soil, and sunlight to grow big and strong.</td></tr>
<tr><td>Applying</td><td>Can you show me how to plant a seed in a pot?</td><td>Demonstrate planting a seed in a small pot, covering it with soil, and watering it gently.</td></tr>
<tr><td>Applying</td><td>How do you take care of a seed after planting it?</td><td>After planting, make sure to water the seed regularly and keep it in a sunny spot for sunlight.</td></tr>
<tr><td>Applying</td><td>What would happen if we didn't plant seeds?</td><td>Without planting seeds, we wouldn't have new plants, and the world would have fewer trees and food.</td></tr>
</table>
</td></tr>
<tr><td>DBE BOOK ACTIVITIES page numbers:</td><td>18-19; 22-23; 24-25; 27-27</td></tr>
<tr><td>LTSM - Flashcards: Scientific vocabulary</td><td>Seeds, stem, roots, soil, sunlight, water, pot [Flashcards]
Different types of seeds, size, shape, edible, none-edible</td></tr>
<tr><td>E – resources USE OF TECHNOLOGY</td><td>Packet so seeds – pumpkin, sunflower
Fruit and vegetable seeds

Seeds, stem, roots etc (different items for plants and what makes plants grow)
Seed dispersal song https://youtu.be/3CCOWHa-qfc
What plants need to grow (germination) https://youtu.be/oYzXToyEzBU
<table>
<tr><td>seeds</td><td>soil</td></tr>
<tr><td>pot</td><td>water</td></tr>
</table>
</td></tr>
<tr><td>Strategic moments in video</td><td>Concepts to note
Strategic - stop and .... concept... Small group discussion, think-pair-share etc.
BLOOMS Questions
Clarity of .... concept / misconception</td></tr>
<tr><td>LEARNER ACTIVITIES</td><td>Learners plant seeds record
Make a poster
Show and tell</td></tr>
<tr><td>ASSESSMENT FOR LEARNING</td><td>
<table>
<tr><th colspan="7">Growth of my bean seed</th></tr>
<tr><td>Day 1</td><td>Day 2</td><td>Day 3</td><td>Day 4</td><td>Day 5</td><td>Day 6</td><td>Day 7</td></tr>
<tr><td>Day 8</td><td>Day 9</td><td>Day 10</td><td>Day 11</td><td>Day 12</td><td>Day 13</td><td>Day 14</td></tr>
<tr><td>Day 15</td><td>Day 16</td><td>Day 17</td><td>Day 18</td><td>Day 19</td><td>Day 20</td><td>Day 21</td></tr>
</table>
</td></tr>
</table>



Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28
Day 29	Day 30	Day 31	Day 32	Day 33	Day 34	Day 35
Day 36	Day 37	Day 38	Day 39	Day 40	Day 41	Day 42

INTEGRATION: Show and tell Oral

Growth of my bean	
Day 6	*Day 12*
Day 20	*Day 35*

Vocabulary

Match the words
Label the bean plan

LEARNERS DEMONSTATE WHAT THEY CAN DO/ MASTERED OUTCOMES

DEMONSTRATE LEARNING	**DEMONSTRATE**
I can explain how seeds grow into plants and what they need, like water, soil, and sunlight.	Discussion, questioning, demonstration
I can name the parts of a seed, like the seed coat and cotyledons.	Demonstration, labeling
I can describe the steps to plant a seed and explain why each step is important.	Demonstration, explanation
I can explain the life cycle of a plant, from seed to seedling to mature plant.	Discussion, drawing, explanation
I can ask questions about seeds and plants to learn more and understand better.	Questioning, discussion, observation
I can communicate what I learned about seeds and plants through drawings, writing, or discussions.	Drawing, writing, discussion
I can measure and record the growth of a planted seed over time and understand how plants grow.	
I can work with others to learn about seeds and plants, sharing ideas and helping each other.	Observation, group work

Appendix 11: NT 7's individually developed, comprehensive lesson plan

	SCIENCE LESSON	
PERSONAL AND SOCIAL WELL-BEING	Personal well-being Social responsibility	
OBJECTIVE / AIM / LEARNING INTENTION	KNOWLEDGE OBJECTIVE: • Understand the concept of recycling, reusing and reducing waste • Identify recyclable materials • Explain why recycling is important for the environment SKILLS OBJECTIVE: • Demonstrate the ability to sort recyclable items and non-recyclable items • Develop a creative thinking skills by designing a poster promoting recycling • Apply critical thinking skills to propose ides for implementing a recycling programme at home or at school or in the community ATTITUDE OBJECTIVE • Develop a sense of responsibility towards environmental conservation • Show appreciation for the impact of their actions on their environment and the importance of sustainable practices BEHAVIOURAL OBJECTIVE • Learners participate in hands-on activities, discussions and group work related to recycling • They demonstrate environmentally friendly behaviours, such as reducing waste and recycling materials	
SCIENTIFIC PROCESS SKILLS Technological Process skills	**SCIENTIFIC PROCESS SKILLS**	
	SCIENTIFIC PROCESS SKILLS	**CORRESPONDING ACTIONS**
	OBSERVE	Conduct a waste audit: Learners' sort and count recyclable items from their lunch boxes, then discuss their findings group.
		Nature walk: Collection of materials. Learners go on a short walk around the schoolyard to observe and collect litter, then discuss why it's important to keep the environment clean
	COMPARE	Recycling sorting game: They compare the recyclable items they found with their classmates to see if they found the same things [sorting] and how much they found. They count their items and compares who has found more
	CLASSIFY	Recyclable project: sorting the materials into different categories (e.g., paper, plastic, metal) and give them a name
		Sort a pile of recyclable and non-recyclable items into separate bins. Check which team sorted the most items correctly.
	MEASURE	Waste reduction challenge: track the amount of paper used in their classroom for one week, then brainstorm ways to reduce paper usage and measure the difference in paper usage the following week.
		Recycling bin weight guessing: Guess the weight of a bag of recyclable materials collected from their class-

	room, then weigh the bag together and see whose guess was closest
EXPERIMENT	Decomposition jars: Making compost. Fill jars with soil, leaves, fruit peels, and other compostable materials, then observe and compare how each item decomposes over time
COMMUNICATE	Explain what they have learned – Make a poster. Use poster of Science table displays Tell the story of recycling happening at home [Started by the learner] Communication- happens all through the lessons. Make a poster for Science table display of the compost, ways to save our Earth; Learners tell about their recycling project at home and what is happening.
Prediction may be used for the CLASS experiment.	

SCIENTIFIC CONCEPT	Matter and materials -making new things form old things [different materials]. An old newspaper into a cereal box…tin into a desk tidy Planet, Earth and beyond-recycling helps keep our planet [the earth] clean by reducing trash in landfills [where it goes after the municipality collects our dirt. Energy and change -making things from recycled stuff we use less energy that making it brand new
VALUE AND ATTITUDES	Respect for ourselves, others [do not litter] and the environment Responsibility Social responsibility
BEGINNING KNOWLEDGE REMEMBER to always be aware of activities to promote Executive Functioning: Working memory, Inhibitory control and Self-regulation **Learner talk, discussion, exploration, INQUIRY 'find-out", problem solving, thinking and reasoning is of utmost importance**	**INTRODUCTION OF THE LESSON: Main lesson:** **SCENARIO** **WHAT WILL I / TEACHER DO?** **STRATEGIES:** **KWLS STRATEGY**

What I know	**What I would like to know**	**What I have learned**
Learners write independently would like to know They list as many as they can	Learners to pose their question They write down their question	Individual learners - Demonstrate - Explain - Share information as an individual group

WHAT WILL THE LEARNERS DO?	• Questioning / Probing – questions open-ended • Allow for 'wait and thinking time' • Facilitate Discussion - Small group discussions. Why do you think ..? Explain why …. What do you think would happen if …….?

Hands-on and minds-on INQUIRY-BASED LEARNING

- Direct teaching: Misconceptions noted will be addressed by Direct teaching
- Small group teaching – collecting, sorting and classifying
- Set activities/ monitor the activities [record observations]
- Show and tell
- LEARNERS ARE GIVEN MULITIPLE OPPORTUNITIES TO QUESTION- OPPORTUNITY FOR TEACHING

CLASSROOM MANAGEMENT [when and what]		
Whole class discussion	**Think-pair -share [two's]**	**Small Group activity**
KWLS CHART Introduction: Beginning of the lesson	Think about the concept ALONE [what do I think] Sharing ideas with my friend about the concept -Small group or whole class	Learners plant seeds, prepare for planting, m discuss and record growth [by drawing and la what they see]
		Show and tell – group or individual

HANDS-ON EXPERIENCE

- Collecting, Sorting and categorising, Designing

QUESTIONING POSSIBLE QUESTIONS BLOOMS:
Remembering
Understanding
Applying
Evaluating
Creating
Analysing
Creating

BLOOMS LEVEL	**QUESTION**	**POSSIBLE ANSWER**
REMBERING	What is waste? Where do we find waste?	Waste is the emptied containers such as tins and plastic bags
	What are some of the items that we can be reused instead of thrown away?	Items like plastic bottles, glass jars, and paper bags can be re-used.
	What happens to our waste after we throw it away?	Our waste goes to a landfill or an incinerator where it's either buried or burned
UNDERSTANDING	Can you explain the difference between re-using and recycling?	Re-using means using something again, while recycling means turning something old into something new.
	Why is it important to reduce waste by using less?	Using less helps protect the environment and conserve natural resources.
APPLYING	Can you give an example of how you can reduce waste at home or at school?	We can reduce waste by using a reusable water bottle instead of buying disposable ones.
	How can you re-use items like plastic containers or cardboard boxes?	We can re-use plastic containers to store leftovers or cardboard boxes for crafts.
ANALYSING	Why do you think some items cannot be recycled?	Some items cannot be recycled because they are contaminated or made of materials that can't be processed.
	Can you compare the amount of waste produced at home versus at school?	We produce more waste at school because there are more people, but we can reduce it by recycling a re-using.

	EVALUATING	Do you think recycling is an effective way to reduce waste? Why or why not?	Yes, because it gives old items a new life and reduces the need for new raw materials.
AFTER THE LESSON	**REMEMBER**	What are the three R's of recycling?	Reduce, Reuse, Recycle.
		Can you name some items that can be recycled?	Paper, plastic bottles, aluminum cans, glass jars.
	UNDERSTAND	Why is recycling important for the environment?	Recycling reduces waste in landfills and conserves natural resources.
		How does reducing waste help conserve natural resources?	By using less, we save energy and raw materials.
	APPLY	How can you reduce waste at home?	By using reusable bags, buying products with less packaging, and composting food scraps.
		Can you think of ways to reuse items instead of throwing them away?	Donate old clothes, repurpose containers for storage, or turn scrap paper into crafts.
	ANALYSE	What happens to our waste after we throw it away?	It gets sent to landfills or incinerators, or it may be recycled into new products.
		Why is it important to separate recyclables from non-recyclables?	So that recyclable materials can be processed and made into new products.
	EVALUATE	Do you think everyone should recycle? Why or why not?	Yes, because recycling helps protect the environment and conserve resources
		What are some challenges to recycling, and how can we overcome them?	Lack of awareness, limited access to recycling facilities, education and outreach programs can help overcome these challenges
	CREATE	Design a poster encouraging people to recycle.	Learners can draw a poster with messages and images promoting recycling.
		Create a plan for a recycling program at your school or in your community.	Learners can outline steps for setting up recycling bins, educating others, and monitoring progress.
DBE BOOK ACTIVITIES page numbers:	Page 55 to 59 Things that can make good compost. Recycling: Things that can be used to make useful things Making a compost heap – what can we use to make a compost heap		
LTSM - Flashcards: Scientific vocabulary	Recycle, reuse, reduce, water, recycled materials, new life, raw materials, protect, environment, plastic, glass jars, paper bags, newspaper, landfill, buried, burned containers		
E – resources USE OF TECHNOLOGY	https://youtu.be/OasbYWF4_S8 recycle reduce and reuse https://www.youtube.com/watch?v=Fex-wvrOZf4 https://youtu.be/u8MQwOR2og8 Discussions and Questions _Blooms		
LEARNER ACTIVITIES	Sort. Classify etc. Make a poster		

<table>
<tr><td>ASSESSMENT FOR LEARNING</td><td colspan="2">Teacher monitors the group activities to determine which learners may need support.
Activities given to support misunderstanding</td></tr>
<tr><td>INTEGRATION:</td><td colspan="2">HOME LANGUAGE:
Show and tell – Oral
Think-pair—share: Develop discussion, Questioning and sharing ideas
Make a poster and share your ideas with the class
Write a letter to your grandmother to tell her about what you learned about recycling
Alphabetise the vocabulary</td></tr>
<tr><td>TECHNOLOGY</td><td colspan="2">Make a desk tidy using recyclable materials
Research- Find an item you would like to make [GROUP ACTIVITY]
Design [Draw] the item
Collect the materials
Make the item
Evaluate your item- Discussion with different group presentations
Communication- Explain what they made, why they chose the material; would they change the material or design</td></tr>
<tr><td>VOCABULARY</td><td colspan="2">Match the words
Label the recyclable and non-recyclable materials</td></tr>
<tr><td rowspan="8">LEARNERS DEMONSTATE WHAT THEY CAN DO/ MASTERED OUTCOMES</td><td>I CAN OUTCOME</td><td>THE LEARNER DEMONSTRATION</td></tr>
<tr><td>Identify the three R's of recycling (Reduce, Reuse, Recycle).</td><td>Learners can verbally explain each R and provide examples of each.</td></tr>
<tr><td>Explain why recycling is important for the environment.</td><td>Learners can discuss the benefits of recycling, such as reducing waste and conserving resources.</td></tr>
<tr><td>Identify items that can be recycled.</td><td>Learners can list various materials that are recyclable, such as paper, plastic, glass, and aluminum.</td></tr>
<tr><td>Describe ways to reduce waste at home and at school.</td><td>Learners can provide examples of reducing waste, such as using reusable bags, avoiding single-use plastics, and composting food scraps.</td></tr>
<tr><td>Demonstrate proper sorting of recyclables from non-recyclables.</td><td>Learners can participate in a sorting activity and accurately separate recyclable items from non-recyclable items.</td></tr>
<tr><td>Create a simple poster or visual display promoting recycling.</td><td>Learners can design a poster with messages and images encouraging recycling and displaying the three R's.</td></tr>
<tr><td>Propose ideas for implementing a recycling program.</td><td>Learners can develop a plan for starting a recycling program at their school or in their community, including steps for education, collection, ar monitoring.</td></tr>
<tr><td>SCIENCE TABLE</td><td colspan="2">

We need to remember the three Rs.
Reduce: We should reduce our littering.
Re-use: We should re-use as many things as we can before throwing them away.
Recycle: We need to find ways of using paper, bottles and tins.
BINS OUTSIDE THE CLASSROOM TO ENCOURAGE THE REST OF THE PHASE TO RECYCLE</td></tr>
</table>

Appendix 12: Post-IP semi-structured individual interview schedule

Name:

Date:

Questions were posed to each NT (online interviews)

Interview Questions	Aim: To ascertain the NTs' preparedness, pedagogical practices, experiences, confidence and challenges teaching NS. This information will be utilised to ascertain their cognitive and affective growth during and after the IP.
20 to 30 minutes	Duration of the interview
Welcome and set the scene	
1	What pedagogical practices and Natural Science strategies are you implementing to teach Natural Science lessons after the intervention?
2	How confident are you now to teach NS after the intervention? Can you explain your experiences?
3	Are you experiencing any challenges teaching Natural Science? Please discuss these challenges.
4	When reflecting on the intervention program, are there any aspects you would like to add, modify, or that you found particularly effective and enjoyable?

Appendix 13: Post-IP semi-structured focus group interview schedule

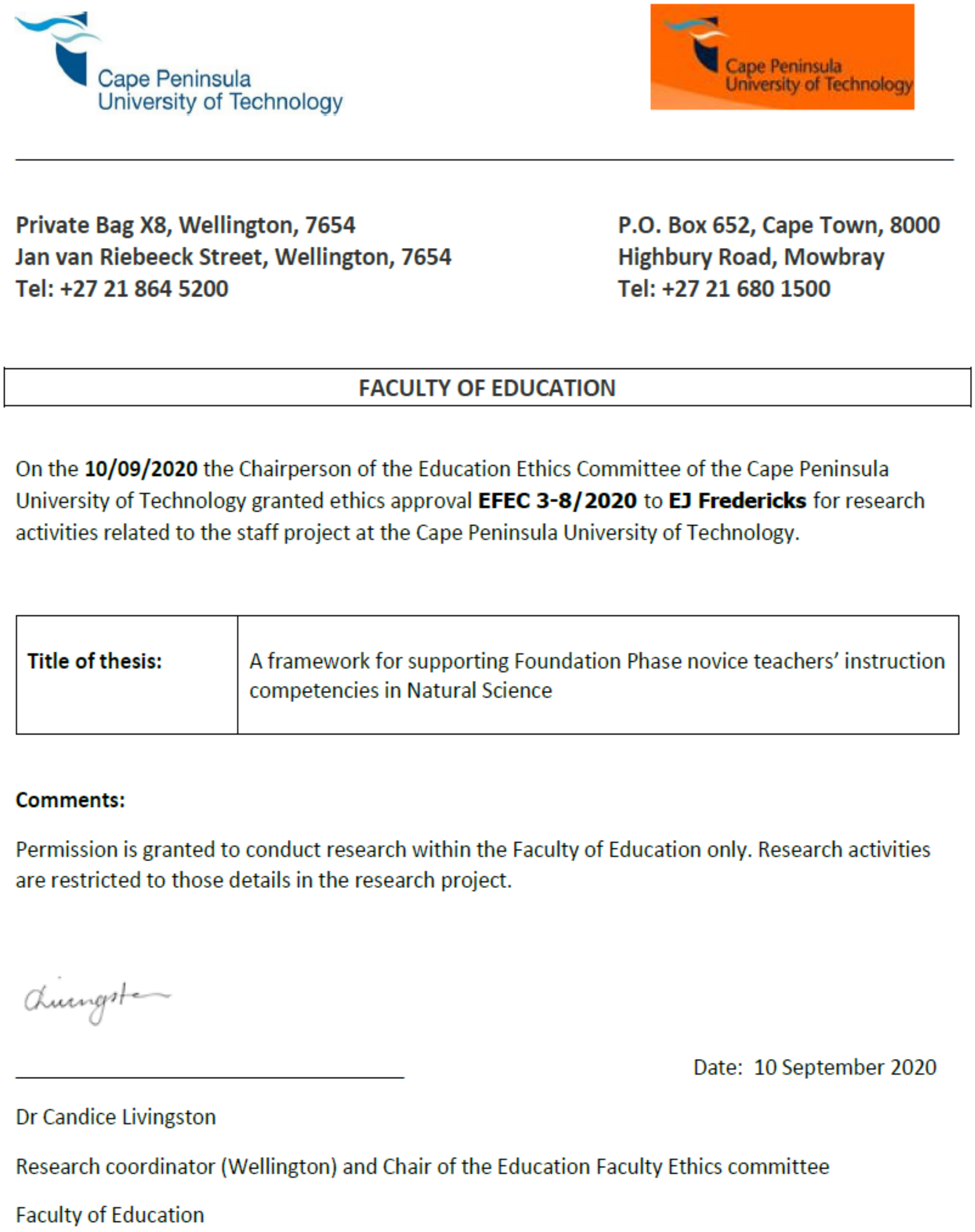
Name:

Date:

Questions are posed and NTs are asked to discuss each question. Researcher to interject when needed to steer the conversation**.** (Face-to-face)

Interview Questions	Aim: To ascertain whether the NTs were still enthusiastic about teaching Natural Science, their pedagogical practices and how their thoughts and feelings have evolved over the period of time. This information will be utilised to ascertain whether the NTs are sustaining their practice.
30 minutes	Duration of the interview
Welcome and set the scene	
1	Could we discuss the changes you've experienced in your teaching practice and how you feel you've grown as a teacher?
2	How has your thinking and teaching practices evolved over time, and what changes have you observed in your professional approach? Could you describe the experiences that contributed to this shift in your development as a teacher?
3	Would you please share any final reflections on your professional shifts, personal growth, and development throughout this period?

Appendix 14: CPUT Research Ethics Clearance Certificate



Private Bag X8, Wellington, 7654
Jan van Riebeeck Street, Wellington, 7654
Tel: +27 21 864 5200

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FACULTY OF EDUCATION

On the **10/09/2020** the Chairperson of the Education Ethics Committee of the Cape Peninsula University of Technology granted ethics approval **EFEC 3-8/2020** to **EJ Fredericks** for research activities related to the staff project at the Cape Peninsula University of Technology.

Title of thesis:	A framework for supporting Foundation Phase novice teachers' instruction competencies in Natural Science

Comments:

Permission is granted to conduct research within the Faculty of Education only. Research activities are restricted to those details in the research project.

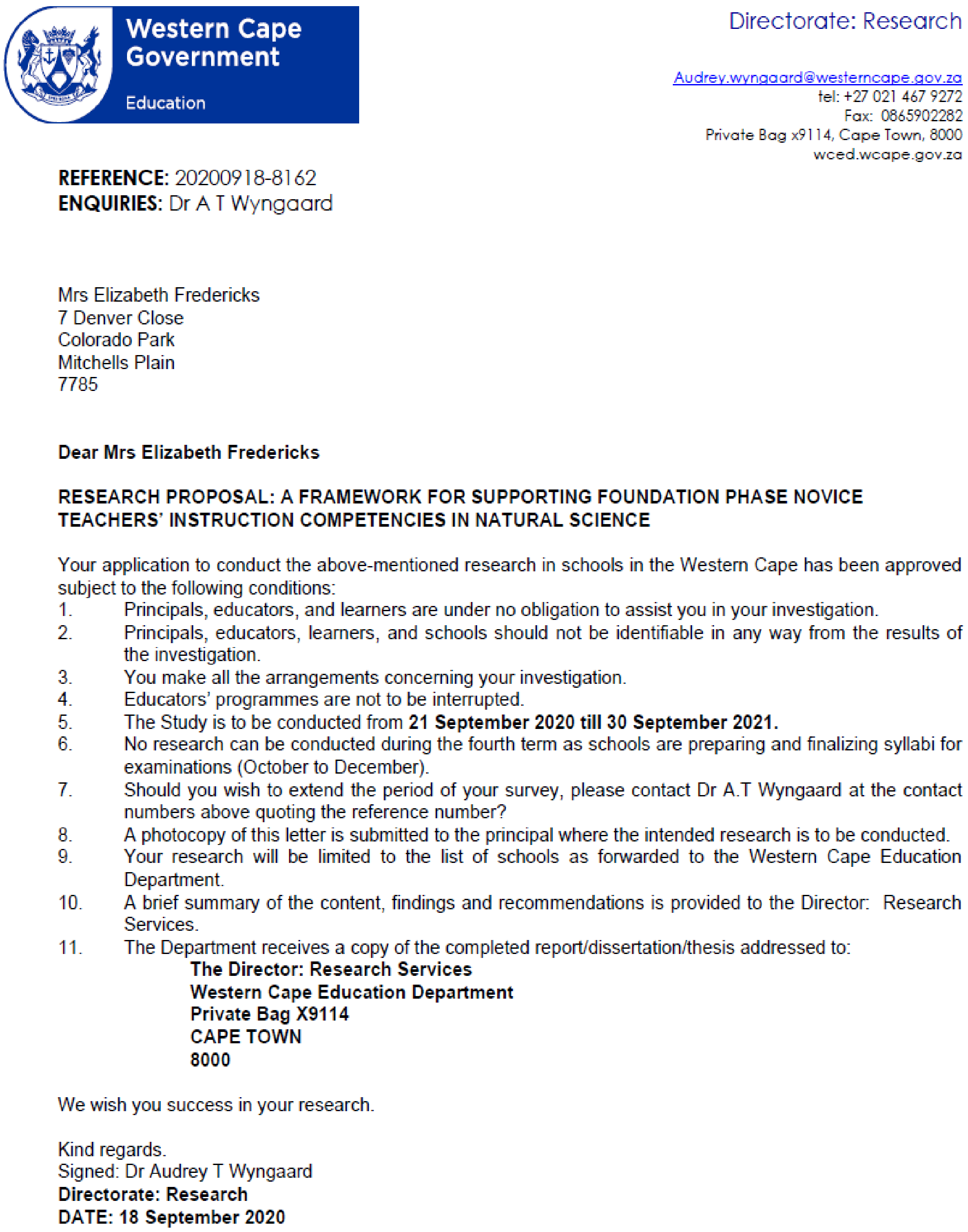
Date: 10 September 2020

Dr Candice Livingston

Research coordinator (Wellington) and Chair of the Education Faculty Ethics committee

Faculty of Education

Appendix 15: Western Cape Education Department research approval letter



Western Cape Government
Education

Directorate: Research

Audrey.wyngaard@westerncape.gov.za
tel: +27 021 467 9272
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Private Bag x9114, Cape Town, 8000
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REFERENCE: 20200918-8162
ENQUIRIES: Dr A T Wyngaard

Mrs Elizabeth Fredericks
7 Denver Close
Colorado Park
Mitchells Plain
7785

Dear Mrs Elizabeth Fredericks

RESEARCH PROPOSAL: A FRAMEWORK FOR SUPPORTING FOUNDATION PHASE NOVICE TEACHERS' INSTRUCTION COMPETENCIES IN NATURAL SCIENCE

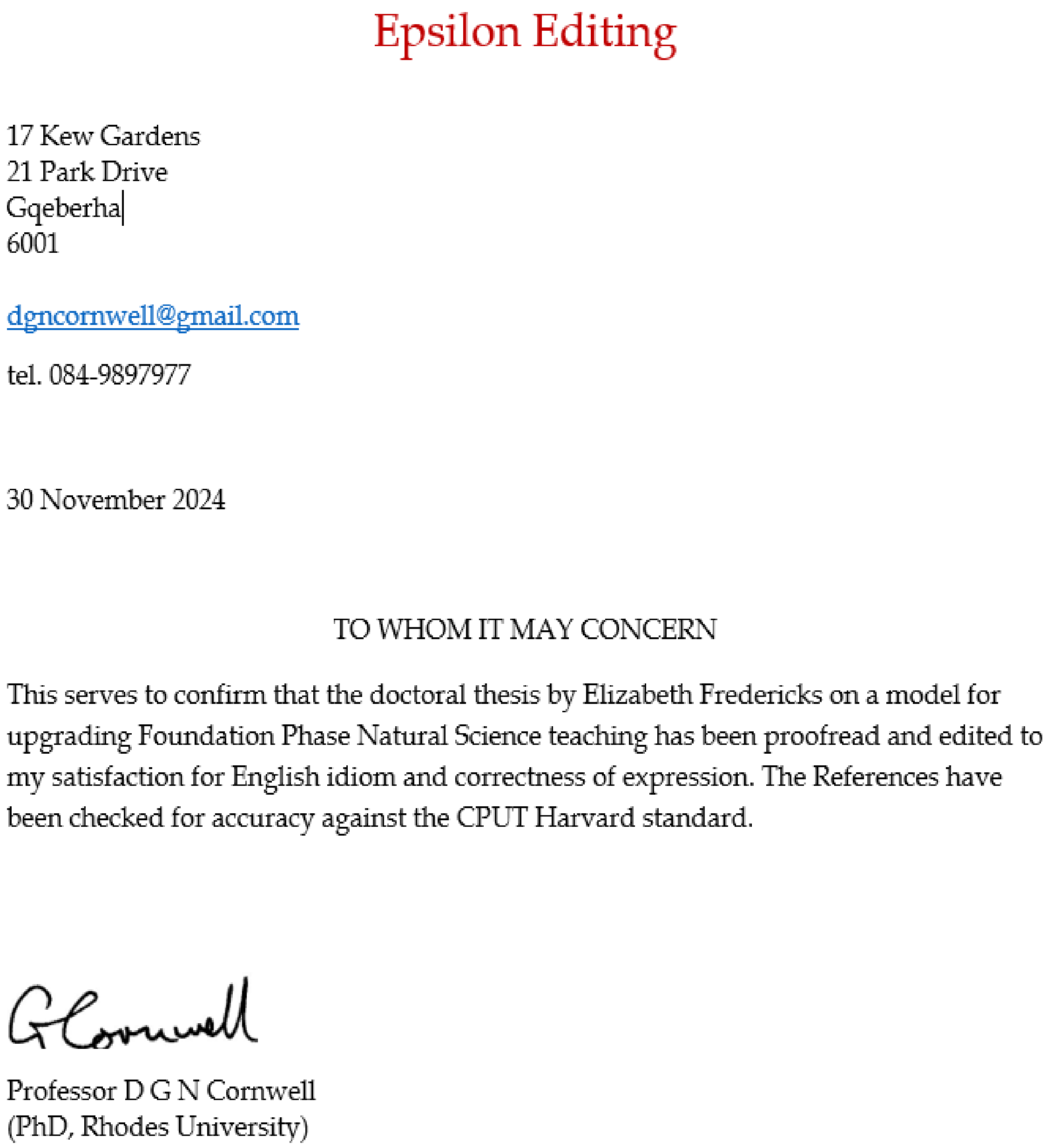
Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators, and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners, and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **21 September 2020 till 30 September 2021.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 18 September 2020

Appendix 16: Letter from language editor



Epsilon Editing

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30 November 2024

TO WHOM IT MAY CONCERN

This serves to confirm that the doctoral thesis by Elizabeth Fredericks on a model for upgrading Foundation Phase Natural Science teaching has been proofread and edited to my satisfaction for English idiom and correctness of expression. The References have been checked for accuracy against the CPUT Harvard standard.

G Cornwell

Professor D G N Cornwell
(PhD, Rhodes University)

Appendix 17: Letter from the South African Journal of Education

South African Journal of Education
Official publication of the Education Association of SA

Executive Editor: Prof. Ronél Ferreira

2024–10–18

Enquiries: Ms Estelle Botha
Administrative Editor
E–mail: Estelle.Botha@up.ac.za
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Fax: +27 12 420 5511
Web site: http://www.sajournalofeducation.co.za

To whom it may concern

This letter serves as confirmation that the manuscript entitled "Novice teachers' professional discourse on teaching Natural Science in the foundation phase in the Western Cape, South Africa" has been accepted for publication in the ***South African Journal of Education*** for the February 2025 issue. The authors are Elizabeth Joy Fredericks, Janet Condy, Carien Maree, Heather Nadia Phillips and Agnes Chigona.

Technical editing is expected to be completed by the end of March 2025.

The February 2025 issue will be finalised from 31 March 2025 onwards.

Yours faithfully

Ronél Ferreira
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0001
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