Let's Learn Together! A Mixed Methods Case Study of Nigerian Primary Teachers' Pedagogical Approaches

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Statements and Declarations

Declaration of Originality

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Statement of Ethical Conduct

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, as approved by the University of Tasmania Human Research Ethics Committee (reference number: H0017300) and the Ministry of Education, Plateau State, Nigeria (reference number: SUBEB/OFF.6VOL.1/17).

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Dedication

I dedicate this thesis to my beloved husband Dr. Ali Kidmas, and our amazing children Aaron, Eunice, and Esther.

This journey has not been easy, and I could not have achieved this without you all. Thank you all for your patience, for believing in me and for encouraging me to keep going.

To our children, I hope I have inspired you to continue working hard and following your dreams because it is possible! I will always be there to be your greatest cheerleader. I love you all so much!

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Glossary of Key Terms

Term	Meaning
Inquiry-Based Learning (IBL)	A constructivist approach to learning in which students develop the ability to make meaning about the world through their direct interactions and investigations (Chen & Tytler, 2017; Harlen, 2013b; Llewellyn, 2014)
NCE	Nigeria Certificate of Education. It is the minimum teaching qualification in Nigeria (National Teachers Institute, [NTI] 2017).
Pedagogical Interactions	Pedagogical interactions include the teacher's deliberate choices of words and actions to generate a response by students in words and actions that relate to the learning process
Relief/Substitute/Casual Teachers	These are registered teachers who can teach when the regular teacher is absent for a certain period (Lunay & Lock, 2006; McCormack & Thomas, 2005).
Procedural Interactions	Instructions that teachers give students and expect them to carry out
Scientific Literacy	"the capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions to understand and make decisions about the natural world and the changes made to it through human activity" (Organisation for Economic Co-operation and Development [OECD], 1999, p.60).
Student Agency	The idea is that students have a voice and can make decisions about their learning; they take on an active role in their education (OECD, 2021).
Student-centred/Learner-centred	A classroom learning environment that considers the role of the student in the learning process; learner-centred is the term I use in this thesis as it indicates that both teachers and students adopt a learning mindset
Sub-Saharan Africa	African countries that are located at least partially south of the Sahara Desert and includes Sudan (United Nations, 2003).

List of Acronyms

Acronym	Meaning
ACARA	Australian Curriculum Assessment and Reporting Authority
BEC	Basic Education Curriculum
5Es	Engage, Explore, Explain, Elaborate and Evaluate
FME	Federal Ministry of Education
LGA	Local Government Area
MDGs	Millennium Development Goals
NEEDS	National Economic Empowerment and Development Strategy
NTI	National Teachers Institute
NoS	Nature of Science
NERDC	Nigerian Educational Research and Development Council
NPC	National Population Commission
NPE	National Policy on Education
NPST	Nigerian Professional Standards for Teachers
OECD	Organisation for Economic Co-operation and Development
PAR	Participatory Action Research
PCK	Pedagogical Content Knowledge
PL	Professional Learning
QDAS	Qualitative Data Analysis Software
RP	Researcher Participant
SGRs	Student-Generated Representations
STEM	Science, Technology, Engineering and Mathematics
TaL	Teacher as Learner
TPs	Teacher Participants
TRCN	Teachers Registration Council of Nigeria
UBE	Universal Basic Education
WEF	World Economic Forum

Abstract

This study set out to explore current teaching practices in Nigerian primary classrooms through the lens of science education. I chose science education because it is globally recognised as an important avenue for national development. Research indicates that teachers play a vital role in students' engagement and understanding and that effective science pedagogy reflects a shift from teacher-centred to learner-centred inquiry approaches, in which students learn to appreciate the relevance of science to their lives. However, the strategies teachers adopt can be influenced by many factors, including the learning environment, curriculum, cultural, political, and historical factors.

The case study took a sequential mixed-methods approach, incorporating Participatory Action Research (PAR). Phase one (quantitative) comprised an initial questionnaire sent to a broader group of primary teachers in schools in the Local Government Area (LGA), in which the study was conducted. The quantitative data were analysed using descriptive statistics to assess the internal consistency of the dataset. I also used the Mann-Whitney U and Kruskal-Wallis tests as non-parametric methods to look for any statistically significant relationships between selected data variables. The data from the first phase gave a sense of the teachers' general views and beliefs about teaching science and the approaches they utilised and informed the design of the second phase (PAR) and the choice of participants. In this second phase, qualitative data were obtained through classroom observation, conversations, and reflections with teachers in selected primary schools to better understand the actual teaching practices used in science and to identify any support needs. The qualitative data were thematically analysed.

The findings showed a mismatch between what research suggests as effective science teaching and the actual practices of Nigerian Primary Science teachers. While the teachers claimed to use learner-centred and practical experiences in their classrooms, the study revealed that their existing classroom practice did not match those claims, as traditional didactic, teacher-centred approaches were prevalent.

I identified teachers' support needs through reflective discussions and then designed a professional learning (PL) program. I also supported the teachers to make small changes to incorporate more inquiry-based learning strategies. The research showed that teachers had limited or no access to relevant PL in science. Furthermore, when teacher PL was tailored to their needs, the teachers became active participants, willing to try new classroom strategies.

Further research into longer-term support would help teachers develop their expertise by designing lesson plans and units of work that take an inquiry-based approach. The impact of these lessons on student learning could also be more comprehensively assessed.

During this phase of the research, a range of significant contextual challenges emerged, including systemic issues, poor infrastructure, and community tensions. Political unrest affected the planned methodology and caused the second phase to be curtailed. This provided unexpected but important insights into conducting research in Nigeria, which may have implications for other researchers working in developing countries. It further revealed the benefit of the PAR methodology in enabling me as the researcher to adjust my plans in response to these unforeseen circumstances.

Keywords: Pedagogical Approaches, Inquiry-Based Learning (IBL), Participatory Action Research (PAR), Mixed Methods, Cultural Context, Disruption, Professional Learning (PL)

Stage One: Genesis

Here, I explain the thesis structure, provide an overview of how I organised the key ideas, and clarify the thinking process that guided this write-up.

Instead of a conventional structure, I choose to present my research in a form more suited to the narrative that emerged during the study's stages, particularly the PAR stage. Some headings reflect the cyclical action inquiry processes of *Observation, Reflection, Planning and Action* (Kember & Corbett, 2018; McNiff, 2015), which occurred in three main stages.

The first stage, ***'Genesis'***, commences with **Chapter 1**, which identifies and explains 'the stone in my shoe' (Corbett & Hill, 2018) that instigated my learning journey and my adaptations to challenges along the way.

The literature review is divided between **Chapters 2** and **3**. **Chapter 2** explains the research context by providing a broad contextual background of teaching and learning of Primary Science in Nigeria. It progresses to explore what constitutes effective contemporary Primary Science teaching and learning approaches and provides the rationale for choosing science for this research in **Chapter 3**. The literature review in these chapters was not only to understand what has been documented about the research area, if anything, but to identify the gaps relevant to the Nigerian context. The process of reviewing the literature is further interwoven throughout the research as new ideas emerged from the findings (Kember & Corbett, 2018).

The **fourth chapter** provides an overview for the choice of case study approach using sequential mixed-methods and PAR as a methodology that seeks to generate knowledge of real-world problems and promote change in thinking and practice (O'Leary, 2017; Yin, 2018). This study sought to explore Nigerian Primary Science teachers' pedagogical approaches and work collaboratively with them to identify their strengths and address challenges or gaps that may be a hindrance to utilising effective science teaching approaches. Because of this, I deemed a PAR approach to be appropriate.

Stage Two: Analysis and Interpretation of Data commences with **Chapter 5**, which provides the analysis and results of the quantitative part of the research. I conducted this quantitative research first to give a broader understanding of the teaching and learning approaches within a selected geographical area. This first phase of the study also facilitated deciding the schools to be involved in the PAR phase.

Chapter 6 provides some contextual understanding of the two schools involved in the study. In **Chapter 7**, I describe the initial classroom observations of teacher practices. Further, I discuss the themes that emerged from these initial classroom observations. **Chapter 8** describes the process of reflection with teacher participants (TPs). The reflective discussions provided an avenue to further understand the TPs' perspectives about their practices and helped identify their PL needs. Chapter 8 further describes the political unrest that disrupted the study and called for re-planning, demonstrating PAR's non-static and highly pragmatic nature. I further discuss the role of reflective practice in understanding the TPs' perceptions and practices and identifying strengths and gaps in those practices. Through the provision of professional learning (PL), described in **Chapter 9**, TPs were supported to identify and plan strategies to continue developing their teaching expertise. I also explored teachers' use of inquiry-based learning (IBL) techniques. **Chapter 10** discusses the impact of the PL sessions and how they assisted in bridging the identified gaps. Furthermore, I also discuss the small shifts teachers made in their thinking and practice in developing their expertise and how they were supported in this process.

In **Stage Three: '*Personal Reflections of the Researcher and Recommendations*',** the last chapter (**11**) captures my reflections and growth through this research process. Further, I proffer recommendations for curriculum development, science teaching and learning, and teachers' professional learning, and for processes used to support teachers in developing expertise.

Chapter 1

My Journey of Learning and Adaptation

1.1 The ‘Stone in my Shoe’

Quickly we rushed to beat the traffic to be at school in time for assembly at 8 am; otherwise, the ‘school police’ would get us. Who were the school police? Senior students in primary six were appointed to catch latecomers and then assign various chores around the school as punishment. I remember having to miss classes a few times to clean the toilets or cut the grass around the schoolyard for that offence. After the whole-school assembly, where our nails were checked and general neatness was evaluated, we would be excused to go with our class teachers. If we did not appear neat, we would get punished with a ‘good spanking’ or ordered to pick up trash around the school.

Sitting in rows of our peers at our desks was the setup for all my childhood classes in Nigeria. What I had not realised then was that this arrangement was ‘luxurious’ and something I owed to my parents' commitment to providing a good education for my siblings and I. I attended a private school, the University Staff School, so we had such basic facilities. However, that was not the case for many children whose parents could not afford to send them to private schools. Generally, state public schools in Nigeria were poorly resourced, and many facilities were absent or dilapidated. So, I was among the privileged few to have these very basic amenities available for learning, and I was learning from day one (or at least, so the teacher thought), the teacher writing notes on the blackboard, and we students copying them into our notebooks. The teacher expected that we would go home and read those notes as homework. Tests were mainly in the form of ‘fill in the gaps’ in the copied text. It was, therefore, important to memorise the text to write the correct words.

Passing tests and then final exams at the end of each term was the goal, especially at the end-of-year exams if you didn’t want to repeat a class. Repeating a year level was a sign that you were not smart enough. Before then was the red pen on the report card (probably why I don’t like red pens); red ink on your report card meant you got below 50 per cent and had failed that subject. It felt quite shameful!

My secondary schooling was partly in Nigeria and partly in Kenya, as my family had relocated there. Secondary school education was not much different from primary, except that we had some choice of subjects. I chose a mixture of things based on what I thought I was good at and on which teacher would teach them. Chemistry and Biology were among my choices because I thought they would provide me with opportunities to experiment. I soon changed my mind as I struggled to keep up with the many hard words and drawings I had to do. This wasn’t Art, was it? I had given up on Art after the teacher remarked that my still life drawing did not resemble anything close to what I was instructed to draw. So, biology was off, and I took history instead, and though I was stuck with remembering dates, at least some of the events that occurred were interesting. I wondered why such things could happen, or how they ended, and that curiosity kept me going.

At the tertiary level, learning was also teacher-centred. Students had to buy the lecturer's handouts, cram them, and regurgitate what seemed like knowledge during exams to pass. There were limited or no opportunities to think critically or apply what we had learned. It was difficult to understand the relevance, so it was easy to forget. Within this system, those who were naturally 'smart' seemed to thrive, and teachers celebrated them, while the rest of us seemed to be left by the wayside, feeling lost.

My understanding of learning changed when I decided to become a teacher after my husband and I relocated to Tasmania, Australia, for work purposes. I was excited but was soon faced with the pedagogical adjustments I had to make. The learning approaches here were more student-focused. There was an expectation that I will be actively involved in my learning by questioning and challenging ideas and researching and sharing my opinions. I was even expected to question the information in textbooks or offered by my tutors and lecturers. These were unfamiliar practices to me, and I needed to learn quickly. The differences in learning approaches between the two cultures made me realise that there is more than one way to engage students in learning.

My first Science unit during my pre-service teaching degree re-ignited my interest in that subject. I came home that day after the tutorial and said to my kids, "You know, if I learned science the way I am learning to teach it, I would have been very smart." I told my children how I loved science but never really understood many of the things we were taught and did not see its relevance.

Due to these pedagogical differences, I became intrigued by how recent migrant school students adjust to the learning and teaching environment in Australia. I thought the adjustments I made might have been because my education in Nigeria was during the 1980s and '90s, and I thought that current students' experiences would have differed from mine.

This 'stone in my shoe' led to my honours research on how Nigerian-Australian secondary school students in Tasmania adapted to new pedagogical practices by exploring their perceptions of teaching practices in their immediate schooling context (Tasmania). The study revealed that the pedagogical approaches that teachers in Nigeria adopted were quite similar to those I had experienced and quite different from those in Tasmania (Kidmas, 2014; Kidmas et al., 2017).

According to the students, their Nigerian teachers used approaches that were reliant on the teacher as the primary source of knowledge, with students being the recipients of that knowledge. The students revealed that their Tasmanian schooling context allowed for more student-centred learning individually and in groups. Though not without its challenges, they described the teaching and learning as more relaxed and said it provided opportunities for deeper understanding. The students commented that they appreciated the varied teaching approaches of their Tasmanian teachers. One such strategy was to provide opportunities for self-exploration of the content through research, small group discussions, and sharing of their findings.

Although many factors such as resilience, culture, language, and friendships played a role in students' adjustments to a new environment, the teacher's approaches to learning and teaching consistently and significantly affected students' adaptation (Bitew & Ferguson, 2012; Kidmas, 2014; Kidmas et al., 2017). Teachers' pedagogical choices in engaging and retaining students' interests are therefore crucial in any cultural setting.

Upon graduation, I secured a teaching position. One of my goals was to be the teacher who inspired my students to learn and to challenge me. I was willing to learn *with* my students, admitting that I do not have all the answers. I wanted my students to be empowered, take ownership of their learning even in those early years, and see the relevance of what they were learning. So, I always welcomed and encouraged students to ask ‘why’ in my classroom, even though it was sometimes annoying! Through my discussions and observations, my students’ feedback, and their assessment of their learning, I could see that they were growing in their thinking. This growth was not only evident for my students but also for me as a teacher.

As a primary school teacher in Australia, I am expected to teach all subjects. I remember that when I shared the subjects I enjoyed with my students and those I found challenging, I mentioned Art as one of the challenging subjects. I told them, though, that I was willing to learn, and they could teach me. After a series of Art lessons, one of my then Grade Four students commented, “Mrs Kidmas, you said you are not good at Art.” I said, “Yes, I thought so, but you have taught me—we learned together!”

The ‘stone in my shoe’ kept niggling at me as I thought about my role as a teacher and reflected on my learning, my students’ learning, and lessons from the student participants in my honours research. I wanted to find out, and I wanted to know how Nigerian primary teachers are teaching and why they were teaching that way. The initial review of Nigerian literature revealed that instructional methods were a key factor in students' low interests and achievements in science (Afolabi, 2013; Hardman et al., 2008; Oludipe, 2011). This accorded with my observations in my honours’ study. The literature review also revealed scholars calling for pedagogical renewal to improve the quality of Universal Basic Education (UBE) in Nigeria (FME, 2014, Hardman et al., 2008; NPE, 2013; Sunal et al., 2009). The introduction of the UBE policy led to rapid growth in demand for teachers, resulting in the employment of many underqualified teachers. Although the intention was to up-grade their expertise through PL to meet the demands of 21st century learning, the observations above indicated there may be problems with the implementation of the UBE and/or the PL program.

This study seeks to explore first-hand; how Nigerian primary science teaching occurs and how the teachers could be supported to improve their pedagogical approaches to enhance student outcomes. This commences by identifying how they are currently teaching, what their needs are before suggesting and implementing changes. I wanted to support them in any little way I could, and this sparked my PhD journey. I embarked on this research with the belief that the teacher is in a pivotal position to support students in creating a narrative of student empowerment.

1.2 Significance of the Research

This study is significant for three main reasons. Firstly, the Nigerian Educational Research and Development Council [NERDC) policy (2013) is for students to acquire 21st-century learning skills. I sought to understand how Nigerian teachers are implementing this policy and how they are preparing their students to develop these skills. I sought to understand how teachers supported their students to be active and engaged learners who can make informed personal and societal decisions. Specifically, the study focuses on whether Nigerian primary teachers in teaching science utilise contemporary teaching and learning approaches.

I chose to explore this question through science because the subject supports the development of 21st-century skills that are needed in our rapidly changing. These skills include critical thinking, creativity, problem-solving, communication, collaboration, personal and social skills, and information technology skills. Increased globalisation, competition, advanced technological and scientific innovations (Bybee, 2010b; OECD, 1999) are all products of these skills. I also wanted to find out how the teachers see their role as science teachers and their students' roles in learning science.

Secondly, I explored the teaching practices of Nigerian primary teachers through a constructivist lens to understand their current practices. Furthermore, to understand how these practices may support the development of scientific literacy, encouraging students to make informed personal and societal decisions (Fitzgerald & Schneider, 2013; Hackling et al., 2007; Murcia, 2009, OECD, 2017).

Thirdly, my study explored avenues available for teacher professional learning (PL) in a Nigerian context. The aim here was to examine the literature on teacher PL, including research on science teaching in Nigeria and the teachers' perceptions of their strengths and any areas for improvement in teaching science.

This part of the study involved working with teachers to trial and evaluate an in-service PL program to explore the opportunities to offer teachers an effective PL suited to the Nigerian context and supporting the country's curriculum requirements.

1.3 Theoretical and Conceptual Underpinning

Vygotsky's social constructivist learning theory posits that learning is a social and cultural construct (Vygotsky, 1978). This theory underpinned the research to examine how inquiry learning occurs within a particular educational and sociocultural context. Within the Nigerian primary school context, various researchers have identified the didactic instructional method used as a critical factor in students' low interest and achievement in science-related subjects (Afolabi, 2013; Hardman et al., 2008; Oludipe, 2011).

Focusing on effective science teaching, this research sought to explore and reflect on contemporary science teaching practices as described in the literature compared with those advocated in the Nigerian curriculum and applied in practice by Nigerian primary teachers. I aimed to work with practising teachers to identify their strengths and areas needing improvement and how they might be supported in that process.

Figure 1.1 below shows the framework that guided this study. The framework provided a structure for examining the key educational issues facing Nigerian primary school teachers and the pedagogical approaches they utilised in teaching science. The framework also outlines questions on the TPs' perceptions about science and their roles as science teachers. The need for ongoing professional learning and how teachers could be supported to develop their expertise is also outlined. The framework maps how I intended to address each research question to achieve the aims of the research. It was important that I constantly review this framework throughout the research process.

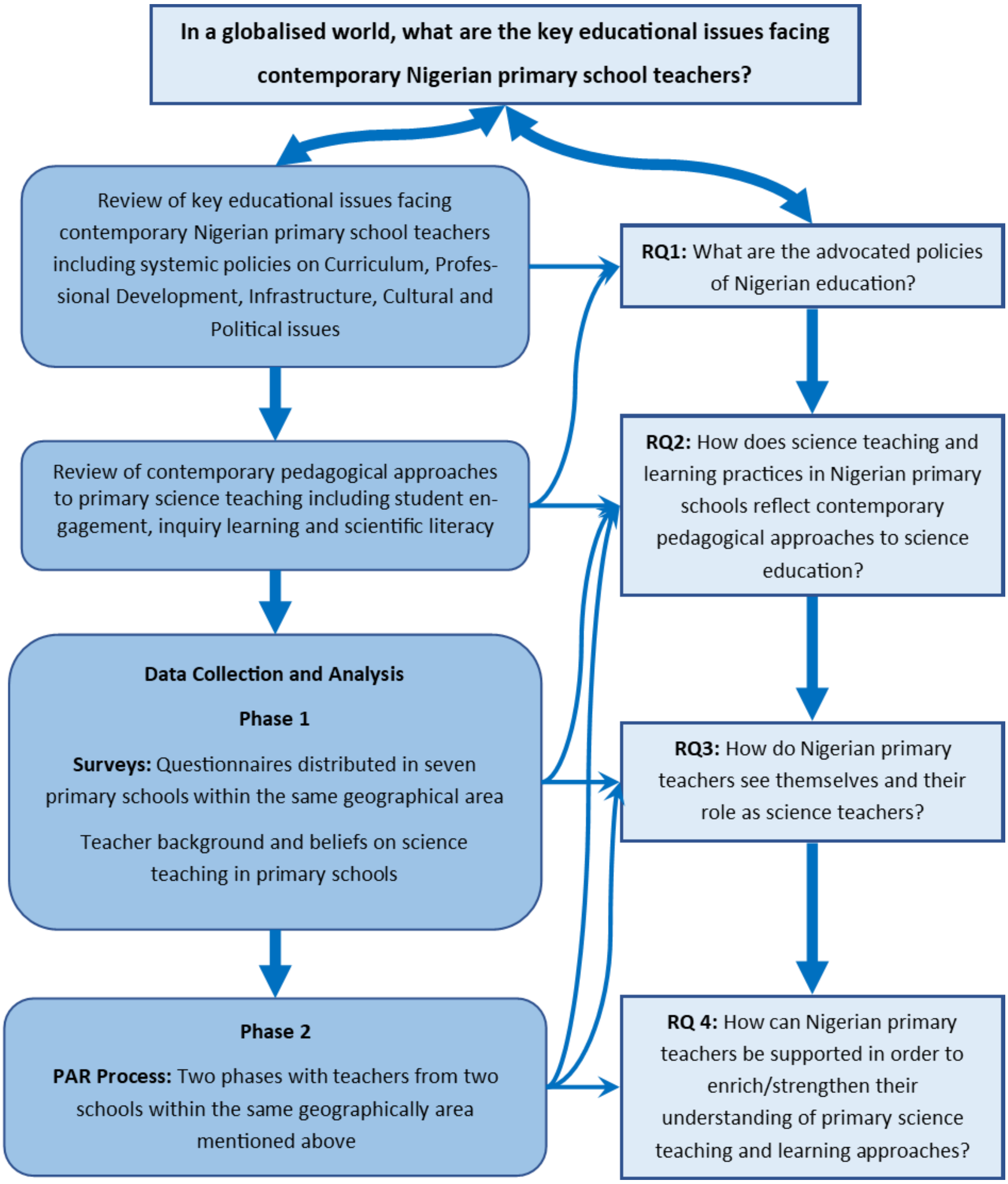

Figure 1.1 Conceptual Framework

1.4 Research Aims and Objectives

My research had the following aims and objectives:

- To investigate the teaching approaches of Nigerian primary teachers in supporting their students to be active participants in their learning process through the lens of effective science teaching practices.
- To investigate how these practices are applied in Nigerian Primary Science classrooms.
- To provide opportunities for Nigerian primary school teachers to reflect upon their practices and consider pathways or professional learning to develop their expertise in science teaching and learning.

1.5 Research Questions

I used the following research questions (RQs) to provide insight into the difficulties Nigerian teachers face, the pedagogical approaches they predominantly use, and to identify how the teachers could be supported to enrich their practices. The overarching question is:

In a globalised world, what are the key educational challenges facing contemporary Nigerian primary school teachers?

There are also the following sub-questions:

1. What policies are advocated in Nigerian education?
2. How do science teaching and learning practices within a Nigerian cultural context reflect contemporary pedagogical approaches to science education?
3. How do Nigerian primary teachers see themselves and their role as science teachers?
4. How can Nigerian primary teachers be supported to enrich/strengthen their understanding of effective Primary Science teaching and learning approaches?

1.6 Summary

The power and influence of a teacher cannot be overstated. In this chapter, I have tried to recall my own teaching and learning experiences, how I adapted to these as a student, and how I relate to current teaching practices in Nigeria. This journey spanned from my childhood years into adult life at university as a student, teacher, and now researcher. I have been empowered to think about my learning and the learning of my students and other students, including newly arrived migrants from cultural backgrounds like those in my honours research. Teaching and learning, I believe, is not something to be done *to* students but an opportunity to provide a positive and supportive environment where students are challenged to think and take ownership of their learning, identifying their strengths and areas for improvement.

When I think about my years of schooling in Nigeria and Kenya, I believe there are many aspects to celebrate in the approaches to teaching and learning utilised then. However, the more I reflected, the more I thought of the unique position of the teacher to model the desire for ongoing learning by reflecting on their practice and taking steps to make learning relevant to students. This awareness prompted my desire to learn more about Nigerian primary teachers' practices, to celebrate and support them in embracing their unique role.

In the next chapter, I review the literature to understand the nature of education in Nigeria with specific reference to primary school education. I explore the Nigerian curriculum with a focus on Primary Science to understand the nature and structure of the curriculum and curricular expectations. I focus on science teaching and learning because this was a subject area where the teaching approaches I was exposed to during my pre-service teaching years re-ignited a love for the subject. But maybe, more importantly, I look to science as a subject globally and nationally recognised as fostering individual and societal development. Further, I seek to understand the educational issues teachers face in the Nigerian context that impacts effective teaching practice.

Chapter 2

Contextual and Historical Positioning

In this chapter, I explore the literature to understand the key educational challenges facing contemporary Nigerian primary school teachers. The chapter begins with descriptions of Nigeria, Plateau State, and the Nigerian education system, focusing on primary education. Subsequently, I will justify my use of science as a vehicle to explore teaching and learning practices in Nigerian primary schools by first reviewing what science is and the goals and aims of Primary Science education internationally and nationally. I review relevant Nigerian policies on education, including the national curriculum, to understand the place of and need for science within this context. Further, I explore initial teacher education, professional standards, and PL opportunities for teachers in Nigeria to understand how they are supported to develop their expertise.

2.1 Nigeria

Nigeria is a West African country bordering Benin, Chad, Niger and Cameroon, and Guinea. It is Africa's most populous country, with over 190 million people. Nigeria displays a rich ethnocultural diversity with more than 350 distinct ethnic groups and over 500 indigenous languages. The three main languages are Hausa, predominantly spoken in the north, Yoruba in the south, and Igbo in the eastern states (Nigeria Population Commission [NPC], 2021). Although various dialects are spoken, English is the official language and the language of instruction in schools, which serves as a unifying force in a multilingual nation (Afolayan, 1984; Fakaye, 2014). Nigeria has an abundance of natural resources. It is the largest oil producer and has the largest natural gas reserves in Africa. Christianity and Islam are the two major religions with a smaller percentage practising indigenous religion. Nigeria has 36 states, and Abuja is the country's capital (World Bank, 2020).

2.2 Plateau State

This research was conducted in Plateau State, Nigeria. Plateau State is the twelfth largest of the 36 states in Nigeria. It is located in the country's middle belt. It is surrounded to the north by the mountainous Jos Plateau. Plateau State has a population of about 3.5 million people with a temperate climate averaging between 18 and 22 degrees Celsius (Plateau State ICT Development Agency, 2017). Plateau State is well known and celebrated as the 'Home of Peace and Tourism.' Many visitors are attracted by its cooler climate and come to enjoy its natural wonders, such as its beautiful hills, waterfalls, and captivating rock formations. Jos is the capital, with 17 Local Government Areas (LGA), and borders Bauchi, Kaduna and Nasarawa States.

2.3 The Nigerian Education System

Formal education, which commenced in the mid-19th century, was administered by Christian missionaries (1843–82) and the British colonial government. During this time, it focused mainly on reading, writing and arithmetic (Fanfunwa, 1976). After gaining political independence in 1960, the Nigerian government shifted its expectation for the education sector to develop a highly trained workforce to power the socio-economic development of the nation (Amaghionyeodiwe & Osinubi, 2006). The government soon recognised that for the education system to cater to the new nation's aspirations, it was necessary to expand the curriculum to be more inclusive of the needs of Nigerian society. Various committees were established to develop the curriculum, which led to the establishment of the National Policy on Education (NPE) in 1977, revised in 1981, 1989, 2004, 2007 and most recently in 2013. In 2004, the passing of the *Universal Basic Education (UBE) Bill* (Oni, 2009) was a catalyst for introducing a basic, compulsory, universal and free nine years of education for all Nigerian children, irrespective of their socio-economic background (Oyeleke & Akinyeye, 2013).

The Basic Education Curriculum (BEC) was revised in 2014 to provide a more coherent structuring of subjects with the aim that, upon the completion of nine years' basic education, a Nigerian child should have developed the appropriate foundational levels of literacy, numeracy, communication, and critical reasoning for ongoing learning (Ajeyalemi & Ogunleye, 2009; Asodike & Ikpitibo, 2014). The underlying educational structure to support this comprised the:

1. Lower Basic Education Curriculum (Primary 1–3)
2. Middle Basic Education Curriculum (Primary 4–6)
3. Upper Basic Education Curriculum (Junior Secondary 1–3)

The nine-year structure was also designed to ensure that students remained in school throughout. Upon attainment of the nine years basic education, students were expected to take an entrance exam to proceed to Senior Secondary School (SSS) to complete a further three years (Ajeyalemi & Ogunleye, 2009).

Nigeria has tried to align its NPE with global challenges and educational trends, particularly the United Nations Millennium Development Goals (MDGs) and the National Economic Empowerment and Development Strategy (NEEDS). The Nigerian educational goals, as identified within the NPE, are to:

- Ensure and sustain unfettered access and equity to education for the total development of the individual;
- Ensure the quality of education delivery at all levels;
- Promote functional education for skill acquisition, job creation and poverty reduction;
- Ensure periodic review, effectiveness and relevance of the curriculum at all levels to meet the needs of society and the world of work;
- Collaborate with the development partners, the private sector, non-governmental organisations, and local communities to support and fund education; and
- Promote information technology capability at all levels (NERDC, 2013, p. 2)

2.4 Primary Education in Africa and Nigeria

Based on Goal 2 of the Millennium Development Goals (MDGs) (United Nations (UN), 2015), which advocates for universal compulsory primary education, a significant amount of research has been conducted into primary education and its provision to all children in Africa (Anero, 2014; Oni, 2009; Sunal et al., 1989; United

Nations Economic Commission for Africa (UNECA), 2015). The drive for free primary education has significantly improved the number of children attending primary schools (African Development Bank Group (ADBG), 2017). However, with such an increase in numbers comes the challenge of assuring the quality of the education provided. Literature has identified various factors such as dilapidated facilities, lack of resources, large class sizes, teachers' inadequate pedagogical content knowledge, and lack of professional learning opportunities as factors that have negatively impacted students' learning outcomes (Afolabi, 2013; ADBG, 2017; Ajeyalemi & Ogunleye, 2009; Asodike & Ikpitibo, 2014; Dembe´le´ & Lefoka, 2007; Sunal et al., 1989). These factors can also reduce students' engagement.

The following are the objectives for primary education in Nigeria, as stated in the National Policy on Education (NERDC, 2013, p. 7):

a. Inculcate permanent literacy, numeracy and the ability to communicate effectively;
b. Lay a sound basis for scientific, critical and reflective thinking;
c. Promote patriotism, fairness, understanding and national unity;
d. Instil social moral norms and values in the child;
e. Develop in the child the ability to adapt to the changing environment; and
f. Provide opportunities for the child to develop life manipulative skills that will enable the child function effectively in the society within the limits of the child's capability.

To achieve these goals, researchers call for learner-centred activities in which teaching is "practical, activity-based, experiential and IT-supported" and "special provisions and incentives shall be made for the study of the sciences at each level of the education system" (NERDC, 2013, p. 2). How effectively these goals are implemented formed part of my observations during this research.

Dembélé and Lefoka (2007) advocate for pedagogical renewal to improve the quality of universal primary education in Africa. Their argument has been supported by research in primary classrooms in other African countries, including Botswana (Fuller et al., 1991), Kenya (Archers & Hardman, 2001; Hardman et al., 2009), Tanzania (O-saki & Agu, 2002), Zambia (Hennessy et al., 2016) and Nigeria (Ajeyalemi & Ogunleye, 2009; Hardman et al., 2008; Onocha & Okpala, 1990; Sunal et al., 2009). Based on their findings on classroom interactions and teaching practices among Nigerian primary school teachers, these scholars have found that teacher-centred approaches—primarily rote learning with little attention paid to students' understanding—still dominate. The student's voice is almost lost or only heard when choral responses are elicited. These researchers confirm that little research has been conducted into classroom practices of teachers in Nigerian primary schools and the provision of PL to support their pedagogical choices (Ajeyalemi & Ogunleye, 2009).

My study aimed to address this gap, firstly by observing Nigerian primary teachers in their classrooms. If it had confirmed the above findings, the study would have explored how to support teachers to adopt more learner-centred pedagogical approaches in their practice to achieve the desired outcomes of the NPE.

2.5 Science: A Vehicle to Explore Nigerian Primary Teachers' Pedagogical Approaches

I have chosen science as the vehicle to explore the pedagogical approaches of Nigerian primary teachers for several reasons. Firstly, science has been recognised globally as having a significant impact on our everyday lives, being key to many innovations and advancements in many fields (Harlen & Qualter, 2018; United Nations (UN), 2020; United Nations Educational Scientific and Cultural Organization (UNESCO, 2019). Science is therefore considered an essential subject for all students to develop a basic understanding of the world. Many countries have recognised the significance of science learning as a means of national advancement and have thus prioritised it as a key curriculum area (Australian Curriculum Assessment and Reporting Authority (ACARA), 2017; National Teachers Institute Nigeria (NTI), 2020; NERDC, 2013).

Secondly, science is a way of thinking about the world (Skamp, 2015). Encouraging students to learn science is essential to nurturing their natural curiosity as they develop critical, creative, and problem-solving skills to address personal, community and global problems (Harlen & Qualter, 2014; Rennie et al., 2001). Learning and developing scientific knowledge and skills is necessary in understanding our world and how it works (Harlen & Qualter, 2014).

Thirdly, science learning is ongoing, as scientific knowledge is modified or expanded with each new discovery (Martin, 2000). This may lead to the rejection of previously accepted theories and the adoption of newer theories. By educating its citizenry, educators and their institutions support the development of a scientifically literate society.

There are also growing international movements in Science, Technology, Engineering and Mathematics (STEM) to ensure that young people are equipped with the necessary skills to participate in future economic growth (Badmus & Omosewo, 2020; Bybee, 2010e; Daugherty et al., 2014; Formunyam, 2020; Li, 2020; Marginson et al., 2013; Office of the Chief Scientist, 2014).

A further benefit of teaching science through social constructivist lenses is the development of 21st-century learning skills (Bybee, 2010c; Chu et al., 2016b). These are skills students need now and, in the future, with the world becoming an increasingly connected community where distances and isolation have been reduced via the internet and other technological advances. These skills include critical thinking, working collaboratively, being creative inquirers, problem solvers, and effective communicators (World Economic Forum [WEF], 2016). The development of a future generation with 21st-century skills is also one of the economic goals of Nigerian society (Aina, 2012). My research seeks to understand how Nigerian primary school teachers can support students to develop these essential skills through science.

Teaching science as inquiry is advocated as an essential teaching practice in supporting students to develop scientific literacy (Bybee, 2010c; Murcia, 2009; Skamp, 2015; Treagust & Duit, 2008). Bybee (2010c) states that teaching science as inquiry trains students to formulate questions, collect evidence, determine explanations through experiments, make informed decisions based on the evidence (Lederman et al., 2013), and present their ideas.

Science has also been recognised as a subject where students can develop the knowledge and skills to find answers to questions they may have or challenges they and others face (Chin & Osborne, 2008). The nature of science (NoS) supports students' natural curiosity. Through this process, students can develop critical and problem-solving skills that can be applied to other subject areas and other areas of their lives in general, which relates to the development of 21st-century skills.

There is also growing interest in student-generated representations (SGRs) to facilitate inquiry, engagement and development of scientific understanding and skills (Tippett, 2016; Waldrip & Prain, 2012). I also observed and documented how these inquiry-based teaching approaches can best be utilised or represented within the Nigerian context.

2.6 Primary Science Education in Nigeria

Primary education in Nigeria is the oldest part of Nigeria's education system, dating back to when Christian missionaries were in the country between 1843 and 1882. The system was further refined during the British colonial era (1882–1950s) (Anero, 2014; Oni, 2009). Primary education is considered a foundational formal institution within Nigeria's education system (Aina, 2012).

Since its inception as part of the curriculum in the 1970s, science education in Nigeria has gone through significant transformations (Ojimba, 2013). This need for change in the curriculum led to the formation of the Nigerian Educational Research and Development Council, which is responsible for developing the national curriculum with an online presence in 2014 (NERDC, 2017a).

These reforms were based on dissatisfaction with the didactic practices of science teaching, leading to the disengagement of students from science-related courses (Ojimba, 2013). Research has shown that students do not learn the necessary scientific concepts through such approaches, which leaves a citizenry that is not adequately prepared to face rapid social changes (Aina, 2012; Lyons, 2007). African scholars have advocated for developing students' scientific literacy by suggesting that teachers need to teach science in ways that focus on relatable societal issues and to teach in ways that not only capture the cognitive but also the affective interests of all students (Olorundare, 1988; Webb, 2009).

Primary science education is strongly emphasised within the Nigerian education system in the National Policy on Education: "in recognition of the fundamental importance and cost-intensive nature of science, technology and trade/entrepreneurship, Government shall provide adequate funds for science, technology and trade/entrepreneurship education" (NERDC, 2013, p. 16). However, research indicates a discrepancy between the expected and the actual experiences of science teaching and learning practices. Teachers have been observed using rudimentary and didactic approaches to teaching science, often with inadequate teaching facilities (Afolabi, 2013; Arigbabu & Oludipe, 2010).

In this research, I sought to understand the extent to which Nigerian primary school teachers can create opportunities for students to develop the creative and critical thinking skills called for as they prepare for future learning, at home or overseas. By exploring contextual pedagogical approaches used in science education, this research aims to promote and enhance teaching and learning in Nigeria.

2.7 The Nigerian Curriculum: Basic Science and Technology (Primary 1–6)

The Nigerian curriculum has gone through various transformations, evolving from one designed in the colonial period to one that embraces national values of honesty, the dignity of labour, respectfulness, loyalty, and perseverance, with recognition of the Nigerian culture and relevance to the needs of African/Nigerian society in the post-colonial era (Okpilike, 2010; Oludipe, 2011).

Various stakeholders, such as teachers and curriculum experts, were involved in the development of the national curriculum. The National Policy on Education guided these reforms (NERDC, 2013; Oludipe, 2011).

The NPE lists the subjects that should be taught at each level of a child's education, and specifically states that "teaching shall be participatory, exploratory, experimental and child-centred … specialist teachers shall be provided for particular subjects such as Mathematics, Basic Science, Basic Technology, Physical and Health Education" (NERDC, 2013, p. 8). The developers of the Nigerian curriculum have attempted to make changes to it by reducing the number of subjects in primary schools from a minimum of 12 and a maximum of 16 in the previous curriculum to a minimum of eight and a maximum of nine in the latest curriculum by grouping related disciplines (Igbokwe, 2015; NERDC, 2017b; Oyeleke & Akinyeye, 2013). They also infused learning about issues such as culture, drugs, and security awareness into the content. Textbook guides for teachers have been developed and provide more detailed advice on how teachers are to carry out their activities. These guides directly refer to the activities in students' workbooks (Bika, 2016; Igbokwe, 2015; Olatunde, 2018).

I conducted further analysis of the Nigerian Primary Science curriculum to ascertain its objectives and the specific science content to be taught, and how it was structured. The Nigerian Basic Science and Technology curriculum seeks to support students in learning science by helping them:

- develop interest in science and technology;
- acquire basic knowledge and skills in science and technology;
- apply scientific and technological knowledge and skills to meet contemporary societal needs;
- take advantage of the numerous career opportunities provided by science and technology;
- become prepared for further studies in science and technology;
- avoid drugs and related vices; and
- be safety and security conscious (NERDC, 2017a).

These objectives seem to align with contemporary science goals, such as the need to encourage students' interests in science-related subjects and how they can apply their science knowledge and skills to meet personal and societal needs. In this research, I was particularly interested in how they are implemented in classrooms.

The curriculum has been divided into themes, with various topics and activities to achieve the aforementioned objectives. Table 2.1, below, shows the structure of the Year One Nigerian BST curriculum by way of example.

Table 2.1 Example of the Basic Science Curriculum for Year One (adapted from NERDC, 2017a)

Theme	Topic	Performance Objective	Contents	Teacher Activities	Student's Activities	Evaluation Guide
Theme 1 **Learning About our Environment**	1. Exploring your environment 2. Soil, air and water	1. Observe and identify things in and around the classroom, school and home 2. Identify other parts of their surroundings—soil, air and water	Things in and around the classroom, school and home Other parts of the surroundings (e.g., soil, water, air)	1. Takes pupils on a study walk around and outside the school Demonstrates walking safely along the road and crossing the road	1. Pupils observe and list things in the school environment	Identify things in and around the classroom, school and home Sketch any two things identified in and around the classroom, school and home Demonstrate how to walk and cross a road safely
Theme 2 **Living and Non-living Things**	Living things	1. Identify self as a living thing	Living things in the school environment	Uses pictures and charts to guide pupils to identify living things in the school environment and home Guides pupils to explore the school surroundings identifying living	Identify from pictures and charts living things	Identify self as a living thing

				things (to include themselves)		Identify living things in their classroom Identify at least two living things outside their classrooms
	Non-Living things	Pupils should be able to identify non-living things in the classroom, at school and at home	Non-living things in the classroom, at school and at home	Uses pictures and charts to guide pupils to identify non-living things in the school environment and home Guides pupils to explore the school surroundings identifying living things (to include themselves)	Identify non-living things from pictures and charts Identify non-living things in the classroom and school Identify air, soil and water as non-living things	Identify three non-living things in the classroom Identify five non-living things around the school

This structure of themes, subthemes, topics, activities, and evaluation is similar across all six years of the Primary Science curriculum, with progressing complexity (NERDC, 2017a). Teachers are expected to utilise the curriculum as a guide to developing their scheme of work (lesson plans). The thematic structure is intended to provide a holistic approach to teaching and learning science and technology with the goal of making learning relevant to students and economic, societal goals.

2.8 Initial Education and Professional Standards for Nigerian Teachers

The NPE states that "the minimum qualification for entry into the teaching profession shall be the Nigeria Certificate in Education (NCE)" (NERDC, 2013, p. 28). Teacher Colleges of Education and the National Teachers Institute provide this essential teaching qualification. Higher teacher qualifications, such as a Bachelor's in Education (B.Ed.), Master's in Education (M.Ed.), Post-graduate Degrees (PDGE) and PhDs are offered by various Nigerian universities (Ogunyinka, Okeke, & Adedoyin, 2015).

I also reviewed the professional teaching standards document for Nigerian teachers to understand the professional expectations. These standards aim to provide clear guidance so "there is no more ambiguity about what exactly a particular category of teacher is expected to know and do and how to assess these variables" (Teachers Registration Council of Nigeria (TRCN), 2010, p. 2). The standards consist of four key themes for appraising a teacher's professional standing: *professional knowledge*, *professional skills*, *professional values, attitudes and conduct* and *professional membership obligations*. The teaching standards vary according to academic qualifications, with categories for Doctoral teachers (A), Master teachers (B), Graduate teachers (C), and NCE teachers (D) (TRCN, 2010, p. 18). The policy further highlights the importance of all teachers aspiring to update their skills and academic qualifications to teach at higher institutions. This means that a teacher with NCE qualification should not be allowed to teach at a tertiary level, no matter their experience level, but would need to gain the required graduate or post-graduate degree. While this may be sound, the structuring of the standards by qualifications (see Appendix A) seems to assume, for instance, that a teacher with a Master's degree has more expertise and ability than a teacher with an NCE when this may not be the case (TRCN, 2010).

The standards specify that "teachers should apply several teaching strategies including excursion, project, and problem-solving techniques to promote learning" (TRCN, 2010, p. 31). The standards welcome the use of various teaching strategies to promote learning, including constructivist approaches, as indicated above. Although inquiry-based learning (IBL) is not explicitly listed, it is consistent with constructivist approaches as advocated by the Nigerian standards.

The teaching standards also advocate for collaborative and cooperative learning by specifying that "teachers utilize various grouping techniques and group exercises and projects to elicit effective participation and boost learning by students" (TRCN, 2010, p. 31). I observed how these collaborative and cooperative approaches are demonstrated in the classrooms during the PAR phase (see Chapter 7).

Assessment is integral to the learning process, with the professional standards for Nigerian teachers specifying that, at the NCE level, "teachers at least thrice in a term or semester test the knowledge, skills and values in their subjects and ensuring that the tests are valid and reliable" (TRCN, 2010, p. 31). The professional standards also specify, at the Master's level, that "teachers make testing a collaborative activity between the teacher and learners in which both enthusiastically participate in determining the nature and success [of testing]" (TRCN, 2010, pp. 31–2). The involvement of students in assessing their learning is essential, and all teachers should be encouraged to practise this. The assessment strategies to be used are not clearly stipulated but seem to rely on tests and end-of-year exams, with the expectation that teachers would use the results to monitor students' performance.

The standards also specify that the process of reporting requires that "teachers provide parents and guardians with copies of details and results of assessments carried out to monitor the academic performance of their children" (TRCN, 2010, p. 32). Teachers are encouraged to discuss these in more detail with parents during visiting days for boarding schools or during Open Days.

2.9 Challenges of Primary Science Teaching in Nigeria

The lack of teaching and learning resources and facilities due to poor governance and limited funding has been identified as a hindrance to effective Primary Science teaching and learning in Nigeria (Afolabi, 2013; Aina et al., 2017; Ugwoke, 2018). Within the education system, low pay and lack of incentives have harmed the teaching and learning of Primary Science. These problems have been exacerbated by local and national economic and political insecurity (Aina et al., 2017). Further, various scholars have identified the quality of teaching as a significant detriment to science teaching and learning in Nigerian schools, leading to students' low levels of interest in science and the high drop-out rate for science at secondary school (Afolabi, 2013; Aina, 2012; Owolabi et al., 2014; Ugwoke, 2018). These scholars have observed unqualified teachers being hired to teach in primary schools and a classroom climate characterised by teacher-centred approaches, such as teacher talk, reading and working from textbooks, and exam-focused teaching (Owolabi et al., 2014). In his study of Primary Science teaching in Nigeria, Aina (2012) observed that teachers still utilised rote learning. He argues that teaching methods should go "beyond the traditional … talk and chalk method" and recommends that students should be engaged in projects and go on science fields trips to ignite and maintain their interest in science (Aina, 2012, p. 35). To address these issues, Aina and Langenhoven (2015) advocate for a paradigm shift from the lecture method, which focuses on the information and not the learner, to strategies that encourage students' active involvement in their learning.

2.10 Professional Learning for Teachers in Nigeria

Research suggests that ongoing learning in any profession is vital, and teachers should not be exempt from this (Guskey, 2002; Havnes & Smeby, 2014). As with education policies in other countries, the Nigerian Education Policy has identified the need for ongoing professional learning (PL), also often referred to as professional development (PD) and makes it mandatory for all teachers to engage in some form of PL to maintain their registration (Federal Ministry of Education (FME), 2014; NERDC, 2013).

Teacher PL involves the upgrading of professional skills and knowledge to perform duties more effectively. Opportunities for ongoing PL should be provided to support teachers, especially given societal changes and educational reforms (Garet et al., 2001; Guskey, 2002). The TRCN (2010) stipulates that teachers should have a minimum of 130 PL credit units (hours) per three-year cycle. Recognised PL programs include TRCN workshops, conferences, and approved stakeholder seminars and workshops. The NTI has the mandate of providing initial teacher qualifications and offers distance education for teachers who are upgrading their qualifications (NTI, 2017). These PL sessions generally take the form of lectures, where teachers attend out-of-school sessions for a few hours and listen to a specialist lecture on an area considered important by the school administration (Ajani et al., 2018; Fareo, 2013). However, many teachers cannot attend these workshops due to other demands on their time or the lack of funding for them to attend. When teachers attend workshops, they often find it difficult to implement the lessons learned because they may be irrelevant to their context, lack continuity in developing these ideas, or may not know how to implement the content (Ajani, 2018a).

Another approach to PL in Nigeria is for teachers to attend courses at the local university to enhance their knowledge and gain additional qualifications. The introduction of the Universal Basic Education policy, aimed at providing basic education for all students, created such a demand that underqualified teachers were employed in the educational sector in Nigeria to cater for the large number of students, as discussed in Chapter 2 (Iyunade, 2011; NERDC, 2013). However, with the review of planning goals to focus more on quality than quantity, having unqualified teachers in schools are being phased out, with the minimum requirement being a Nigerian Certificate in Education (NCE).

Many of these under-qualified teachers enrol at a university or the National Teachers Institute to obtain a recognised teaching qualification such as an NCE or a relevant degree (NTI, 2017). Some qualified teachers enrol to enhance their qualifications by doing a Bachelor's, Master's, or short courses they consider relevant to their field. These teachers are mostly self-funded and attend classes on weekends or school holidays (Ogunyinka et al., 2015).

The continual sharpening of professional knowledge and skills is invaluable in the education sector, as the capabilities acquired during teacher training remain inadequate to real-world teaching and learning demands. Through this study, I hoped to understand teachers' perceptions and experiences of PL.

2.11 Summary

Education is highly regarded within Nigerian society. This has led to the establishment of various policies and reforms in a bid to improve outcomes for students. Science has been accepted as an essential curriculum subject area to be taught across all educational levels to promote the development of a scientifically literate society. However, how these policy statements and goals are made a reality remains a challenge within the Nigerian education system. More specifically, how science teaching and learning occurs within Nigerian primary schools remains an area of concern. The literature suggests that the limiting factors to achieving some of Nigeria's education goals include inadequate teaching and learning resources, the nature of teaching and learning practices in Nigerian schools, the nature and structure of teacher professional standards and the curriculum, the test- and exam-driven nature of the education system, and the nature of teachers' PL opportunities. In the following chapters, I will explore how these critical elements in achieving teacher expertise are developed in the light of contemporary approaches to science teaching and learning and effective PL practices.

Chapter 3

Building Expertise to Teach Inquiry-based Science

In this chapter, I review the literature to understand teacher expertise and the processes and challenges of developing teacher expertise to teach inquiry-based science. I also review science education literature to understand the importance of science as a subject and to discover contemporary and effective science education goals and practices. Further, I explore the literature on effective science teaching and learning practices and how this compares with the practices of Nigerian Primary Science teachers. I also examine constructivist approaches to teaching and learning science, with a specific focus on inquiry-based learning. Later, I examine the importance of teachers' reflective practices and how these can aid in understanding teachers' perceptions and how they can be supported in their professional learning. Finally, I examine the role of Professional Learning in supporting teachers to develop their expertise in teaching Primary Science and how such practices align with the Nigerian PL policy and the nature of the PL experiences of Nigerian primary teachers.

3.1 Effective Primary Science Teaching Practices

The goal of learning in science is to guide students in answering a question, understanding a phenomenon, developing a theory, or solving a problem (Martin, 2000). Many researchers have recommended adopting a constructivist mindset when teaching science (Bybee, 2010b; Harlen, 2013b; Harlen et al., 2015; Harlen & Qualter, 2018; Skamp, 2007, 2015; Skamp, 2018). This means the ability to teach science in ways that students best learn- by constructing their own ideas within a social and cultural context (Bächtold, 2013; Traianou, 2006). Piaget's theory of personal constructivism asserts that students construct and develop their own ideas rather than absorbing knowledge from the teacher or other sources (Feldman, 2017). From this perspective, students are active participants in their learning, with the logical and rational ability to develop meaning in their learning journey based on their experiences. However, a student's journey does not occur in isolation but within a social context leads to Vygotsky's social constructivist theory of learning (Vygotsky, 1978). The learner engages with others to form a community of learners in developing knowledge and understanding. In Primary Science learning, this community of learners includes the students, teachers, the local community or any other resources that the students engage with to develop their scientific understanding and reasoning (Traianou, 2006). Bächtold (2013) argues that since learning science is a social process, it is vital to merge personal and social constructivist ideas.

The EQUALPRIME research team, consisting of renowned science educators, collaborated to research quality teaching in Primary Science education. In their findings from three countries, Taiwan, Australia, and Germany, Chittleborough, Ramseger, Hsiung, Hubber and Tytler (2017), proposed the following as the main aspects of quality Primary Science teaching:

- engaging students by tapping into their natural curiosity;
- monitoring and acknowledging students' ideas, providing feedback and using this interaction to purposely shape scientific understanding;
- the coordinated use of representations, which could be verbal, visual, written or embodied forms of representations;
- inquiry skills and inquiry teaching that focus on the learner, inquiry process skills and science content; and
- use of dialogue and questioning to direct students' learning.

These scholars argue that teaching and learning commence by tapping into students' natural curiosity and encouraging their participation. They further suggest using inquiry skills and teaching strategies to share and stimulate students' ideas, which could be represented in various forms. Through these inquiry approaches, teachers use dialogue and questioning to challenge students' deep thinking and creativity to develop their scientific understanding.

The literature on Nigerian teachers' science teaching and learning practices revealed differences from the contemporary practices described in this section. These differences warranted further investigations to understand the current practices of Nigerian primary teachers, as discussed in the PAR phase of the study.

3.2 Scientific Literacy: A Goal for Science Education

As explained briefly in Chapter 2, I chose to explore the development of teacher expertise through a science education lens because, internationally, science education has become central to most educational curricula. Scientific literacy has become increasingly important and widely accepted globally as the goal of science education (Bybee, 2010b; Evans & Rennie, 2009; Harlen & Qualter, 2014; OECD, 1999; Vieira &

Tenreiro-Vieira, 2016). The term ‘scientific literacy’ dates back many decades (Hurd, 1958; Bybee, 1997). Hurd defines scientific literacy as the ‘opportunities to look through the doors of science and be tantalized by the unknowns’ (Hurd, 1958, p. 16). He suggests that scientific literacy aims to develop an understanding of science as an interwoven part of societal life. The OECD’s Programme for International Student Assessment (PISA) (1999, p. 60) defines scientific literacy as: “the capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions to understand and make decisions about the natural world and the changes made to it through human activity.”

This definition signifies a shift in the purpose of science education from the learning of rudimental facts to a mindset of questioning and applying scientific understandings to real-life situations. Therefore, being scientifically literate means that students can make informed decisions about the environment, their health, and well-being in the light of rapidly changing and developing technologies (Murcia, 2007, 2008). In addition, if science education aims to develop scientific literacy, then understanding its meaning and relevance is fundamental to providing effective science teaching and learning experiences.

Harlen and Qualter (2014) argue that if the role of education is to prepare students for life, then it needs to prepare them to engage with the world in which they live, where science and technology play significant roles. Through this research, I have sought to discover how scientific literacy is implemented or interpreted within the Nigerian primary school context and how teachers support their students in being scientifically literate.

3.3 Why Science in Primary Schools?

For many, formal learning begins with primary school. Learning through science caters for students at various intellectual, physical and/or emotional ability levels, as it provides opportunities for exploration within and outside the formal classroom environment (Tytler et al., 2009). Primary teachers are pivotal in providing these foundational experiences to students and are responsible for developing and harnessing students' curiosity and interests (Afolabi, 2013; Rennie et al., 2001; Tytler et al., 2004). Humans are curious and creative beings, and these attributes manifest themselves early in childhood. The notion of 'catching them young' is crucial, as children's interests can be developed at these early stages of life (Fitzgerald & Schneider, 2013; Tytler et al., 2009; Walan et al., 2015). Therefore, teaching science effectively in primary schools provides the opportunity to nurture students' curiosity and to extend and challenge their developing scientific ideas and skills (Skamp, 2015). Such understandings will prepare students to be informed and critical thinkers in making social and personal decisions that fit with the espoused Nigerian educational goals discussed in Chapter 2.

Historically in primary science learning, the teacher delivered the content and students copied and memorised with few or no opportunities to analyse the content or to be critical and creative thinkers (Gluckman, 2011; Goodrum, Rennie, et al., 2001; Harlen et al., 2015; Smith & Fitzgerald, 2013). This history of primary science teaching and learning practices in western countries is mirrored in Africa and, more specifically, Nigeria (see Section 2.4). On the other hand, there is an emphasis in many primary science classrooms on 'doing' where students are involved only in hands-on activities (Tytler et al., 2009). Skamp (2015) argues that, although this is not bad, the end goal should not be based on what students are doing but on what students learn. Further, there is a growing shift in the west on how students learn science, focusing on supporting students to develop a deeper understanding. Understanding how teachers approach science will assist in answering the question of how students are supported to be scientifically literate.

3.4 Generalist Primary School Teachers

Generalist primary teachers are teachers who have acquired the ability to teach different curriculum content without necessarily having one area of specialisation (Smith & Fitzgerald, 2013). This generalisation may mean that they may lack the confidence to teach certain subjects because of a perceived lack of in-depth knowledge (Appleton, 2003; Appleton & Kindt, 1999). This lack of content knowledge may explain why some generalist teachers' focus on hands-on activities or resort to rudimental approaches (Goodrum, Rennie, et al., 2001). Unfortunately, these practices have been reported as having adverse outcomes for students' learning and interest in science (Van Aalderen-Smeets et al., 2012).

Smith and Fitzgerald (2013) argue against this criticism of generalist teachers being necessarily less effective at teaching primary science. In their research on primary teachers in Australia, they found that many were willing to learn to improve their content knowledge and possess a vast knowledge of pedagogical strategies. These strategies include valuing and respecting the diversity of their students' learning abilities and needs, relating the content to real life, and providing opportunities for their students to be creative and critical learners. These strengths align with constructivist teaching approaches and are the bedrock of effective science teaching.

Smith and Fitzgerald (2013) argue that it is important to deviate from teaching science as rudimental facts or absolute truths but emphasise the relevance and place of science in our lives to boost generalist primary teachers' confidence in teaching science. Martin (2000, p. 9) supports their argument by adding that "elementary science teachers do not need to have extensive knowledge about science to be able to teach it well." Instead, Martin says, 'science teachers need to know certain basic and fundamental aspects of science and, more importantly, should focus on knowing how students learn and how to teach them.' The ability to listen and understand the students' perspective and their reasoning processes is key to engaging and supporting them (Harlen et al., 2015).

The use of generalist primary teachers as described in the global literature above is similar in primary schools in Nigeria. However, the government advocates for specialist science teachers in Nigerian primary schools. In some schools, some form of 'specialist' teachers are used for teaching subjects like Mathematics and Science, as I will discuss in later chapters.

3.5 Development of 21st Century and Inquiry Learning Skills

Teaching practices must keep abreast of our changing society. It means possessing the skills needed to address the changing societal issues and demands. These changes call for developing adaptable, critical, creative, communicative, collaborative, and problem-solving skills (Harlen & Qualter, 2018; Llewellyn, 2014; NERDC, 2013; Omorogbe & Ewansiha, 2013). Through inquiry in science, teachers can support students to develop these essential skills during their early years and primary education. These skills cannot be developed when teachers employ rote learning and lecturing practices (Bybee, 2010b; Chu et al., 2016a; Harlen et al., 2015). Using inquiry to develop these skills also fosters students' engagement with their learning and understanding of the science content explored. It is also important to use assessment practices that complement these goals (Harlen et al., 2015). Based on the literature reviewed in Chapter 2, it appears that the test- and exam-based assessment practices in

Nigerian schools may not be appropriate for supporting the development of such learning.

Starting with students' natural curiosity, creativity and teaching science through inquiry, students can be equipped with the confidence to deal with challenges and make informed decisions about matters that directly affect their lives and the broader society (Alozie et al., 2012; Bybee, 2010b). These ideas support the education outcomes stated in the NPE in 2.3 above.

There is some debate, however, about the suitability of learner-centred approaches in the African context. Tabulawa (2003) argues that most reforms in Africa fail due to the ‘borrowed’ nature of approaches that African leaders and schools try to implement. He argues that student-centred constructivist approaches to teaching and learning advocated for in schools are designed to promote the neoliberal economic agenda of international aid agencies (Tabulawa, 2003). His arguments are based on the limited resources of most sub-Saharan African countries. Sharra (2015) refutes that constructivist approaches should be linked to neoliberal ideas. He argues that, although constructivist approaches may not be the perfect fit for education reforms and policies, constructivist pedagogies can be and have been successfully applied in varying cultural and educational contexts. Inquiry-based learning and its contribution to strengthening student learning have been widely used with some degree of success in African schools (Ayodele et al., 2014; Bybee et al., 2006; Ramnarain, 2020; Vavrus et al., 2011).

In my study, I explored how learner-centred constructivist approaches can be incorporated into socio-cultural practices with the belief that learners come with pre-existing ideas and knowledge that can and should be revealed, explored, and challenged as they learn. However, I acknowledge that contextual and cultural nuances may affect the incorporation of such approaches and examined this by considering the perspectives and practices of Nigerian primary teachers. I recognise that implementing any educational policy or change is not without challenges, and I draw on existing research to consider how to do it effectively and context-sensitive.

3.6 Constructivism and Constructivist Models for Teaching Science Through Inquiry

Constructivism, although a highly debated theory of learning, has influenced education over the past decade. It suggests that people learn by developing meaning influenced by their prior experiences and understandings (Churchill et al., 2018). Student-centred or child-centred pedagogy refers to when students are actively involved in the learning process. This contrasts with teacher-centred or traditional approaches to teaching, where the teacher delivers content and does everything in the class for and to the students. Vygotsky takes this concept further by suggesting that students can construct their knowledge through interactions with others within their community (Vygotsky, 1978). Therefore, students' cultural and social contexts have a significant effect on their learning.

Constructivism has been adopted, and student-centred pedagogies have been applied in various school settings believing that it results in more positive outcomes for students than teacher-centred approaches (Ayodele et al., 2014; Martina et al., 2016). Research shows that the application of student-centred pedagogies such as inquiry has been reasonably successful, though not without challenges, in many countries, especially in the developed world (Fitzgerald & Smith, 2016; Hackling et al., 2015; Tytler, 2002). Some of the challenges of implementing inquiry approaches are inadequate time, limited resources, teachers' knowledge and skills, and how to successfully implement science inquiry learning in classrooms (Fitzgerald et al., 2019). However, through these pedagogical approaches, students are given opportunities to have a say in what and how they learn and to be part of the evaluation of their learning. In student-centred lessons, learning is not done *to* the students but *with* students actively involved in the process.

For this study, I use the term *learner-centred,* as my work is focused entirely on the processes of learning. This focus on learning links with the definition of the NoS by Lederman et al. (2013, p. 140) as “the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge.” This means that science is a *process* of learning and knowing that is socially and culturally embedded and derived from experimentation, observation, and interpretation to make informed personal and societal decisions. This process involves an imaginative, creative, and inquisitive mindset (Lederman & Lederman, 2014).

Researchers have put forward several frameworks to support inquiry-based learning. For example, Kober (1993) proposed a four-stage problem-solving approach to teaching science constructively (see Table 3.1 below).

Table 3.1 Four stages of Problem Solving in Science (Kober, 1993)

Stage	**Explanation**
Invitation	Learning commences with a question posed by the teacher or student that becomes the platform for investigation
Exploration, discovery, creativity	Students carry out experiments using inquiry to find answers to the question posed
Proposing explanations and solutions	Students are supported to develop explanations of the results of their investigations
Taking action	Students are challenged to think of ways *to use* their new learning from the entire process (questions, investigations and results) within their homes and communities

In the first stage of Kober's model, students are invited to think about a question posed by the teacher or ask their own questions that they then investigate. Next, they are encouraged to provide explanations of their solutions and are challenged to think about how they can apply their new learning in their lives and the broader society.

Another model proposed by Milne and Cremin (2017) is designed to teach science through inquiry and to develop creative thinking (see Table 3.2), showing that the process of scientific inquiry stems from students' natural curiosity.

Table 3.2 Sequential Elements of Creative Exploration Model for Developing Understanding in Primary Science (adapted from Milne & Cremin, 2017)

	Creative Explorations	
Explore	… a problem, situation, phenomenon, artefact, model, event, story	Wonder
Observe	What is happening? What changes happened? What materials are involved? What are the main parts? What are the key aspects? What do these parts/structures do?	Wonder about
Identify Evidence	What is the cause and effect of changes? What is the function? What parts are interacting with other parts? What are the outcomes of these interactions? What trends and patterns keep occurring?	
Create explanations	Personal explanations supported by evidence are created and processes to test them are planned	Wonder at
Investigate	Find out, measure, compare, verify, test, clarify, identify	
Evaluation	A self-evaluation of these investigations may lead to new or modified explanations, doubts about existing ideas or tentative conclusions. These tentative explanations need to be communicated to others for peer evaluation and feedback	
Further investigation	Evaluated explanations can lead to re-exploration, seeking further explanation, leading to further investigation	Wonder whether
Making connections	Explanations are used or applied to make sense of or clarify other contexts where similar phenomena are involved	

This focus on developing the learners' curiosity means that students seek explanations or answers to their own questions or problems or to do with a phenomenon or event. Students can then be supported to investigate and present explanations of the outcomes. Further, in this model, students may need to carry out further investigations based on their initial explorations and explanations. Although the stages of learning appear sequential, it can also be an iterative process, with stages repeated to improve understanding.

To support and enhance students' learning of scientific concepts, lessons and learning experiences need to be sequenced. Effective primary teachers ensure that the topics to be explored are linked to students' lives and enable students to effectively interact within their community (Tytler, 2007). Without such connections, learning science can be abstract, leading to student disinterest.

In trying to close this gap in Australia, the Australian Academy of Science developed the Primary Connections resources to support primary teachers and students in understanding scientific content, processes, and skills. Primary Connections is a series of resources based on the National Curriculum and utilises a 5Es model. The 5Es—*Engage*, *Explore*, *Explain*, *Elaborate* and *Evaluate* (see Table 3.3)—were developed in 1987 by Roger Bybee with the goal of helping the teacher to make each aspect of the subject relevant to their students (Bybee, 2014).

Table 3.3 Adapted Primary Connections 5E model: A framework for guided inquiry (Australian Academy of Science [AAS], 2021; Hackling et al., 2007)

Phase	**Focus**
Engage	Engage students and elicit their prior knowledge.
Explore	Provides hands-on experiences of the phenomenon
Explain	Development of explanations for the phenomenon students have explored.
Elaborate	Application of learning to new situations, making connections or extending understandings.
Evaluate	Review and reflection of learning, opportunities for re-representation of understandings.

The *Engage* phase captures students' interest and is recommended as the starting point for scientific inquiry based on the belief that students bring with them not only questions but some pre-existing knowledge about the phenomenon, problem or event, or about a specific scientific concept being explored (Bybee, 2014). During this phase, the teacher identifies what students already know, which could reveal students' misconceptions. In this phase, students are also challenged to make predictions.

Through the *Explore* phase, students are given various opportunities and experiences to explore the phenomenon or concept. These explorations support them in developing their understandings, from which they can then provide explanations in the *Explain* phase.

In the *Explain* phase, students are encouraged to represent their ideas in various forms, with the teacher also providing explanations of the phenomenon explored to deepen students' understandings. The teacher also provides direct instruction to clarify content and introduces scientific language.

The *Elaborate* phase is when students are challenged to think of how they can apply their learning in a different context or situation.

Finally, in the *Evaluate* phase, students reflect on and review their learning to demonstrate their understanding. Through this evaluation phase, teachers can determine how students achieve the learning outcomes (AAS, 2008; 2017b). The evaluation process should be ongoing with various forms of assessment at each stage of the 5*E's*.

The implementation of PC has had a significant impact in many primary schools across Australia in engaging and supporting students and teachers' understandings, and for many, has reignited their interest in teaching and learning science (Aubusson et al., 2019; Australian Academy of Science, 2012; Fitzgerald & Smith, 2016; Hackling et al., 2007).

The models explored in this section are similar in that they adopt a systemic approach to support students to develop conceptual understandings. Although they vary in the number of stages and the language used to describe them, they seek the development of students' conceptual understanding in a progressive manner and reflect how students learn and the nature of science (Churchill et al., 2018). This progression commences from what the students know and works with that to support the active involvement of students in problem-solving to develop deeper conceptual understandings to a level where students can represent their new understandings in various forms.

This inquisitive and interactive approach to teaching places a demand on teachers (Tytler et al., 2013), including the need to create an atmosphere and environment for such explorations, which can be time-consuming. Teachers are also faced with the need to cover curriculum content and the fear of being unable to answer students' questions. When practised over time, however, the benefits are significant: through questioning and discussions, the teacher challenges students to reason and provide justifications for their claims through their investigations and the evidence they draw (Kenny & Cirkony, 2018a; Tytler, 2017; Tytler et al., 2013), which significantly enhances their understanding of science.

In my study, I sought to apply the 5Es model in the Nigerian context and conduct PL sessions to support teachers in considering the use of this inquiry approach to develop their science lessons. Through a series of reflections with the teacher participants on their lessons, I hoped that the 5Es model could support them to incorporate inquiry approaches into their practices.

3.7 Inquiry-based Learning in Science

Inquiry-based learning focuses on the desire to know or find out. The inquiry model has been in use in education for more than a decade and has been applied in various subjects, such as Geography, History, Science, Mathematics and, more recently, the arts (Kidman & Casinader, 2017).

In science, inquiry has been defined by various scholars as the ability of students to develop deeper understanding through their direct interactions with the world (Chen & Tytler, 2017; Harlen, 2013b; Llewellyn, 2014). Through scientific inquiry, students are challenged to develop researchable questions, make predictions about possible outcomes and carry out investigations into a phenomenon to answer those questions, which broadens their knowledge and understanding about our world (Chen & Tytler, 2017; Hackling, 2007; Hackling et al., 2010; Harlen & Qualter, 2014; Haug, 2014). Minner, Levy and Century (2010), in their research on the “impact of inquiry science instruction on K-12 student outcomes”, categorised the elements of science instruction into three aspects:

1. the presence of science content;
2. student engagement with science content, which involves student participation in decision making about what and how they learn; and
3. student responsibility for learning, active and creative thinking by making links and building on prior knowledge.

Tytler and Hobbs (2011) argue that inquiry-based approaches provide students with quality learning and opportunities to develop higher-order thinking. Inquiry-based learning engages students, stimulates their curiosity, and supports them in developing scientific skills and understanding (Crawford, 2014; Hackling, 2007). The teacher's role within the inquiry process is to be a facilitator who supports students through discussions and provides feedback to enable them to make links to previous learning or raise more questions (Hackling, 2007; Llewellyn, 2014). The teacher supports students to develop scientific practices of "asking testable questions, creating and carrying out investigations, analysing and interpreting data, drawing warranted conclusions and constructing explanations that promote a deep conceptual understanding of fundamental science ideas" (Wilcox et al., 2015, p. 62).

Literature suggests that there should be a gradual progression in the nature of IBL approaches where students progress from a more structured form of inquiry to open inquiry, as shown in Table 3.4 below.

Table 3.4 Inquiry as an Evolutionary Process (Bonnstetter, 1998)

	Traditional Hands-on	Structured Inquiry	Guided Inquiry	Student Directed Inquiry	Student Research Inquiry
Topic	Teacher	Teacher	Teacher	Teacher	Teacher/Student
Question	Teacher	Teacher	Teacher	Teacher/Student	Student
Materials	Teacher	Teacher	Teacher	Student	Student
Procedures/ Design	Teacher	Teacher	Teacher/Student	Student	Student
Results/ Analysis	Teacher	Teacher/Student	Student	Student	Student
Conclusions	Teacher	Student	Student	Student	Student

This continuum of inquiry suggests that the development of inquiry skills is a process and not a product (Bonnstetter, 1998). For inquiry to occur, there is a gradual shift in practice from traditional approaches that focus on the teacher to a focus on students carrying out inquiry with minimal teacher input or entirely on their own (Bonnstetter, 1998). This model also suggests that traditional hands-on approaches are not science inquiry at all. Some scholars have further classified these approaches into four broad levels—*confirmation*, *structured*, *guided*, and *open* inquiry—as shown in Table 3.5

The four levels of inquiry and the information given to the student in each one.

Inquiry Level	Question	Procedure	Solution
1–Confirmation Inquiry *Students confirm a principle through an activity when the results are known in advance.*	✔	✔	✔
2–Structured Inquiry *Students investigate a teacher-presented question through a prescribed procedure.*	✔	✔	
3–Guided Inquiry *Students investigate a teacher-presented question using student designed/ selected procedures.*	✔		
4–Open Inquiry *Students investigate questions that are student formulated through student designed/selected procedures.*			

below.

Table 3.5 Four levels of Inquiry (Banchi & Bell, 2008)

The four levels of inquiry and the information given to the student in each one.

Inquiry Level	Question	Procedure	Solution
1–Confirmation Inquiry *Students confirm a principle through an activity when the results are known in advance.*	✔	✔	✔
2–Structured Inquiry *Students investigate a teacher-presented question through a prescribed procedure.*	✔	✔	
3–Guided Inquiry *Students investigate a teacher-presented question using student designed/selected procedures.*	✔		
4–Open Inquiry *Students investigate questions that are student formulated through student designed/selected procedures.*			

The four levels begin with *confirmation*, where teachers provide students with the questions, procedures and solutions and students test already-known results. Teachers guide students to develop the ability for more open inquiry in which students decide what they want to investigate, determine the procedures, and record the outcomes of their investigations. At each stage of the inquiry teaching process, the teacher's role is to scaffold learning through questioning to stimulate deeper thinking, and to support and offer students a varying degree of freedom in their decision-making processes as they develop conceptual understanding and inquiry abilities (Kenny & Cirkony, 2018a; Kenny & Cirkony, 2018b; Kidman & Casinader, 2017). The teacher serves as a guide, supporting students to see possibilities and navigate challenges.

Regardless of the number of steps, the models described above have as their end goal a shift in student agency as they are empowered to take more ownership of their learning process (OECD, 2021). They also indicate that this shift in developing student agency is gradual. In specific reference to inquiry learning in science, this means supporting and guiding all students to develop competence and use investigative skills and attributes to make informed personal and societal decisions. Getting to the stage of open inquiry may or may not be feasible depending on the contextual and systemic factors that may be present in a specific situation. In the following sub-section, I will explore ways IBL in Primary Science could be applied in the Nigerian context.

3.7.1 The Purpose and Place of Assessment in Inquiry Learning

The type of assessment used should be based on the assessment's purpose. Assessment practices are essential to foster students' engagement and learning and need to be coherent with the intended learning goals. Terms such as 'Assessment *as* Learning', which is mainly diagnostic and formative, mean that students have the opportunity to reflect and make necessary adjustments (Bell & Cowie, 2001; Earl, 2013). ‘Assessment *for* Learning’ is a formative assessment process in which the teacher provides ongoing feedback during learning and modifies their teaching in response to the findings and interactions from this process (Bell & Cowie, 2001; Earl, 2013; Harlen, 2013a). ‘Assessment *of* Learning’, which is mainly summative, captures an overall picture of the student’s learning and progress, usually at the end of a learning period or session (Black & Wiliam, 1998; Corrigan et al., 2013; Panizzon & Keast, 2018).

Formative assessment provides a way of clarifying the ‘*what*’ and the ‘*why*’, which results in action by both teacher and students and should be prioritised (Black & Wiliam, 1998; Harlen & Qualter, 2018). Providing constructive feedback is also a crucial part of this learning process; teachers monitor students’ progress and provide feedback that supports or extends their learning (Hattie, 2012). Opportunities for students to partake in the assessment process are also important. The ability of students to reflect on their learning and gauge where they are supports them in taking ownership of their learning (Earl, 2013; Harlen, 2013a). Peer assessments are another way of students supporting each other’s learning by giving verbal or written feedback (Black, 2013). Although summative assessments are judgements made after learning, it is recommended that, when tests and exams are used, the questions should encourage students to demonstrate their understanding of concepts by explaining their answers or applying their knowledge in new ways and contexts (Panizzon & Keast, 2018).

Further, the use of student-generated representations (SGRs) has been advocated as an effective means of assessment to support students’ inquiry learning in science. In this process, students are encouraged to construct and represent their ideas using various forms of communication (Waldrip et al., 2010). When assessment is considered an integral aspect of teaching and learning, the student is positioned at the heart of this process with a clear focus and awareness of what they can achieve and are supported in a collaborative way to achieve to their best potential. The suggested contemporary assessment strategies to support inquiry learning in science seem to differ from the nature of assessments in the Nigerian science curriculum and from teachers' approaches observed by researchers (NERDC, 2017b; Sayed & Kanjee, 2013). This disparity influenced the PAR phase of this study to understand the assessment practices Nigerian primary science teachers utilise.

3.8 Challenge of Building Teacher Expertise to Teach Inquiry-based Science

The term 'expertise' has been defined "as the characteristics, skills, and knowledge that distinguish experts from novices and less experienced people" (Ericsson et al., 2006, p. 3). This definition advocates that there are certain criteria or expectations that one must demonstrate to be considered an expert in their field. The description of 'teacher expertise' is quite complex, carrying a variety of criteria (Palmer et al., 2005). Although there seems to be a generalisation in policy documents as to what expertise entails, the definition of teacher expertise needs to be context- and subject-specific (Berliner, 2004). This need is based on a study of 'expert' and 'novice' teachers' pedagogical practices that found expert teachers struggled with unfamiliarity with the context when teaching new students and with the environment they had to work in (Berliner et al., 1988). They felt their lack of knowledge of the students affected their pedagogical practices.

This raises a question: should expert teachers not be those who are able to adapt to different teaching environments and contexts? Berliner (2004) argues that expertise is domain- and context-bound and not applicable over a broad area or to students with different characteristics. Berliner (2004) proposes that there are two types of experts:

crystallised and fluid. The former use fixed procedures thoroughly learned and practised routinely within a familiar context, while the latter can use their abilities to adapt when confronted with new or challenging tasks. According to Berliner, although expertise is context- and subject-specific, teachers' pedagogical expertise should be adaptive, with teachers willing to be challenged and to learn when faced with new or challenging tasks. Further, Berliner identifies coaching/mentoring as an important element in supporting teachers to develop expertise (Berliner, 2004). This approach will be explored in the PAR phase of this study.

Although knowledge of a subject area is important, Hattie (2012) suggests that content knowledge has little effect on the quality of student outcomes. He further argues that "expert teacher and experienced teachers do not differ in the amount of knowledge that they have about curriculum matters or knowledge about teaching strategies, but expert teachers do differ in how they organise and use this content knowledge" (Hattie, 2012, p. 28). This relates to the structure of the qualification-based on Nigerian professional teaching standards (see Chapter 2); contrary to those standards, the recognition of teaching expertise should be based not only on qualifications but on how teachers use their content knowledge to support the development of students' understanding.

Loughran (2010, p. 5) argues that "expertise is derived from purposefully moving beyond knowing and into learning about consciously doing and doing with reason." Essentially, these scholars suggest that teachers display expertise in their ability to successfully blend the 'what', 'why' and 'how'. They suggest that the teacher's constant awareness of their actions in order to adjust their practice in pursuit of positive outcomes for their students accounts for the growth in their expertise. Years of experience, though important in accruing expertise, do not themselves produce expertise (Loughran, 2010; Winkler, 2001). Similarly, Ericsson et al. (2006) opine that expertise grows over time but that this growth is not just a result of experience but of more conscious efforts and choices of tasks that improve performance. The teacher's ability to reflect on their practice and make adjustments leads to the continual growth of expertise.

3.9 Process of Developing Teacher Expertise

Change takes time, including for a teacher in any educational context (Guskey, 2002). Teachers' conscious shift in pedagogical approaches is not a product but a process "conceptualized as a complex system rather than as an event" (Opfer & Pedder, 2011, p. 378). Guskey (2002) argues that one reason that teacher PL sessions fail is the lack of consideration of the process of change for teachers. He further contends that early conceptions of PL often began with the need to change teacher beliefs, attitudes, and perceptions before a shift in practice occurred. Although it is necessary to identify teacher beliefs and attitudes, Guskey suggests that a change in practice does not start with changing beliefs and attitudes. Instead, "significant change in teacher's attitudes and beliefs occurs primarily after they gain evidence of improvements in student learning … the experience of successful implementation that changes teachers attitudes and beliefs" (Guskey, 2002, p. 383). Although his model demonstrates a linear approach to PL, he recognises that "any change that holds great promise for increasing individuals; competence or enhancing an organization's effectiveness is likely to be slow and requires extra work" (Guskey, 2002, p. 388).

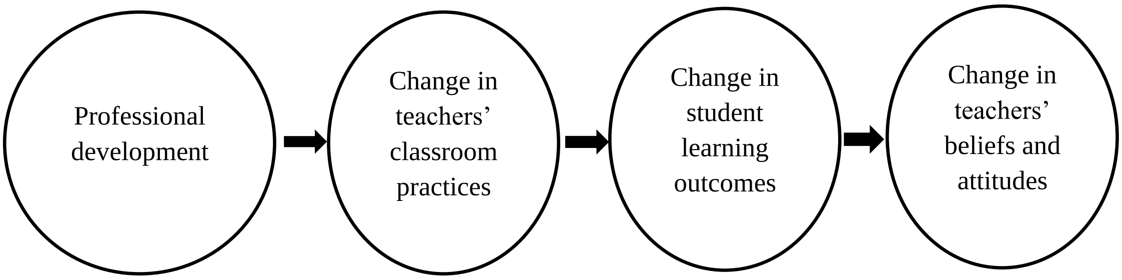

Figure 3.1 Guskey's Model of Teacher Change (Guskey, 2002, p. 383)

Guskey's model has been criticised for its linearity and for not taking into consideration the functioning of the teacher within a contextual and systemic environment, which has a significant impact on the process of teacher change (Clarke & Hollingsworth, 2002; Opfer & Pedder, 2011). Clarke, Hollingsworth and Opfer and Pedder suggest that the process of teacher change is not as simplistic as Guskey's model depicts but rather a more complex one. Clarke and Hollingsworth (2002) propose that professional change involves cycles of growth and is impacted by internal and external factors (see Figure 3.2).

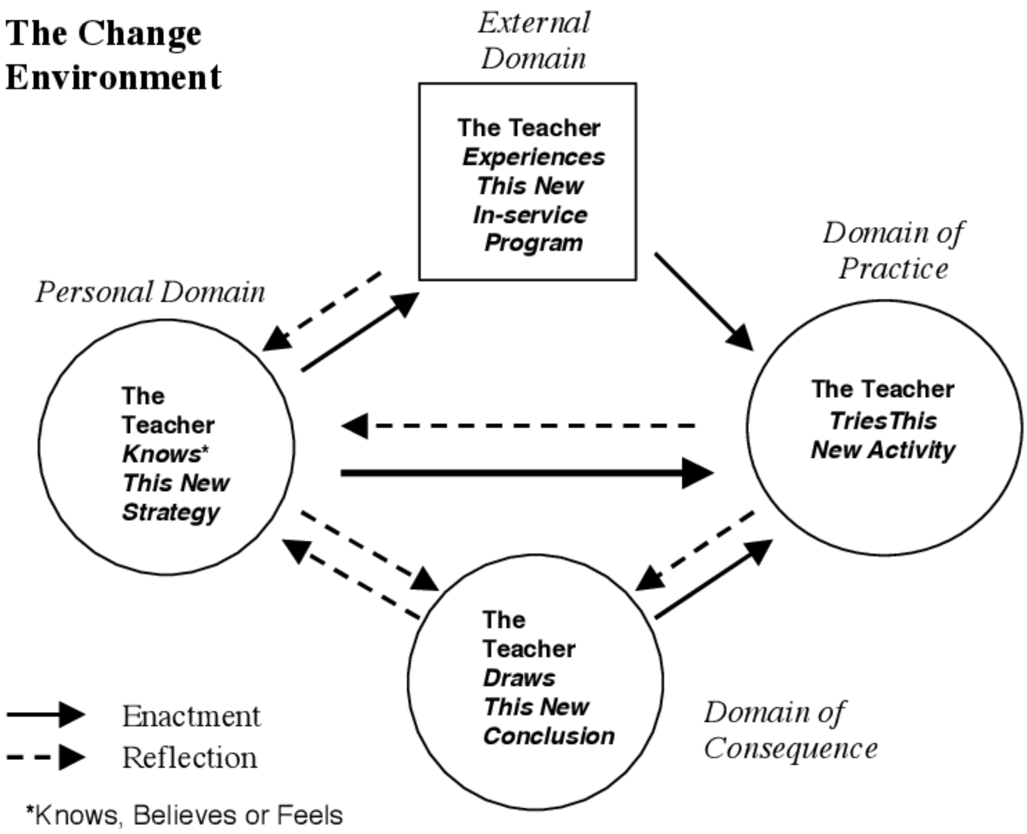

Figure 3.2. Interconnected Professional Growth Model (adapted from Clarke & Hollingsworth, 2002, p. 957)

Evans (2014) proposes a PL model that focuses on the teacher's cognition, arguing that the other models fail to question what goes on in the teacher's head as they undertake PL. She acknowledges that teachers should be at the centre of professional learning but argues that their awareness of a "better way of doing things may occur unconsciously and unintentionally" and that "change in knowledge, beliefs or attitudes does not necessarily involve reflection; more often it occurs spontaneously" (Evans, 2014, p. 185). She further explains that such change could have an impact on various aspects of development and acknowledges, to some extent, how this model aligns with the sequential nature of change in Clarke and Hollingsworth's model, depicted above.

In this study, I designed the PL sessions to begin with classroom observations, interactions, and reflections with teacher participants, taking into consideration the significant impact of their context as suggested by Clarke and Hollingsworth (2002) and Opfer and Pedder (2011). The process of reflections on practice and the impact of context aligns with the social constructivist theoretical underpinning of this study. Although the identification of a 'better way' of doing something may occur unintentionally and subconsciously, as Evans suggests, it is through a reflective process that this subconscious thought is brought to light, along with the possibility of these 'better ways' becoming sustainable practices over the longer term (Darling-Hammond et al., 2017; Hargreaves & Fullan, 2012; Sedova, 2017).

Furthermore, the PL in this study promoted teacher agency, as TPs actively participated in identifying their PL needs and solutions during the sessions and beyond (Boylan et al., 2018; Clarke & Hollingsworth, 2002; Garet et al., 2001). Throughout the cyclical process of the study, I adopted a supportive approach to encourage TPs as they identify their PL needs and to develop solutions to meet those needs. Adopting this approach aligns with the PAR methodology in facilitating educational change, acknowledging that "change tends not to be neat, linear, or rational" (Mills, 2016, p. 232). As part of considering the context, it is important to understand teachers' perceptions of their practices.

3.10 Teacher Perceptions and Reflective Practice

Teachers' perceptions include their thoughts, attitudes, and how they view or the meanings they attach to their roles (Skamp & Preston, 2018). Therefore, teachers' perceptions relate to their identity and have a significant impact on their practice (Hofer, 2016; Hofer & Pintrich, 2012).

An understanding of teachers' thoughts and attitudes towards science is essential to comprehending how teachers teach science (Bell & Linn, 2016; Fitzgerald et al., 2009; Van Aalderen-Smeets et al., 2012). This understanding further reveals how teachers interpret the curriculum, their classroom actions, how they view their relationships with their students, and how they assess them. However, the process of identifying teacher perceptions can be challenging, as teachers may be reluctant to share their professional and practice-related beliefs. Therefore, I adopted a more subtle approach to tap into these underlying beliefs by making observations in class and using these observations as a discussion point for reflection with the TPs. Video or audio recordings of classroom observations can support teachers to reflect on their practice and reveal attitudes and beliefs they hold that they may not be aware of (Impedovo & Malik, 2016; Mphahlele & Rampa, 2015). I will discuss the use of video and audio recording as a means of supporting reflective practice further in Chapter 4.

Reflective practice has been demonstrated to be an essential element for professional education and improving teaching practice by early educators such as Dewey (1933), Schon (1983) and, more recently, Farrell (2015). Farrell (2015, p. 8) defines reflection as a “conscious thinking about what we are doing and why we are doing it.” Various approaches to reflection have been suggested, such as *reflection in action* (where the person is dealing with real-time issues, dealing with them as they occur), *reflection-on-action* (recalling practice and exploring the ‘why’ of actions and behaviours), and *reflection-for-action* (reflecting on actions before taking future action) (Farrell, 2015). I propose *learning* as central to reflective practice whether a teacher’s reflection is *in, on* or *for* action. It is through this process of reflecting that learning can occur or be improved upon (Ghaye, 2011; Myers, 2012).

After collecting information in the classroom about what goes on during the planning, teaching, and learning phases, a teacher can analyse and evaluate this to understand their practice and, more importantly, their underlying beliefs (Mathew et al., 2017; Russell, 2018; Walkington, 2005). Engaging in this process may also lead to the identification of aspects of their practice that are going well and areas that need modification. Teachers may then seek to make changes or improvements to their practice. Teacher reflective practice should not be a one-off but an iterative process in which teachers continually strive to develop their expertise. More recent studies have advocated for teacher support in the process of reflection as teachers may be too busy with other tasks to engage in such practice or may not be familiar with how to do it (Impedovo & Malik, 2016; Loughland & Nguyen, 2016).

In this study, I encouraged TPs to engage in a reflective process, facilitated using video recordings and semi-structured interviews to stimulate our discussions. As a researcher participant (RP), I supported the teachers as they reflected on their practices to identify their strengths, gaps, and their PL needs.

3.11 Identifying Effective Approaches to Professional Learning

Societal changes such as technological advancements and global events such as the COVID-19 pandemic demand ongoing modification of teaching practice (Alterator, Deed, & Prain, 2018; Darling-Hammond, Hyler, & Gardner, 2017). It is vital within the broad field of education to develop practices that can support students to adapt and develop 21st-century competencies to function effectively within society, now and in the future.

Teachers must be supported to continue to develop their expertise in order for them to adapt to changing societal needs. Although PL has been identified as useful for remedying educational challenges faced by teachers and schools, the effectiveness of their approaches has been questioned (Evans, 2014; Garet et al., 2001; Guskey, 2002; Luft et al., 2015; Opfer & Pedder, 2011). To keep abreast of changing societal demands, teachers need to shift to a more balanced approach to teaching and learning that goes beyond memorisation of facts and incorporates strategies that promote deeper thinking and understanding (Darling-Hammond et al., 2017; Garet et al., 2001).

Knowles and colleagues (2015) emphasise the importance of understanding how adults learn (andragogy) if they are to be supported in developing expertise. The authors identify some assumptions to be considered when working with adults, who by virtue of their maturity, are able to develop a self-concept to direct their actions and decisions. Adults bring experiences that shape their worldview, and these must be respected to help them feel accepted, respected, and supported.

Scholars have suggested important characteristics of effective PL. Firstly, it should include a reflective process in which teachers examine their practices and identify their needs (Bates & Morgan, 2018; Russell, 2018); this could be individually or done with a colleague who can provide support and feedback (Darling-Hammond et al., 2017). Starting from teachers needs and interests acknowledges that they come with experiences that “should be utilized as resources for new learning” (Darling-Hammond et al., 2017, p. 7).

Second, teacher PL should go beyond one-off workshop sessions (Brand & Moore, 2011; Garet et al., 2001). Such workshops typically occur after school or on weekends, often at a venue other than the school, last for a couple of hours and are usually delivered by specialists in specific fields. This model has been found to be ineffective because teachers may not understand how to apply the lessons of these workshops or may lack the resources to do so (Brand & Moore, 2011; Darling-Hammond et al., 2017; Luft et al., 2015).

Due to the short length and the format of some of the workshops, teachers are unable to fully practise or engage in in-depth discussions about the concepts. Even when teachers try to implement the content from such workshops, they may not receive feedback on how they went and may give up applying the strategies. Further, the fact that the process of teacher change takes time supports the need to go beyond the ideas explored during a one-off workshop session (Garet et al., 2001; Hargreaves & Fullan, 2012).

The design of PL should be influenced by what students are doing in the classroom and respecting the teacher's role and voice in decision-making processes (Clarke & Hollingsworth, 2002; Loughland & Nguyen, 2016). In my study, the PL was based on classroom observations, and the collaborative involvement of TPs meant that they were meaningfully and actively involved throughout the PL. Scholars also suggest that PL should be a collective experience involving teachers from the same school, grade or subject area who have shared goals (Evans, 2014; Hargreaves & Fullan, 2012; Kenny et al., 2020). This collaboration means that teachers can provide collegial support as they implement new learning in their school's context (Garet et al., 2001). In so doing, too, the practices implemented may be more sustainable as a community of practice is developed (Darling-Hammond et al., 2017).

In developing their understanding of IBL approaches, TPs needed to experience IBL in the PL sessions to see how it works and how they could implement it in their classrooms. Adopting a PL approach that models the strategies that teachers intend to trial in their classrooms with their students helps them see how the strategies work and how they could adapt them when teaching their students. Fitzgerald and colleagues (2019) confirm this approach in their initial PL sessions for Australian secondary science teachers' applying IBL. The teachers criticised the lecture model of the PL and the lack of opportunity to practice the methods being taught. However, the authors also reported success in later PL sessions on IBL approaches where the teachers were provided "models and actual experiences in implementing them before attempting to do so within their classrooms", going on to state the teachers "continue to do so" (Fitzgerald et al., 2019, p. 562). It is clearly important for teachers to experience the approaches they hope to implement during PL (Darling-Hammond et al., 2017).

A coaching and mentoring approach to supporting teachers is encouraged to enable teachers to develop their expertise (Kenny, 2012; Kostoulas et al., 2019). In this study, I adopted these strategies as I considered how to structure the PL sessions. I planned to provide teachers with an opportunity to experience the approaches they hope to implement, as well as support while they trialled them in their classrooms.

As a final consideration of what characterises effective PL, Hargreaves and Fullan (2012) argue that the development of expertise should occur within a specific discipline and context of practice. On this basis, in this study, I explored the development of teacher expertise with particular reference to science education.

3.12 Summary

Over the past decades, many scholars have advocated for the learning of science to move beyond rudimental facts to the learning of science where students understand its relevance and impact in their everyday lives. It is hoped that this understanding leads students to make informed personal and communal decisions that enhance their lives and society in general. Using constructivist approaches such as inquiry for teaching and learning of science is encouraged to tap into students' natural curiosity. Such an approach can enhance students' inquisitiveness as they are actively involved in finding answers to their questions and explanations of phenomena. Although the Nigerian educational goals include developing students' critical, communicative, and creative skills, a gap exists between these objectives and the teaching and learning practices in Nigerian primary schools. Through this study, I further examined the current practices of Nigerian Primary Science teachers to understand if and how their practices support students in achieving Nigeria's education goals.

The reviewed literature suggests that assessment practices must align with the intended goals. Literature on the methods of Nigerian Primary Science teachers revealed the use of summative assessments, as documented in the national curriculum. Through this study, I observed teachers' assessments practices to see whether they align with contemporary recommended assessment practices in science education.

Through reflective discussions with teachers, I hoped to support them to identify strengths and gaps in their practices as they discovered their PL needs. To support teachers' development of expertise, it is essential to provide effective PL in which teachers are actively engaged and are able to experience the strategies they hope to implement. Therefore, I planned to provide effective PL sessions that supported teachers in developing their expertise by working in their context and adopting a collaborative approach to identifying teachers' needs, making the learning more authentic. This contrasts with the lecture-based style of PL documented in Nigeria (see section 2.10), which does not support the development of teacher expertise.

Further, I planned to provide in-class support as TPs trialled their new ideas, with opportunities for further reflection on their progress to encourage a more sustainable way to develop expertise and a community of practice. Again, as the literature shows, the provision of in-class mentoring is not common practice in teacher

PL in Nigeria. I discuss the processes involved in implementing these plans in more detail in the following chapter on the study's methodology.

Chapter 4

Methodology

In this chapter, I present the research design and planned methodological approaches applied in this study as informed by the literature and by the intended outcomes espoused by the Nigerian Policy on Education.

The purpose of this study was to investigate teaching and learning approaches in Nigerian primary school (with particular reference to science) and to explore teachers' awareness of what constitutes effective science teaching and learning strategies, as well as how they implement such approaches within their contexts.

This chapter consists of four sections. Section one provides a rationale for adopting a qualitative interpretive methodology. Through this interpretive research paradigm, I consider the viewpoints of the TPs, their perceptions, feelings, and attributes. Section two describes the population and sample. The ethical considerations, data gathering techniques and instruments used are explained in section three. Section four details the data analysis methods and procedures.

4.1 Research Paradigm: Ontological and Epistemological Stance

I considered an interpretive methodological approach relevant for this research as it draws on both quantitative and qualitative data to provide an in-depth understanding of the context and nature of teacher practice (Creswell & Guetterman, 2019). I adopted a sequential mixed methods design in two phases. In Phase one, the quantitative data provided a broader insight and general trends about the teachers' beliefs and practices in connection with science teaching and learning within the specific geographical area. The quantitative data also aided in selecting schools to participate in the study's second phase (Creswell & Guetterman, 2019; Mills, 2016).

In the second phase, I used Participatory Action Research (PAR) to work cooperatively with a small group of teachers to understand their context and needs and to support them to develop their expertise in science teaching (Corbin & Strauss, 2015; Ivankova & Wingo, 2018; Ivankova, 2015). The PAR phase generated qualitative data about what was happening in classrooms. The mixed-methods approach allowed triangulation to validate, interrogate, and elicit a richer understanding of both the quantitative and qualitative data to provide answers to the main and sub- research questions:

In a globalised world, what are the key educational challenges facing contemporary Nigerian primary school teachers?

And:

1. What policies are advocated in Nigerian education?
2. How do science teaching and learning practices within a Nigerian cultural context reflect contemporary pedagogical approaches to science education?
3. How do Nigerian primary teachers see themselves and their role as science teachers?
4. How can Nigerian primary teachers be supported to enrich/strengthen their understanding of effective Primary Science teaching and learning approaches?

The questions are based on gaps identified in the literature review and on the call for pedagogical renewal to improve the quality of universal primary education in Africa and, more specifically, in Nigeria (Afolabi, 2013; Dembélé & Lefoka, 2007). The review of the literature also indicated that instructional methods were a key factor in low student interest in science-related subjects, coupled with limited in-service support for primary school teachers on pedagogical strategies that encourage student involvement in the learning process (Aina, 2012; FME, 2014).

I chose science as the vehicle for exploring teaching and learning practices in Nigerian primary schools because of its globally recognised importance of directly impacting on the economic progress and innovations in many countries, including Nigeria. The justification for students to learn science is described in more detail in Sections 2.5 and 3.3 above. Comparing actual teaching practices in science with practices recommended in the science education literature practices gave some insights into the beliefs and lived experiences of Nigerian teachers.

This information also enabled a deeper understanding of teachers' needs, leading to my development and delivery of a PL program with the TPs, designed to address some of the contextual affordances and constraints under which teachers in Nigeria work and to introduce them to alternative teaching and learning strategies they could try in their science classrooms.

This interpretivist approach is set within a social constructivist worldview. An interpretive–constructivist approach enables the development of a deep understanding of the different realities of the participants in the study (Mertens et al., 2010). The teachers' realities produce multiple meanings based on their different experiences (Creswell, 2014; Creswell & Guetterman, 2019). Given this interpretivist method, it is important for me, as the researcher participant, to acknowledge potential bias. My observations, reflections, and discussions with the TPs in this study are filtered through my own beliefs and experiences as a pre-service teacher, teacher, and now researcher. Further, a social constructivist paradigm is apt for this research because all the participants were actively involved in the study taking into consideration their beliefs and values in the co-construction of our realities (Adu, 2019; Creswell & Guetterman, 2019).

4.1.1 Background, Beliefs, and Bias

As described in the introduction in Chapter 1, my understanding of my background and experiences as a student and teacher continue to evolve. I have shifted from being passive to a more active and engaged learner. As a teacher, I have strived to encourage and motivate my students to be active learners in all areas. I strive to demonstrate an inquisitive mindset and willingness to learn with and from my students. In this study, I modelled this inquisitiveness through my willingness to learn from the teachers in my interactions with them by asking questions and listening to their explanations of their approaches and the challenges affecting their practice. I adopted the role of a learner because the teachers are more knowledgeable about the school context, culture, and curriculum than I am (Mills, 2016).

A power imbalance can be present in any relationship. This is especially true in the African context and, more specifically, the Nigerian context, where the adult-child relationship is one in which the adult is considered 'all-knowing' and in which children do not necessarily question or challenge adults' ideas or instructions. Children are expected to do as instructed, which is reflected strongly in the teacher-student relationship at school (Mordi, 1991; Njoku & Alalibo, 2020). This was something I experienced growing up in Nigeria, and this hierarchical relationship is also present in many work environments, where subordinate teachers do not question or challenge the instructions from their lead or headteachers (Bush & Glover, 2016). To minimise this aspect of my relationship with the teachers, I spent the first two weeks visiting their classrooms, engaging in informal interactions at recess and lunchtimes, and attending staff meetings. This enabled an equal and positive relationship to develop between me and the teachers such that by the time I commenced more formal observations, they seemed relaxed and carried out their activities without appearing too concerned about my presence. Most of the teachers considered me to be one of them.

4.2 Ethics and Recruitment of Participants

Before embarking on the recruitment of participants for the study, I sought and obtained ethics approval (Ref: H0017300) because the research involved working with and gathering data from human participants. The initial phase included collecting quantitative questionnaire data from teachers, while the PAR phase involved working with teachers who participated on a voluntary basis in their classrooms. Although the PAR phase focused on teachers, it did involve working with these teachers in their classrooms, which meant that contact and interaction with students under 18 years of age may have occurred. Because of this, a full risk ethical approval was sought and granted by the Human Research Ethics Committee (HREC), Tasmania in compliance with the National Statement on Ethical Conduct in Human Research (National Health and Medical Research Council (NHMRC), 2007) (see Appendix B). Necessary approvals to conduct research were sought from the Plateau State Ministry of Education and the principals of the schools the research was conducted in (see Appendices C and D). This ethics approval process was necessary to ensure the integrity of the researcher and to assure participants of its credibility, taking the emotional, physical, and intellectual wellbeing of the participants into account (O'Leary, 2017).

After obtaining the necessary approvals, participants (teachers) were recruited for the study by presenting them with letters that informed them about the research and its aims and sought their consent (Appendix E). The participants read these information letters and signed the consent forms prior to participating, and I explained voluntary participation so that the teachers did not feel obliged to participate and that they could at any point decide to disengage without penalty. Necessary precautions to ensure researcher safety were also documented, but this was not a major problem as I had lived, studied, and worked in that area for many years, and I am very familiar with the cultural context and proficient in the local language. However, my safety became a key concern to the extent that the research was shortened by about four weeks due to political and tribal tensions (see Chapter 6). These tensions affected the schools, with frequent closures required, as well as the data collection process in the second phase of the PAR part of the study.

4.3 Research Design and Methods

I embraced a social constructivist epistemic position on the basis that meaning making occurs through interactions that occur between all participants in a study (Creswell, 2014; Yilmaz, 2013). Although the events and perspectives of this small group of teachers should not be over-generalised, the results and recommendations from this research may resonate with education policymakers in developing countries and with teachers who work in similar conditions or contexts (Creswell & Guetterman, 2019; Mills, 2016).

The mixed methods research approach drew on both quantitative and qualitative techniques to corroborate the study's findings (Creswell, 2014). The diverse types of data I collected drew on the strengths of each to reinforce the study and provide a deeper understanding of the research problem (Creswell, 2014; Creswell & Guetterman, 2019; Ivankova & Wingo, 2018).

The quantitative data was gathered using a questionnaire sent to a broader group of primary teachers in schools in the Local Government Area (LGA), where the study would be conducted. Although not a representative sample, these data, largely based on demographic and Likert-scale responses, gave me a sense of the general views of a broader group of teachers and assisted me in identifying their beliefs about science teaching, their roles as science teachers, the strategies they perceive as being important to teaching science, how often they used these strategies, assessment practices and factors that limited quality teaching or posed challenges to effective practice. It also helped me identify candidates for the smaller case study group for the PAR stage.

The qualitative data were obtained through a cyclical PAR approach. The aim was to work with the selected Primary Science teachers to develop an understanding of their practices and to support them in developing their expertise to adopt more learner-centred teaching approaches, as advocated in the curriculum. One Nigerian private school was chosen as a case study site, but the opportunity arose to also include two teachers from another school. A total of six ‘specialist’ science teachers participated in this phase of the study. The exploration of the practices of these six primary science teachers provided rich and in-depth data about their practices, pedagogical beliefs, the explored phenomenon, and contexts (Yin, 2018; Yin et al., 2006).

The mixed-methods approach fits within the iterative, systematic, and cyclical nature of PAR, which in this case encouraged cyclical, collaborative reflection to help teachers understand and change their practices (Ivankova, 2015). The pragmatic nature of mixed methods is based on a belief that there is value in drawing on ‘the combination or mixture of methods and procedures that works best for answering the research questions’ (Johnson & Onwuegbuzie, 2004, p. 17). Figure 4.1, below, provides a visual representation of the mixed methods design of this study.

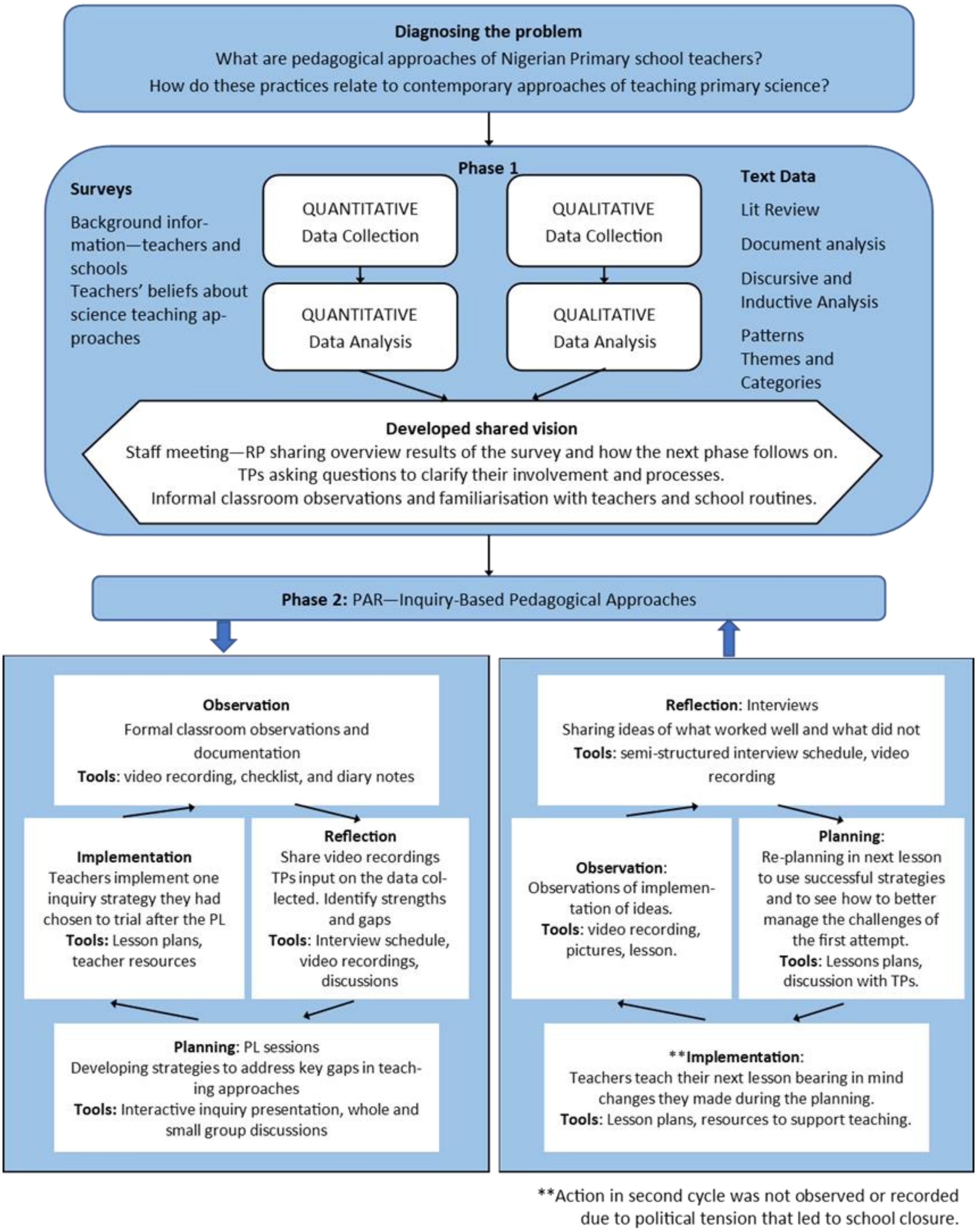

Figure 4.1 Quantitative and Qualitative Phases

In the following subsections, I discuss the quantitative and qualitative phases and how the data generated from both support the understanding of the research phenomenon.

4.3.1 Phase 1: Initial Teacher Questionnaire

The questionnaire was adapted from a previous study of ideal and actual practices of secondary teachers in Nigeria (Ogunmade, 2005). For this study, I distributed questionnaires to 50 primary teachers in public and private primary schools in the Bassa LGA in Plateau State (see Appendix B). This was to obtain a general overview of teachers' backgrounds, beliefs, and perspectives about teaching, and specifically about science teaching and learning in Nigeria. It also provided an opportunity for participants to volunteer for the next stage of the study. The questionnaire data were non-identifiable, as individual participants did not write their names. In order to recruit for the PAR phase, the questionnaire asked the respondent to indicate their school. These data were to be analysed using SPSS software version 24 (IBM Corp, 2016) to explore both descriptive statistics, such as percentages and frequencies, and inferential statistics to tease out relationships between various variables. The complete analysis is presented in Chapter 5.

4.3.2 Phase 2: Participatory Action Research (PAR)

For the second phase of the study, I employed a Participatory Action Research methodology. Action research, a term credited to Levin (1934), has evolved, with varying schools of thought as to its meaning (Mills, 2011). Despite these variations, the goal of action research remains the same: to bring about change or improvement. There has been a recent shift from emancipatory action research to a more participatory form, in which "knowledge is an outgrowth of previous experience" (Mills, 2011, p. 20). A central element of PAR is the way it places emphasis on current practices, making it more relevant as a method for classroom teachers and more persuasive in advocating for change. PAR can be considered as empowering participants in a social setting to take the "construction and reconstruction of their social reality into their own hands"

(Kemmis & McTaggart, 2000, p. 572) and to do that in the knowledge that they are supported. PAR involves the process of critical reflection, where participants think critically about where they are now and how to improve or change that (Kemmis & McTaggart, 2000). In teachers' case, the improvement would be to their practice.

PAR takes place within the context of practice, so the evidence or insights it produces can be adopted easily (Kemmis & McTaggart, 2000). PAR was considered suitable for this stage of the study because it aimed, through teacher participation and reflections, to encourage teachers to be active participants and to take ownership of the changes they made in their practices and classroom environments.

PAR also enables the practitioner/s to be the researcher/s, with or without specialised research training (Mills, 2016). In this study, as reflected in the title 'Let's learn together...' a collaborative approach between the RP and the TPs was adopted with the aim of improving practice. As a social and educative process that encourages and fosters collaboration, PAR provides a critical, recursive process to transform theory and practice (Kemmis & McTaggart, 2000). It also provides an avenue for me, as the RP, to be an active participant who learns and adapts to the cultural context.

Mills (2016) describes PAR as a dialectic action research spiral of identifying an area of focus, collecting data, analysing it, interpreting it, developing an action plan, and carrying out the action. As a cyclical process, each iteration involves participants observing, reflecting, planning, and acting (Mills, 2011; O'Leary, 2012; Stringer, 2014b). The reflection in one cycle leads to new actions and practices in the next, as depicted in Figure 4.2 below.

Figure 4.2 Cyclical and spiral nature of PAR (adapted from Stringer, 2008)

Classroom Observation

I planned to carry out classroom observations of the teachers' science lessons with the aid of an observation checklist informed by the literature, which also had space to write notes (Appendix H). I planned to position a camera at the back to record the lessons focusing on the teacher (O'Sullivan, 2005), and to review the TPs' lesson plans, which I hoped would give an indication of how they interpreted the science curriculum. I also collected samples of students' work.

Reflection

I watched the recorded lessons and reviewed my observation sheets and notes. I engaged in analysis to determine the key issues emerging, focusing on what the TPs did well and identifying areas for improvement. During an agreed time with each TP, we reviewed their lessons by watching the recorded videos. I also used a semi-formal interview schedule (Appendix I) to stimulate discussion and encouraged the TPs to share their thoughts about their lessons, identifying areas they did well and challenges or gaps. I then shared my thoughts with them, and we discussed the ideas and considered ways of modifying their practice, where relevant. These suggestions were documented and discussed further in the PL sessions with all the TPs. At this point, as RP, I offered suggestions to encourage a more inquiry-based teaching approach. The interactions that occurred during the reflection stage were integral to the forming of identified themes. Through this communitive action, the TPs and I formed a collective understanding and language about their practices (Kemmis et al., 2014).

Planning

From the questionnaire, I identified that professional development in science was lacking. PL support for in-service teachers in Nigeria has been found to raise the standard and quality of teaching (Hardman et al., 2008). Research suggests that an in-service, school-based training model can be effective and have a significant impact as it builds on existing structures and gives teachers opportunities to reflect on their practice (Garet et al., 2001; Joyce et al., 1997).

Initially, I planned to offer and explain the 5Es inquiry model for teaching science, and then in the second cycle, to work with the teachers to develop a unit of work to teach a science concept using the 5Es.

Table 4.1, below, captures the goal at each stage of the research process, the research techniques used to achieve these goals and the roles adopted by the RP and TPs.

Table 4.1 Processes and technique used to foster a collaborative action research process

Research process and technique	Direct goal	Expected outcome	Input to data collection	Data analysis and feedback
Observation checklist	Facilitator to gain an understanding of how teachers go about their daily practice	To provide understanding of the research context and a talking point with teachers	Teachers and facilitator	Facilitator
Interviews—reflection Semi-structured interview schedule	To provide a clear idea of teachers' perceptions of their practice (strengths and areas for adjustment). To encourage and promote teachers' reflective practice	To develop shared knowledge and understanding of teacher practice	Teachers and facilitator	Teachers and facilitator
Professional Learning Session	To clarify strengths and challenges that cut across all the teachers who participated in the session	To develop shared knowledge and understanding, and to offer alternative teaching strategies	Facilitator and teachers	Facilitator and teachers
Observations—video and audio recordings	Opportunities to implement alternative teaching approaches	Opportunities to observe how teachers implement alternative approaches chosen	Teachers and facilitator	Facilitator and teachers
Interviews—audio recordings	To reinforce teachers' reflective practice and develop an understanding of their developing expertise	To provide an understanding of the alternative teaching strategy implemented; what worked well, what were the challenges? What could we do differently next time?	Teachers and facilitator	Facilitator and teachers

4.4 Data Analysis: Questionnaire and PAR Data

Data analysis for each phase was carried out sequentially using quantitative and qualitative methods as appropriate.

The questionnaire data were analysed and interpreted using SPSS statistical package version 24.0 (IBM Corp, 2016) to provide descriptive analysis using Cronbach's alpha to assess the internal consistency of the dataset. I also used the Mann-Whitney U and Kruskal-Wallis tests as non-parametric methods to look for any statistically significant relationships between selected data variables.

Analysis of the qualitative data was also an integral part of the PAR process. Throughout this research, the TPs and RP engaged in a recursive process of reflection and discussion that stimulated or refined action (Mills, 2016; Stringer, 2014a). These recorded observations and discussions provided data for analysis and assisted in determining the themes that emerged.

The analytical process adopted after the entire PAR data collection process was completed is represented in Figure 4.3 below.

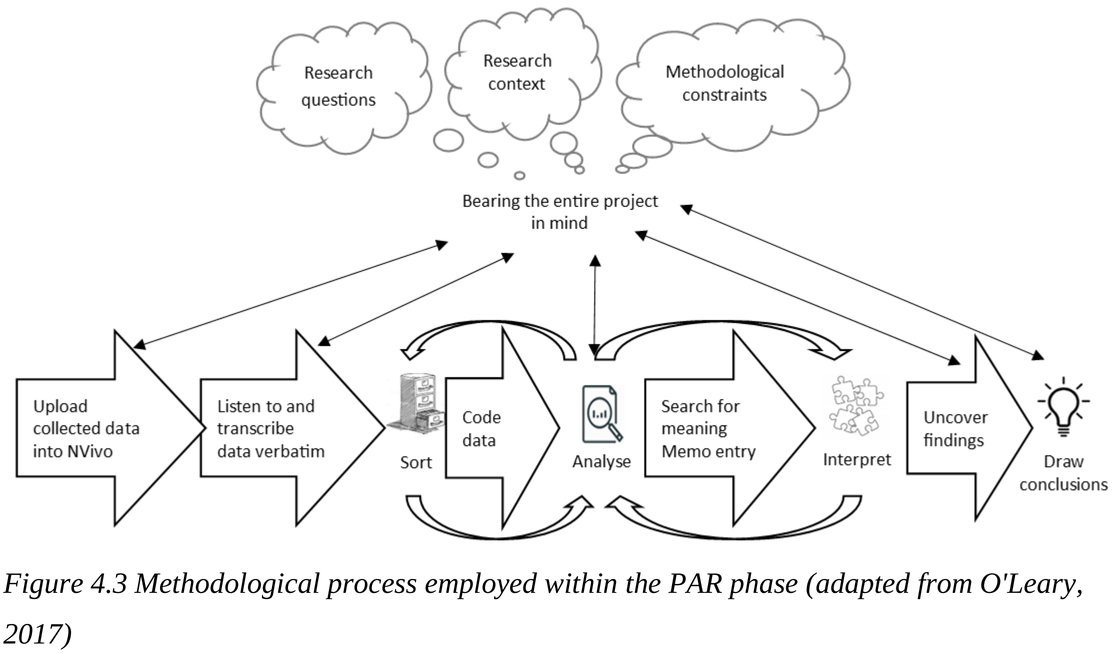

Figure 4.3 Methodological process employed within the PAR phase (adapted from O'Leary, 2017)

In Table 4.2, below, I present a more detailed description of the analytical decisions I took to make sense of and interpret the data collected. I adopted the Braun and Clark framework to guide how I thought through the analysis while allowing room for decisions based on my research questions and context (Braun et al., 2019).

Table 4.2 Analytical decision framework (adapted from Braun and Clarke, 2006)

Familiarising myself with the data	I uploaded the audio files of observations, interviews, PL sessions and reflection recordings into a qualitative data analysis software (QDAS) using NVivo (QSR International, 2018) I transcribed each file verbatim and shared some of the audio files and transcriptions with my supervisors for them to confirm. This process involved listening to, reading, and rereading the transcripts many times and enabled me to immerse myself in the data.
Generating initial codes	I began the coding process by identifying key aspects within the data that stood out and set these as nodes in NVivo (see Appendix J). I had descriptive and to some extent interpretive codes, basically assigning labels to represent the essence of my data. I discussed my codes and what they meant with my supervisors. They read through the raw data and the codes attached, agreed or, in some cases, suggested alternatives. This process also served to check the interpretation of the data and the validity of the codes attached (Bazeley, 2013).
Generating initial themes	I annotated the data with my thoughts (any interpretations) as I progressed through each dataset using the memos feature of NVivo, then organised the codes into potential themes.
Reviewing themes	I reread each case to see what else stood out and summarised each dataset in a linked memo. I consulted with my supervisors and discussed the emerging themes.
Defining and naming themes	I gave each participant a pseudonym to assist me in getting comfortable with using the pseudonym in the writing up phase. I also refined and changed the names of some of the themes to better reflect the set of codes, the research questions, and the goals. This was also to ensure that the themes were coherent and consistent
Producing the report	This thesis represents the collected, analysed and interpreted data.

Although Table 4.2 may appear to describe a linear approach, this analytical process was more recursive, with constant movement back and forth within and between the phases to develop an in-depth understanding of the data in their entirety (Braun & Clarke, 2006; Braun et al., 2019). Throughout this process, it was important to keep in mind the research aims, the theory guiding the study, and the research questions, asking myself how these codes assist in answering those questions. I chose to use NVivo as my QDAS based on its availability and to enable me to explore the large amount of textual data to see patterns.

I applied an inductive approach to the analysis without any pre-existing code frame with the use of analytic memos that aided my interpretation (Charmaz, 2014; Corbin & Strauss, 2015). Initially, I utilised open descriptive and *in vivo* coding to label and identify emerging concepts from the dataset and engaged in constant comparison to identify occurrences that could be grouped into the same conceptual categories (Bazeley, 2013; Saldaña, 2016; Stringer, 2014). Subsequently, I applied axial coding to determine the patterns and links between the categories identified to form themes (Charmaz, 2014; Saldaña, 2016). The key themes that emerged were teacher perception, classroom interactions, teacher expertise, and PL to support further development of teacher expertise. These themes are represented in Figure 4.4, below, and will be discussed further in later chapters.

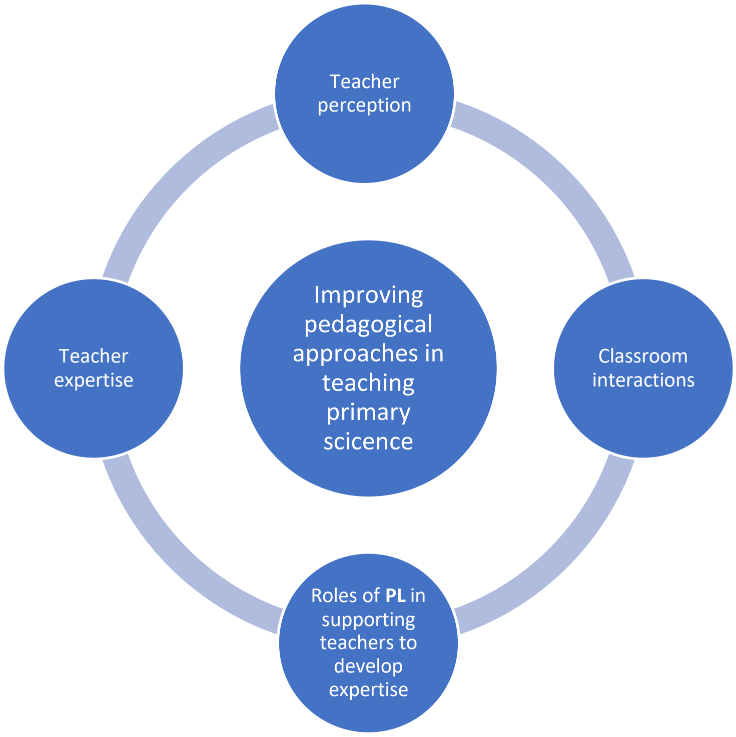

Figure 4.4 Key themes

4.5 Data Trustworthiness: Reliability and Validity

Reliability is maximised by ensuring that the techniques employed could be utilised in future when conducting similar research (Grant et al., 2007; Mills, 2016). Reliability within this study has been ensured by making explicit the theoretical underpinnings, clearly stating how the researcher is positioned, who the participants are, how they were selected, and their roles and active involvement in the research process. Reliability was also ensured through the triangulation of data.

Validity in research is a process of checking that the methods, procedures and data are consistent with the intended outcome (Creswell & Guetterman, 2019). In this research, I ensured validity through member check, iterative comparisons, and the triangulation of multiple methods of data collection and analysis to confirm the findings. The co-participation and co-construction of knowledge accounts for the validity of the PAR phase of the study. Although PAR may not be generalised to a broader population, the findings of the research are relevant to the research audience, and its rich descriptions make it suitable to consider its applicability to similar research contexts (Mills, 2016). Furthermore, the validity of PAR lies in the ability of the participants to take effective actions and develop solutions to the issues they sought to address (Mills, 2016; Stringer, 2008, 2014). This was the case in this PAR study, where the participants worked collaboratively to develop solutions and made the necessary adjustments to involve students more in their learning process. These actions and outcomes make the inquiry process credible.

Stage Two: Data Analysis and Interpretation

This phase marks the beginning of data analysis and interpretation. In the next six chapters, I present and analyse the data collected to get an understanding of the Nigerian educational context. First, in Chapter 5, I draw on the data from the initial teacher questionnaire and its implications for the second PAR phase. That chapter describes my observations and reflections and their impacts on my actions in line with the PAR cyclical process outlined in Chapter 4.

These chapters shed some light on the research aim of exploring Nigerian Primary teachers' pedagogical approaches and how they perceived and adapted to educational change, revealing their attitudes and concerns through their classroom practice in science.

In Chapter 6, I begin by presenting the research context of the schools and the specific context within which the TPs worked, as well as where the PAR phase was conducted. Chapter 7 outlines the classroom observations of the TPs' science teaching approaches. This is followed by a critical reflection on their practices and how they relate to the Nigerian Science Curriculum and contemporary approaches to science teaching and learning in literature.

In Chapter 8, I present the perceptions of the teachers about their roles and practices as science teachers and outline how a reflective process led to the identification of their PL needs. Further, I engage with the literature to understand the reflective process the teachers and I engaged in and how best to support and bridge the gaps identified.

I discuss the PL sessions the teachers and I engaged in Chapter 9, as well as how we explored a range of pedagogic approaches and how these could be incorporated into their practices amidst the systemic and cultural challenges of the context in which they work. Following the TP's reflections on the PL sessions, I engaged in a critical reflection on the PL sessions to provide a grounding for the approaches I used in the PL. In Chapter 10, I describe and discuss the shifts individual teachers made in their practice and the impact of those changes as they tried to implement the new strategies they were exposed to during PL.

Chapter 5
Analysis of the Teacher Questionnaire

This chapter examines the results of the teacher questionnaire, which was used to gather information about teachers' perceptions of teaching and learning of Primary Science in Bassa Local Government Area, Plateau State, Nigeria (see Appendix C). Teachers were asked about the strategies they utilised, believe are important, and how frequently they should be used, as well as about their assessment practices and the challenges that affect their teaching.

Questionnaires were distributed to 50 primary teachers from seven primary schools. Thirty-four of these questionnaires were completed and returned, giving a 68 per cent return rate. The participants' school type, academic qualifications and years of teaching experience are presented below in Table 5.1.

Table 5.1 Demographic information of teachers surveyed (n=34)

Characteristics	n	Percentage (%)
Type of school		
Public	9	26
Private	25	74
Teacher Academic qualifications		
NCE	17	50
OND	2	5.9
HND	3	8.8
B.Ed.	10	29.4
BSc	1	2.9
MSc	1	2.9
Years of teaching Experience		
0–5	9	26.5
6–10	4	11.8
11–15	7	20.6
16–20	12	35.3
Missing	2	5.9

I conducted the analysis in SPSS software version 24 (IBM Corp, 2016). Internal consistency and reliability of the items were determined using the Cronbach's alpha score. Due to the small sample size (n=34) and the fact that the sample data were ordinal and nominal, I used non-parametric tests including Mann-Whitney U and Kruskal-Wallis to assess the difference among two, three or more groups of the ordinal and ranked data (Allen, Bennett, & Heritage, 2014; McKnight & Najab, 2010).

The data in Table 5.1 revealed that 25 (74%) of the primary teachers who completed the questionnaire were teaching in private schools. Nine (26%) were in public schools. They also show the distribution of teachers' academic qualifications, with half of the teachers (50%) holding a National Certificate of Education (NCE), which is the minimum qualification requirement for teaching in Nigerian primary schools. Almost a third (29.4%) had a Bachelor of Education degree, with only two (6%) teachers responding that they had a science degree. The teachers' years of teaching experience revealed that more than two-thirds (68%) of the teachers had between six- and twenty-years' teaching experience, with a little more than a quarter (27%) having less than six years. The number of students in each class is presented in Table 5.2.

Table 5.2 Class sizes at public and private schools (n=34)

Class size	**Public**	**Private**	**Total**
1-20	0	5	5
21-30	0	7	7
31-40	2	13	15
41-50	3	0	3
>50	4	0	4
Total	9	25	34

The smallest class, with only nine (9) students, was at a private school, while the largest class, at a public school, had eighty (80). The most common class size was 31 to 40 students, and classes of this size were mostly at private schools.

5.1 Teachers Beliefs about the Importance of Science Teaching and Their Roles

The questionnaires sought information about the teachers' perceptions about the importance of science and their roles. It asked about how often they taught science and how long their typical lessons tended to last. It further asked teachers if they were familiar with the science curriculum, if they felt confident to teach science, and if they had attended any science PL.

Table 5.3 How often teachers teach science and how long for (n=34)

Category	n	Percentage (%)
Frequency		
Daily	1	2.9
Weekly	32	94.1
Fortnightly	1	2.9
Length of Lesson		
30-40mins	20	58.8
41-60mins	14	41.2

Table 5.4 Science teaching—importance, knowledge of curriculum, confidence, attendance at science PL (n=34)

Category	Yes	Percentage (%)	No	Percentage (%)
Importance	34	100	0	0
Knowledge of curriculum	24	70.5	10	29.4
Confidence	22	64.7	12	35.3
Science PL	8	23.5	25	73.5

Table 5.3 and Table 5.4 show that teachers mostly teach science weekly for about 30 to 40 minutes. Table 5.4 indicates that all the teachers believe science is an important subject. More than half (65%) of them felt confident to teach Primary Science. A majority (70.5%) of the teachers indicated that they were familiar with the curriculum, but as "specialist" teachers, it was somewhat surprising that about a third of them were not familiar with the curriculum. Only 23.5% of them had attended a science PL session, with most (73.5%) indicating they had never participated in a science PL before.

Most (94%) of the teachers said they taught science once a week, with about 59 per cent of lessons being 30 to 40 minutes long. The inadequate teaching time devoted to science teaching compares closely with the findings in the Australian study of science teaching and learning in Australian schools by Goodrum, Hackling and colleagues (2001). In contrast with that study, though, the Nigerian teachers indicated that they are confident in teaching science. These findings were potential areas for further investigation during the qualitative phase of the study.

The questionnaire also had space for teachers to write an open text response to elaborate on their attitudes towards teaching science. The themes that emerged from these responses are summarised in Table 5.5 below. They included their beliefs about the importance of science, how they think their students learn science best, and a description of their science teaching strategies.

Table 5.5 Reasons for the importance of science and ways teachers think their students learn science best (n=34)

Category	**Reasons**
Importance of science	Exposes the child to knowledge of their body and the environment.
	Gives the child practical experience.
	Science influences most aspects of everyday life-it is the basis of science and technology growth.
	It is the basis for secondary education and future science learning, Primary Science is foundational.
	Students learn and discover facts through science.
	It carries creative activities, observations, and experiments.
	Students develop skills of planning, conducting investigations, gathering information, and evaluating findings.
	The teacher is able to bring out the best in students.
	Prepares students for future science learning.
How students learn science best	Through discovery
	Practical lessons, field trips
	Teaching aids and practical examples
	Through exploration, experiment, and observation
	Through hands-on practice relating to complex concepts
	Through critical thinking
	Explanations
	Asking questions
	Through class and group discussions and experiments
Science teaching strategies used	Teacher questioning
	Discussion
	Hands-on, discover method
	Dramatization, relationship establishment between common and complex concepts
	Grouping students, carrying out tasks as a team
	Illustration, examples, teaching aids and practicals
	Telling students and explaining so that students understand it very well

Most of the teachers indicated that they utilised discovery, hands-on activities and discussions when teaching science. Some of the strategies they felt they could use more included practical lessons, experimentation, inquiry, and field trips, but many felt constrained by limited resources.

Teachers were also asked to rate the *importance* of certain teaching and learning strategies in science. During analysis, I grouped responses to these questions based on those strategies that were directly related to the teacher (teacher expertise) and those that focused more on what students did (student participation). The data for these are shown in Table 5.6 below.

Table 5.6 Teachers' beliefs on importance of teacher expertise and students' participation strategies (n= 34)

	Items	**Not Important n (%)**	**Important n (%)**	**Very Important n (%)**
Teachers' beliefs on importance of teachers' expertise				
1	Teachers specify the questions, materials, and procedures of carrying our investigations	0	6 (17.6)	28 (82.4)
2	Teachers have opportunities for Professional Learning through seminars and workshops to improve their teaching	0	3(8.8)	31 (91.2)
3	Teachers have a sound content knowledge	1(2.9)	7 (20.6)	26 (76.5)
4	Curriculum is used to guide teaching and learning decisions	0	8 (23.5)	26 (76.5)
Teachers' beliefs on importance of student participation strategies				
1	Students plan and carry out experiments to investigate their own questions	0	14 (41.2)	20 (58.8)
2	Whole-class discussions are encouraged throughout the learning process	4 (11.8)	12 (35.3)	18 (52.9)
3	Small group discussions and activities are part of students learning	0	11 (34.2)	23 (67.6)
4	Students have opportunities to engage in hands-on exploration of the content taught	2 (5.9)	15 (44.1)	17 (50.0)
5	Students have opportunities to represent and present their understandings in various forms	2 (5.9)	12 (35.3)	20 (58.8)
6	Students are encouraged to ask questions	0	0	34 (100)

5.2 Testing the Internal Consistency and Relationship of Items

The Cronbach's alpha was used to measure the internal consistency of certain items in the questionnaire to give an indication of the internal reliability of the questions. The internal reliability of a group of questions is indicated by a Cronbach's alpha of .07 or greater (Allen et al., 2014).

Table 5.7 and Table 5.8 show the two groups of questions asked in the questionnaires. Table 5.7 focuses on the importance of the strategies, and Table 5.8 focuses on how *often* the teachers utilised the strategies mentioned.

The *teachers' expertise* theme indicates what specific tasks and decisions teachers undertake, and the *students' participation* theme captured the nature of the tasks or decisions made by students. As shown in Table 5.7, the Cronbach's alpha coefficient for all the items of the two themes—that is, *teachers' expertise* and *students' participation*—were 0.74 and 0.76, respectively.

Table 5.7 Cronbach's alpha on teacher's beliefs on ***importance*** *of teacher expertise and student participation*

	Item	Theme	Cronbach's alpha
1	Teachers specify the questions, materials, and procedures of carrying our investigations	Teacher's expertise	.737
2	Teachers have opportunities for PL through seminars and workshops to improve their teaching		
3	Teachers have a sound content knowledge		
4	Curriculum is used to guide teaching and learning decisions		
5	Students plan and carry out experiments to investigate their own questions	Students' participation	.761
6	Students have opportunities to engage in hands-on exploration of the content taught		
7	Students have opportunities to represent and present their understandings in various forms		

The Cronbach's alpha reveals that these items are internally consistent to an acceptable degree. Teachers were further asked to describe how often they thought certain teaching and learning of science strategies should be used. These questions were also grouped based on those strategies that were directly related to the teacher (teacher expertise) and those that focused more on what students did (student participation). The data for these are shown in Table 5.8, below.

Table 5.8 Teachers' beliefs on ***how often*** *teacher expertise and student participation strategies should be used (n= 34)*

	Item	All the time n (%)	Most of the time n (%)	Sometimes n (%)	Never n (%)
Teachers' self-reported expertise					
1	Teachers specify the questions, materials, and procedures of carrying our investigations	19 (55.9)	11 (32.2)	4 (11.8)	0
2	Teachers have opportunities for Professional Learning through seminars and workshops to improve their teaching	11 (32.3)	4 (11.8)	18 (52.9)	1 (2.9)
3	Teachers have a sound content knowledge	22 (64.7)	7 (20.6)	4 (11.8)	1 (2.9)
4	Curriculum is used to guide teaching and learning decisions	20 (58.8)	9 (26.5)	5 (14.7)	0
Teachers' beliefs about *how often* student participation should occur					
1	Students plan and carry out experiments to investigate their own questions	9 (26.5)	12 (35.3)	13 (38.2)	0
2	Whole-class discussions are encouraged throughout the learning process	14 (41.2)	10 (29.4)	9 (26.5)	1 (2.9)
3	Small group discussions and activities are part of students learning	12 (35.3)	17 (50.0)	5 (14.7)	0
4	Students have opportunities to engage in hand-on exploration of the content taught	10 (29.4)	10 (29.4)	13 (38.2)	1(Missing)
5	Students have opportunities to represent and present their understandings in various forms	8 (23.5)	16 (47.1)	9 (26.5)	1 (2.9)
6	Students are encouraged to ask questions	27 (79.4)	3 (8.8)	4 (11.8)	0

In Table 5.9, I calculated the Cronbach's alpha for items 1 to 4 of the teachers' *self-reported expertise* of teaching Primary Science and found it to be .258, revealing a weak correlation. However, when item 4 was removed, the Cronbach's alpha increased to .747, which is considered adequate for internal consistency. The Cronbach's alpha for the six items on how often student participation strategies should be used was .527. This value reveals a weak positive correlation across the six items. If items 3 and 4 were removed, the Cronbach's alpha increases to .717, which is a much stronger positive correlation. Therefore, the Cronbach's alpha for the four remaining items for how often *student participation* should occur should be used, as it indicates an acceptable reliability coefficient correlation (Allen et al., 2014; Hinton et al., 2014).

Table 5.9 Cronbach's alpha on teacher's beliefs about how often teacher expertise and student participation strategies should be used.

	Item	**Category**	**Cronbach's alpha**
1	Teachers specify the questions, materials, and procedures for carrying out investigations	Teacher's expertise	.747
2	Teachers have opportunities for PL through seminars and workshops to improve their teaching		
3	Teachers have sound content knowledge		
4	Students plan and carry out experiments to investigate their own questions	Students' participation	.717
5	Students have opportunities to engage in hands-on exploration of the content taught		
6	Students have opportunities to represent and present their understandings in various forms		
7	Students are encouraged to ask questions		

These Cronbach alpha values are greater than 0.7, showing an acceptable degree of internal consistency for each of the above groups of items. This gives me, as the researcher, confidence to interpret the data, as the items appear to be measuring similar ideas.

5.3 Mann-Whitney U and Kruskal Wallis Tests

Because the data are ordinal, inferential non-parametric tests were used to look for statistically significant relationships between variables. The Mann-Whitney U test was run to explore relationships between two independent variables, and similarly, the Kruskal Wallis test was used to determine whether there was any statistically significant difference between variables involving three or more groups. The test for significance was a *p*-value of <0.05 (Allen et al., 2014; Hinton et al., 2014).

Table 5.10 shows the results of the Mann-Whitney U test to check whether there is a statistically significant relationship between teachers who attended PL and those who did not and their use of teaching strategies such as student participation and teacher expertise.

Table 5.10 Relationship between teachers' science professional learning and student participation and development of expertise

Domain	**Mean Rank**		**U**	***p*-Value**
	Science Professional Learning			
	Attended	Not Attended		
Student participation	13.00	17.67	68.00	.208
Whole-class discussion	11.00	18.13	57.000	.059
Hands on exploration	22.63	14.46	47.000	.017
Curriculum as guide	21.38	14.88	57.00	.057

Based on these results, there was no significant difference (p<0.05) between teachers who had attended PL and those who had not on all questions except one: hands-on explorations. Teachers who attended PL indicated they were more likely to uses hands-on activities. This raises questions about the effectiveness of the professional learning these teachers attended in encouraging the use of other strategies.

A Kruskal-Wallis test was run to see whether there was any statistically significant difference between variables with three or more independent groups. Table 5.11 shows the relationship between teachers' years of teaching experience in comparison to their expertise and use of student participation strategies.

Table 5.11 Relationship between teachers' years of experience and domains of confidence to teach science, teacher expertise, students questions and use of curriculum

Domain	**Mean Rank**				**k**	**p-Value**
	Years of Experience (yrs.)					
	0–5	6–10	11–15	16–20		
Confidence to teach science	14.50	11.00	15.67	15.20	1.629	.653
Teacher expertise	17.88	18.50	19.64	10.05	6.966	.073
Students ask question	16.44	18.50	18.50	11.82	6.737	.080
Curriculum as a guide	18.25	21.50	16.93	10.41	8.515	.036

The Kruskal-Wallis indicated that there were no statistically significant relational differences found to do with the years of teaching experience of the teachers for three of the variables tested, namely: confidence to teach science; teacher expertise; and students asking questions. That the confidence of the teachers to teach science did not increase with experience could be due to their reported confidence to teach science being high from the beginning. This raises the question of how teachers interpreted 'confidence' in teaching, which highlights an area for further investigation in the qualitative phase. These results raise questions about the development of their expertise to teach science, as it might be expected that there would be an increase in each domain over time. Further qualitative investigations may shed more light on the use of these aspects in developing teacher expertise.

However, the Kruskal-Wallis test also revealed a significant statistical difference between the years of experience and the use of curriculum as a guide: 0–5 years (*Mean Rank*=18.25), 6–10 years (*Mean Rank= 21.50*), 11–15 years (*Mean Rank = 16.93*), and 16–20 years (*Mean Rank=10.41*), $H = 8.515, df = 3, N = 30, p =.036$.

It seemed the more experienced the teachers were, the less they used the curriculum as a guide. Futher post-hoc pairwise tests were carried out to determine where the difference lies within this group. The test indicated a difference for ‘all the time–sometimes.’ The effect size of 0.244 is small, though, which implies that the sample size may be too small to make conclusive judgements. This highlights the need for a larger sample.

Table 5.12 shows the results of a Kruskal Wallis test exploring the relationship between items dealing with teachers’ academic qualifications and expertise and students’ participation.

Table 5.12 Relationship between teachers’ qualification and student participation, use of curriculum, students’ investigations and confidence to teach science

Domains	**Mean Ranks**			**k**	**p-Value**
	Academic Qualifications				
	NCE	HND	B.Ed. and above		
Student participation	28.00	16.83	14.50	3.511	.173
Curriculum as a guide	18.47	24.00	12.55	5.531	.063
Students plan and carry out investigations	14.26	11.00	23.36	8.434	.015
Confidence to teach science	14.94	16.67	17.70	.983	.612

The Kruskal-Wallis ANOVA indicated that there were no statistically significant differences in relation to three items—student participation, teacher's confidence to teach science, and use of curriculum—across the three teachers' qualification groups. However, there was a statistically significant difference for the items 'students plan investigations' across the three groups NCE (*Mean Rank = 14.26*), HND (*Mean Rank = 11.00*) and B.Ed. and above (*Mean Rank = 23.36*), $H = 8.434$, $df = 2$, $N = 33$, $p = .015$. This indicates that teachers with a B.Ed. or higher degree are more likely to allow their students to plan and carry out investigations. Further, a Dunn's pairwise analysis showed the significant difference was specifically between the B.Ed. and NCE levels. The effect size of 0.2634 is small, which may mean the difference is unimportant, but this may also be due to the small sample size. Again, the qualitative data may provide further insight on the nature of the use of student investigation strategies.

5.4 Assessment Strategies

The teachers were also asked to describe what they assess in Primary Science, what strategies they employed, why they assess and how they reported the assessments. Table 5.13 shows the teachers' responses.

Table 5.13 Areas of science assessment

	Category	Frequency	Percentage (%)
Assessment area			
1	Science skills and processes	26	76.5
2	Understanding of science content	31	91.2
3	Science attitudes	19	55.9
4	Any other	1	2.9
Reason of assessment			
1	Student feedback on learning	32	94.1
2	Planning for the next lesson	22	64.7
3	Grading and reporting	21	61.8
4	Assessing science attitude	21	61.1
5	Indentifying students' misunderstanding	16	47.1
6	Any other reasons	1	2.9
Technique of science assessment			
1	Written tests	31	91.2
2	Verbal responses	26	76.5
3	Assignments/projects	26	76.5
4	Practical work	24	70.6
5	Presentation	17	50.0
6	Quizzes	15	44.1
Reporting method			
1	Written report	30	88.2
2	Student presentations	20	58.8
3	Students' portfolio	10	29.4

Teachers claimed, most prevalently, to assess students’ science content knowledge (91.2%), followed by students’ skills and processes (76.5%). A slight majority (55.9%) mentioning assessing students’ attitudes to learning science. Only one teacher said that they assessed group work. In terms of reasons for assessment, the vast majority (94%) of the teachers saw assessment as a means of providing feedback to their students, with 64.7 per cent claiming they used assessment results to plan the next lesson and 61.1 per cent assessing their students' attitudes to science. Fewer than half of the teachers (47.1%) used assessments to identify students' misunderstandings. The most-used assessment strategies were written tests (91%), while a little over three quarters (76.5%) of the teachers utilised verbal responses and assignments/projects. Half of the teachers indicated assessing students' presentations, with fewer than half utilising quizzes. The most common way of reporting about students science learning was written reports (88%), with more than half (59%) of the teachers using student presentations. Student portfolios were not a commonly used approach, with only about a third (29%) of the teachers indicating that they use it.

5.5 Challenges Affecting Teachers' Practices

Teachers were asked to comment about some of the factors that inhibited or restricted their teaching of Primary Science. The vast majority (91.2%) of the teachers indicated that not having a well-equipped classroom was a challenge. The table below shows their responses.

Table 5.14 Teachers' responses about their science classrooms

Well-equipped science classroom	**Frequency**	**Percentage (%)**
Yes	3	8.8
No	31	91.2
Total	34	100.0

Teachers also had an opportunity to elaborate on their responses, and many identified the '*lack of sufficient science instructional materials*' as a hindrance to their teaching of Primary Science. Of the nine per cent of teachers who indicated that they had a well-equipped classroom, many still mentioned the '*lack of facilities and materials to carry out most practical work related to the topic of discussion*'. These facilities include laboratories for experiments and basic teaching aids such as charts and pictures. Two teachers identified a lack of interest from students in learning science. One teacher elaborated: "*the teacher's classroom activities, understanding, attitudes and interest determines, to a large extent, the quality and level of students' learning of scienc*e." Another matter mentioned as impacting negatively on their practice was the non-payment of their salaries.

Teachers were further asked to suggest ways they could be better supported to maintain their enthusiasm and to improve their practices in teaching Primary Science. A majority of the teachers (91.2%) commented on the need for the provision of teaching and learning materials and facilities, provision of incentives, prompt and regular payment of salaries, and organisation of seminars or workshops on science teaching.

5.6 Summary

The data indicated that these Nigerian teachers considered science a vital subject to teach and that most of them felt confident to teach it. They mostly believed that science should be taught practically and that students should be active participants. However, analysis raised more questions when the data revealed that teacher expertise and student participation seemed to decrease with years of experience and that the level of teacher confidence did not seem to change over the years. The analysis showed that although the teachers believed science should be taught practically, student participation seemed to decrease as teachers got more experienced. I hope that further explorations in the qualitative phase may provide a clearer understanding of the practical experiences teachers provided their students and the level of student participation.

A majority of the TPs indicated that they had not attended any science PL sessions. This is contrary to the expectation stipulated in the Nigerian PL policy, which mandates the number of hours teachers are expected to attend (see Chapter 2). This indicates a need that should be addressed, and I hoped that teachers could participate in a shared PL experience during the qualitative phase of this study.

All the teachers reported that they carried out assessments for various reasons, mostly to give feedback to students. A majority assessed their students' understanding of the content using written tests. From the data, it seemed that teachers mainly relied on summative assessment to evaluate their students. The teachers did not seem to use formative assessment. Exploration of this aspect in the qualitative phase will provide some more understanding of their assessment practices.

The teachers identified various challenges to their teaching of Primary Science, with most of them indicating the lack of science instructional materials and resources as a hindrance. How teachers work within the constraints of these limited instructional resources is an aspect I will explore further in the qualitative phase.

The results of the questionnaire data analysis facilitated the second phase of the research. They supported my decision to work with private schools within the geographical area, as the majority of the questionnaire responses were completed and returned by primary school teachers from private schools. I compared the results of these analyses with the qualitative data collected in the PAR phase. It was necessary to develop a deeper understanding of teachers' practices through the qualitative phase due to the self-reported nature of the questionnaire data; the teachers may have been providing responses that seemed socially acceptable, or their interpretation of the survey questions may have affected their responses. This further qualitative analysis will provide additional validation of my claims.

Chapter 6

Research Context

In this chapter, I describe the context of the second PAR phase of the research. I draw on information about the social, cultural, political, local, and governmental influences and consider their significant effect on teaching and learning in Nigerian schools. The notion of ‘best practice’ must be understood within a context. Data collection occurred in Term One.

6.1 Geographical Setting

The research was conducted in two schools in Bassa Local Government of Plateau State. All names of schools and participants are pseudonyms. Banke Academy is a Christian Private School located in Mista Ali, with Guyip School located at Farin Gada. The two privately owned schools are located about 12 kilometres from one another. Banke Academy is relatively small, with a population of about 400 students. It has about 300 students in its Nursery and Primary sections and about a hundred in the Secondary Section, which only opened about four years before the data collection period. It operates a Nursery for ages three and under, a Primary Section for Primary Forms 1 to 5 and a Secondary section for Forms 1 to 3. The average class size is 24 students. The school is led by a principal with one administrator, a few auxiliary staff and a leadership team consisting of four other teachers. There is a board and a Parent-Teacher Association (PTA) led by its chairperson.

Guyip School is well-established, having been founded about 40 years ago as a Christian Mission School with a Nursery (three years and under), a Primary Section (Forms 1 to 5) and a Secondary Section (Forms 1 to 6). The total student population is about 1,500. The school provides boarding facilities for Primary and Secondary students. Although it is a recognised school with a thriving Secondary Section, Guyip's Primary Section has seen dwindling student numbers. There was an average of about 14 students in each class I attended. When asked why the school was witnessing this decline, one of the teacher's explained: "*many schools are just popping up everywhere, and parents withdraw their students to different schools. Also, school fees are another challenge for parents.*" He further explained that students move to other schools when they owe fees and that although some schools may charge lower fees, the quality they offer may not be up to standard. Furthermore, the desire of parents to have their children progress quickly through year levels is another challenge, and so if a school is not willing to meet this demand, parents will withdraw their children and enrol them at another school. If this is true, this shuffling of students from one school to another is an indication that there may be some deficiencies within the Nigerian education system in monitoring schools' establishment, resources, and performance before their registration. It also highlights that there may not be regulations on students transferring from one school to another or that, if there are, the managers of such schools easily boycott these processes.

6.2 The Primary School System

Primary school education in Nigeria spans from Primary 1 to 6. Before graduating from primary school, students write entry examinations for admission into Junior Secondary School (JSS). However, it is common in most schools for classes to stop at Primary Year 5. One of the teachers, Mr Dachung, explained why this is the case in his school: "*yes, we stop at Primary 5 to keep up with the current schooling trend because of pressure from the families wanting to move their children quickly to Secondary School*." When asked how the students are supported, especially when the curriculum stipulates content for Primary Year 6, Mr Dachung replied, "*Well, I just have to try and cover some of the Primary 6 content along with the Primary 5 content; which is very hard to fit in.*" This demand poses a challenge for teachers who already have a full curriculum's content to work through within each year level. It is not unreasonable to assume that this pressure to rush through content in preparation for exams affects students' learning.

Most teachers in private primary schools teach according to their area of specialisation, but this is not the case in public schools, as the principal of Banke Academy informed me. She mentioned that some schools have specialist mathematics teachers, although finding such teachers can be challenging. While having specialised teachers teach their respective subjects seems to eliminate the problem of content knowledge, there seems to be little subject integration for students, who do not seem to be aware of the connections between the various subjects they are learning.

6.2.1 School Hours

School starts at 7.45 am with a school assembly, where the national and school anthems are sung. Teachers still inspect the students to ensure that they are neatly groomed, as they did in my youth. Devotions are shared, and the principal or another senior teacher makes announcements. Students are reminded to inform their parents to pay their fees—parents are given a week to pay or make an arrangement with the school, after which students non-paying students are excluded. This may result in students spending their day outside classes but still on school premises.

Students return to their classrooms after assembly, and classes start at 8.05 am. There are two breaks during the school day, one of 30 minutes from 9.50 to 10.20 am, and another of 10 minutes at noon. The school day ends at 1.20 pm for students in primary school and about 2 pm for secondary school students.

6.2.2 Classroom Setting

The number of students in the classrooms at Banke Academy was about 25 to 30 on average. Classes at Guyip School were much smaller, with about 14 students each. In most of the classrooms, students' desks and chairs are set out in rows. An exception to this seating arrangement was seen in a Primary 1 class, in which students sat in cubical-like spaces called 'offices' to do their individualised tasks.

Occasionally, they would take their chairs to the space in front of the class when the teacher wanted to carry out whole-class activities. All the classrooms were painted, with some having a few posters, but most classroom walls were bare. There were no spaces or lockers for students to keep their bags, so most students got their books out and kept them on their desks or placed them in the small spaces underneath their desks.

6.2.3 Testing and Exams

All students are expected to sit at least two Continuous Assessments Tests during the term and an end-of-term exam. End-of-year exams are conducted to determine if students should progress to the next year level. Students who pass are promoted to the next year level; otherwise, they must repeat the entire school year.

These tests and exams are mainly composed of close-ended questions, with students expected to write definitions as provided by the teacher, make lists, or mention names of items based on the topic (see Appendix J for a sample showing the emphasis on rote learning).

6.2.4 Resources

Guyip School and Banke Academy both had limited resources. The electricity supply was erratic, presenting a challenge for even basic functions. One of the schools was not yet connected to the grid, and the principal explained their frustration with the process. The school had applied for connection the previous year, but the Electrical Power Authority had not yet processed the application. Both schools had a generator which they used when needed, but this was unreliable. For example, during the second day of PL, the electricity cut in and out because it rained heavily. Even though the generator was on, the noise from the generator and the rain made it difficult for us to hear one another. The lack of electricity also affected photocopying and printing. Sometimes fuel for the generators was also in limited supply. Other resources such as charts, images, books, and computers were not readily available. Some parents were unable to afford the prescribed textbooks, so some students had to share.

6.2.5 Discipline

Students were expected to follow school rules and show respect for authority. Discipline was regarded as a way of correcting students’ behaviour when they did not adhere to these rules or were perceived to be behaving disrespectfully. Depending on the level of the offence, discipline could take the form of corporal punishment, such as flogging (caning), or to an order to clean the yard, or for a student to kneel with their hands raised, or to stand in a corner. While these forms of punishment seem to be accepted as part of school culture, some researchers have argued that discipline ought not to be so punitive and reactive. Such approaches, they argue, do not provide an opportunity for consultation or negotiation and do not have the corrective results that schools and teachers aim for (Aboluwodi, 2015; Lukman & Hamadi, 2014). Despite the controversy around the use of corporal punishment in schools, schools in Nigeria tend to resort to these methods of discipline, especially when dealing with large classes (Ukpabio et al., 2019).

6.2.6 Security

Political, religious, and communal conflicts have marred Nigeria for many years, with more frequent incidences of violence and loss of lives occurring since 2009 as a result of the well-publicised actions of the insurgent group Boko Haram. The Arabic phrase *Boko Haram* means ‘western education is forbidden’, and the group demonstrated their intolerance of western education with the kidnapping of 250 girls from the town of Chibok in 2014 (Awortu, 2015; Shaibu, Salleh & Shehu, 2015). Attacks by this group have continued since then, resulting in many deaths. In addition, political and communal clashes are common.

Nigeria also faces conflicts between the Fulani herdsmen—a mainly Muslim community, traditionally pastoral and nomadic cattle-herders—and the local landowners and farmers, who are predominantly Christian. As nomads, the Fulani move about to find greener pasture for their cattle. However, these migrations have meant that they sometimes trespassed on others’ property (Kwaghga, 2018; Okoro, 2018). The subsequent conflict has been magnified and intensified by population growth, environmental degradation, and the continued difficulty of ascertaining the legal title to land (Kwaghga, 2018; Okoro, 2018). These conflicts continued to erupt in different parts of the country and different parts of Plateau State during my time there. Another episode erupted in Jos and Bassa, the Local Government Areas of the schools I worked with, which led to the destruction of property and the killing of dozens of people, as reported on television. Many times, when such violence erupts, the effect flows onto the city and towns with demonstrations and protests. During these actions, young people often attack cars, burn tyres, and sometimes kill innocent people in an angry reaction to the violence.

On Friday, 28 September 2018, I had accepted an invitation from a friend who was a teacher at one of the prestigious private schools in Jos to visit the school to witness their annual Nigerian Independence Day celebration. They had planned to have the celebration that Friday since Independence Day (1 October) was on a Monday and was a public holiday. The program was to start at 1 pm, so I decided to go to Banke Academy in the morning and continue my work with the teachers before visiting the other school. By around 10 am, though, news began to filter in that there was tension in the town, and the principal called for the immediate dismissal of students for safety reasons, with the school bus taking most of them home. Parents were contacted, and some had already come to collect their children. Some of the students lived around the school area and walked to and from school, so they were asked to go home that way. After the students were dismissed, I organised a ride back to my house in town instead of visiting my friend’s school as planned.

My trip back from Banke Academy brought back memories of the riots and deaths I had witnessed in Jos in 2001. The roads were rather busy, traffic was thick, with roads blocked by burning tyres, burnt cars by the side of the road, branches and rocks. There was a heavy army presence, including tanks, which seemed to have quelled the unrest somewhat. We navigated through this scene with soldiers stopping and checking us and the car. I wondered what they were looking for. Anyway, they allowed us to pass, and I was so glad to be back at the hospital staff houses where I was staying with family friends—a relatively safe place. However, even from the house where I stayed, I could hear gunshots, and many were reported dead and injured. The first of October is Nigeria's Independence Day, but more riots marred the celebration and tightening the curfew from 6 am to 6 pm in Plateau State.

After a week or more, once there was a semblance of calm, schools reopened, and I could continue working with the teachers. The curfew remained in place, and the sight of many police officers, military and tanks made Jos feel like a war zone. This interruption meant that students missed days from their learning, and there was more to come. Later in October, Local Government Elections were to be conducted, and many schools in the Bassa LGA decided to remain closed as a precaution because such elections are often accompanied by violence. This was the case in Mista-Ali, where Banke Academy is located, with houses destroyed and many people attacked as distorted election results were announced.

During a telephone follow-up to check their progress in February 2019, one of the teachers informed me that schools had been closed on the 21st as a precaution for the Presidential elections. The teacher also said: "*school will be closed today, Wednesday 27th February, as presidential results are being announced and there are predicted violent attacks as opposition denounce the election results*." He went on to explain that, even though school resumed on Monday the 25th, student numbers were low, with parents deciding it would be safer to keep their children at home.

These security concerns interrupt teaching and learning as students miss out on valuable learning time. These missed days sometimes mean that content is partially taught to cover the curriculum requirement or not taught at all. The likely outcome of such interruptions is gaps in learning.

Security problems that lead to school closures also pose a challenge to teaching time when schools resume, restricting methods of instruction to more direct, teacher-centred approaches. Having said this, it is common practice for parents to organise private tutoring for their children multiple times a week, which may go some way to addressing the shortfalls.

6.2.7 The Student-Teacher Relationship

The student-teacher relationship provides the social context in which learning occurs and significantly affects students' learning and academic performance. In most Nigerian classrooms, research suggests that students are expected simply to listen and do as the teacher says. These classrooms appear very formal and rigid, rather than having a relaxed atmosphere for learning (Omodan & Tsotetsi, 2018). There is a culture of unquestionable respect which means that children do not address adults by their first names. Instead, adults are referred to as Sir, Ma, Mr, Mrs, Aunty, Uncle, Mummy, Grandma or Grandpa, depending on their gender and age, even when not they are not related to the person addressing them. It is common to hear these titles used in schools when students are addressing their teachers, the principal, or other adults at the school.

6.3 Summary

This chapter aimed to provide some context for the research to aid the reader's understanding of later chapters and give a sense of the uniqueness of teaching and learning practices in the Nigerian education system. The education offered by these schools seemed traditional, didactic and exam driven. The fact that these and other primary schools in Nigeria end at Primary 5 contradicts the curriculum, which stipulates content up to Primary 6. The class sizes at each school varied, but all were relatively small, which could potentially encourage more student participation or individualised interactions.

I have also described challenges unique to the Nigerian system and the schools represented in the research, including the lack of teaching resources and the erratic electricity supply. Political and national insecurity also posed a major challenge to teaching and learning and meant that schools closed, depriving students of valuable learning time that could lead to gaps in their learning. Further, even when schools re-opened, they operated in a climate of fear due to the possibility of future outbreaks of violence. This fear also limited students' attendance, and the experiences teachers provided for their students.

Some aspects of the schools' contexts aligned with the findings of the literature review (Chapter 2), such as limited or absent teaching resources, and the use of didactic teaching approaches. However, I hoped to see that teachers had progressed in their practices and now utilised more contemporary approaches. I wondered if and how teachers considered their practices and what the formal observations in the next phase of the study would reveal. I also considered how to adapt my plans to work within this context. Although the context is presented here before the formal observations, it was only after these observations, reflections, and the PL that I gained a deeper understanding of it. I tried to approach the observations, reflection, PL, and teacher support with an open mind.

In the next chapter, I present the findings from the initial classroom observations of the PAR phase of the study.

Chapter 7

Participatory Action Research: Classroom Observations

In this chapter, I present a summary of the events as I moved into the PAR stage of the research. It draws on observations and reflections I recorded in my journal and on camera. Commencing with a meeting with the principal and teachers to formally introduce myself and the project, my aim was to get acquainted with the context and the teacher participants (TPs) and address questions or concerns about my presence in the school or the study. Subsequently, I began with informal interactions and classroom observations to immerse myself in the school culture and, most importantly, to develop a positive relationship with the teachers. Lastly, I discuss the initial classroom observations, which provide insight into the pedagogical approaches the science TPs utilised.

7.1 Meeting with Principal and Teachers

On arrival at Banke Academy in Jos, Plateau State, the principal welcomed me warmly and explained that teachers were settling back as students were just resuming, "*so, things are a little messy*". I thanked her for her willingness to work with me on the project, not realising how "*messy*" things were later to get. The teachers at this school had been informed about the study and had consented to be part of it when the survey was carried out earlier in that year (see Chapter 4). I explained that the first two weeks were set aside for me to simply be around and get to know the teachers and students so that they could get used to my presence. She seemed happy with that. After my meeting with her, she called a staff meeting, which was a regular briefing with all the teaching staff. She introduced me to the teachers and gave me a few minutes to share why I was there.

I thanked the TPs for their willingness to have me and explained that I was here to work with them and learn more about their practices, focusing on the primary school teachers and how they taught science. I mentioned that for observation and reflection purposes, I would be recording their lessons. All the teachers involved in the project had already signed a consent form that explained the project to them, but I wanted to be sure they understood what we would be doing. After this meeting, some of the teachers stayed on to say hello, which made me feel quite welcome. One of the lead teachers, who was also one of the science teachers, promised to organise a copy of the school's timetable for me. After this initial contact, I stayed in the staff room and later looked around the school. During this personal tour of the school, I chatted with some of the non-teaching staff and some of the students. I left the school at around 1 pm and was expected to be there by 7.30 am the next day when school started with a whole-school assembly for a formal introduction to other staff and students. Overall, it was a very welcoming experience.

7.1.1 Teachers' Backgrounds and Experience Levels

The TPs had varying educational backgrounds and levels of teaching experience, as shown in Table 7.1 below.

Table 7.1 Teacher Participants (TP) Background Information

	Pseudonym	**Gender**	**Qualification**	**Additional Qualification**	**Years of experience**
1	Mrs Oga	Female	B.Ed.	Teachers Registration Council (TRCN) Certificate	16–20
2	Mr Obi	Male	NCE	Longman Training/Workshop certificate	6–10
3	Mrs Eke[1]	Female	B.Ed.	Teachers Registration Council (TRCN) Certificate	11–15
4	Mr Dachung	Male	B.Sc.	Diploma in Computer Application	11–15
5	Mrs Sambo	Female	B.Ed.	-	16–20
6	Mr Abok	Male	B.Ed.	-	16–20
7	Mrs Laraba[2]	Female	B.Ed.	-	6–10

As shown, all the teachers are qualified to teach within the primary school sector in Nigeria, where, as described in Chapter 2, the minimum qualification is an NCE. Most of these teachers would be regarded as highly experienced and well qualified based on the number of years they have been teaching with varying degree of expertise.

[1] Mrs Eke was only involved in the initial observations. She pulled out due to her child being hospitalised. She did not participate in the reflective or PL sessions.

[2] Mrs Laraba was involved in the study when the PL sessions were open to all teachers. She taught Social Studies but requested for me to observe her implementation of the inquiry strategy she had learned from the PL.

7.2 The First Few Days: Informal Observations and Interactions

Upon entering the school gate, the next day, I saw that the students had lined up in rows and columns, all facing a makeshift stage formed by the steps of the Nursery Section. Most of the teachers were still trying to organise their classes to line up, especially the nursery school students (two- and three-year-olds), many of whom were crying as they got prepared for the assembly. The Principal, Assistant Principal and other senior staff members stood on the stage while the other teachers stood to the side, monitoring their students and ensuring they were quiet and standing still. This sight brought back so many memories: *Wow, so they still do these assemblies like this?* I thought. I quickly joined the teachers and students as the principal began her address. She welcomed everyone back and hoped they had had a good holiday and were ready to get back to learning. She introduced me, saying I was there to work with them for a while and that they may see me around and in some of their classes. Teachers inspected students' tidiness, and the Assistant Principal gave reminders about neatness and tardiness. She also encouraged students to remind their parents to pay their school fees with a warning that if "*they don't pay your school fees, you won't be allowed in school from next week.*"

During the next few days at Banke Academy, I visited various primary classrooms to observe what was going on and to help the students and teachers feel comfortable with my presence. I had a small notebook in which I took notes as I sat in a corner at the back of the classroom. This was my attempt to minimise disruption to the class. Most of the teachers carried on with their lessons as normal. Occasionally, students turned to look at what I was doing, and at the end of the lessons, some came to talk to me, asking questions about why I was in their class, which I was happy to answer.

These early days of observations were useful in establishing a positive relationship with the teacher participants and the students, as developing rapport with participants is an important part of observation (Creswell & Guetterman, 2019). Towards the end of the second week, I decided to introduce the camera, which I mounted on a tripod at the back of the classroom next to where I sat. The camera was focused on the teacher and the blackboard. Initially, most of the students were curious and excited and wanted me to take photos of them. Although I was not focusing on the students directly, my presence in their classroom meant that I had some contact with them. Therefore, to ensure all ethical requirements were met, I sent a letter to all parents informing them about my research and presence at the school before embarking on the project. The principal presented me with a signed copy of a letter from the PTA chairman and said it was signed on behalf of the parents (Appendix G). I explained to the students that I hoped to record their science lessons so I could better understand how the lessons were taught. This gradual introduction of the camera meant that when I was conducting formal recordings of the science lessons I observed, teachers and students were more comfortable with seeing it in their classes. The purpose of the video recording was to augment my observations, but it was mainly to be used during the reflective process when teachers could review and discuss a lesson they had taught (also see Section 8.4).

On my third day, I was given a copy of the teaching timetable, which had only just been finalised. It was at this point that I first noticed that Primary Science was not taught by the class teacher. When I sought further clarification about the science teachers, the principal explained that the classroom teachers used to teach science but thought that having specialist teachers would lead to better outcomes for their students:

Principal (P): Yes, you would be working with the science teachers.
Researcher Participant (RP): Oh, so do you have special teachers who teach science?
P: Yes, we realise that not all teachers are capable of teaching science because of their background.

Here, the Principal alludes to the idea that teachers' knowledge and background are important to their ability to teach science; I will discuss this further below.

For the rest of my time at the school, I planned a personal schedule of the science lessons to observe based on the school timetable. During this second week, too, I noticed that some of the teachers had not yet returned as they had been doing in-service training at the University and were taking exams at that time. This meant that students in the same year group were merged, resulting in larger classes with students sharing desks, other resources, and even chairs. Interestingly, there was no provision for relief teachers to cover these classes while their teachers were absent. The lack of relief teachers was an early indication of the teachers' workload; I later sought their thoughts on this and how they coped with it.

During these initial observations and discussions, one of the teachers wondered if I considered including teachers from another school. Although the initial plan was to work with teachers at just one school, I followed up on this suggestion and decided to investigate involving teachers from another school in the LGA, where the questionnaire had been distributed in the first phase. I contacted Guyip School and met with the Vice Principal who had been aware of the questionnaires. She was supportive and directed me to the head of the Primary Section, who, although hesitant at first, agreed that I could talk with the individual teachers to explain the project and seek their consent. The Primary 1 teacher, who taught all subjects, was willing to be part of the project. For Primaries 2 to 5, the school had a 'specialist' science teacher who was also willing to participate. He explained that he was not the main teacher for the upper grades (Primaries 4 and 5) but had to take on more as the other teacher was in the hospital. This was another instance where teachers had to take on an increased workload due to a colleague's absence.

So now, there were six TPs in the project, including two from Guyip School and four from Banke Academy. The next day, I visited some of these teachers' classes even though they were not teaching science, just for the students to get used to my presence and my camera. I modified my timetable to fit in with the two additional teachers so I could visit their classes when they had their science lessons. I now felt that I was all set to commence more formal observations.

7.3 Science Lesson Observations

The following week, I focused on observing science lessons. I had my camera set up, my checklist, and notepad. I also recorded the lessons on a small handheld audio recorder as a backup to the video. The following sub-sections summarise the key themes that emerged from the analysis of my classroom observations.

I adopted a composite narrative structure to present the occurrences I observed during the various science lessons across the six classes and to tell the story of the TPs. The narrative provides a way of telling their stories while preserving their anonymity (Wertz et al., 2011; Willis, 2019). After transcribing and re-reading the data (see Chapter 4), I began to identify patterns. I used these patterns across the data to generate themes. The themes that emerged were *classroom interactions*, *teacher expertise*, *teacher perception*, *the role of PL*, and *researcher as part of PAR*. The narrative presents a composite description of classroom interactions typical of those I observed at the beginning, middle and end of the lessons.

7.3.1 Classroom Interactions at the Start of the Lesson

After initial greetings, lessons commenced with direct instructions to get the students attention, such as: "*Be quiet, put your books away and fold your arms.*"

Typically, students responded by instantly doing as they were told. However, there were occasions when students did not comply, so teachers would repeat the same instructions as required throughout their lessons:

> *Teacher (T): Afi,[3] fold your hands, close all your books. [x2]*
> *If I find you opening your books or unfold your hands, you are going to kneel down.*
> *Fold your hands... keep the books down...*
> *Eh, Kuvom... fold your hands.*
> *Okay... fold your hands. Nilam, you are not sitting well. Put your legs inside...*
> *Okay we said what? We change in what?*
> *Would you fold your arms there? Fold your arms. Stop touching things, Ali. Did I say you should take your pencil or biro or book? I said, just take up your ruler.*
>
> *(Mr Dachung, Primary 4–5 Science Teacher)*

I noticed a sense of frustration develop as teachers had to give such reminders. I observed that some teachers resorted to using threats of punishment, such as kneeling or flogging:

> *T: Now, I would not tolerate any noise making from you. Sit very well and fold your hands. Who is that person talking again?*
> *Student (S): Zakah.*
> *T: I said fold your hands. Fold your hands so that you will not be tempted to touch something that would cause noisemaking. Rita, I'll flog you… keep that thing away. Very good. So, we are going to start our lesson from where we stopped last.*
> *In our previous class.... what is the full meaning of BSC?*
> *S: Basic Science and Technology.*

[3] All names of teachers and students are pseudonyms.

T: Correct. Sit well and keep quiet.

Okay, keep your mouth shut. This row…

Hadizah, oya,[4] *sit very well.*

All of you " Identification." All of you? Who's that talking?

Precious, oya, leave that place… Dung, put that water down. You know I brought a sweet rubber cane. So, I don't know who will receive it first. So, if you need it first, I'll give it to you, so you better keep quiet.

T: If you are not talking to me make sure your hands are folded so that you would not be tempted to talk.

(Mr Obi, Primary 2 Science Teacher)

[4] *Oya* means 'okay' in a form of Nigerian Pidgin English.

7.3.2 Interactions During the Lesson

Review of Previous Learning

Typically, the teachers went on to review the previous lesson:

T: So, in the morning today, we discussed something with this class. So, could you remind us of what we discussed? Nom?
S: We talked about changes in nature.
T: Okay, we talked about changes in nature... what again? Zarah?
S: Types of changes.
T: Okay, types of what?
Types of changes, okay, good.

(Mr Dachung, Primary 4,5 Science Teacher)

T: In our previous class.... what is the full meaning of BSC?
S: Basic Science and Technology.
T: Correct.
Sit well and keep quiet.
Okay, keep your mouth shut. This row…
Hadizah, oya, sit very well.
Okay, repeat again, all of you.
Now listen.

(Mr Obi- Primary 2 Science Teacher)

When these conversations occurred, it seemed that teachers were seeking a response based on what students could remember, not necessarily what they understood about the concept. For instance, in the quotation above, when the students responded that "*we talked about changes in nature*" the teacher did not probe further to ask, "What did you understand by changes in nature?" but instead asked the students to list what else they had talked about:

T: What other one? Yes.
S: We talked about permanent change and temporary change.
T: Okay, we talked about permanent and temporary change.
Now, changes in living things. The other time we saw changes in non-living things. Now we are going to changes in living things.
Thank God you are a living thing... So, what are some of the changes that you think happens to living things?
S: Sir…
T: What are the changes that you think happens to living things?

(Mr Dachung, Primary 4–5 Science Teacher)

From this statement, it appeared that the teacher was trying to assist his students in developing an understanding of the concept of change in living things by encouraging them to think about the changes that occur in them. Students then listed the changes they thought occurred. However, this listing did not necessarily mean that students understood why and how these changes occurred. It is important to note, though, that the teacher attempted to make the learning relevant to the students by encouraging them to think of what changes occurs in themselves since they are living things. This approach of relating the concept to the students seemed to support their understanding and responses.

Repetition of teachers' statements or a definition written on the board and reading from the textbook was another commonly observed form of interaction. The teachers would ask students to repeat after them:

T: Now, before we close, I want you to read what road is. One, two, start!
S: The road.
T: Wait, Salim, stop playing.
S: The road. Roads are pathways cons—
T: Constructed on land for the passage…
S: Constructed on a land for the pass…
T: Passage.
S: Passage of people, vehicles and animals.

T: Once more.
S: Roads are pathways cons—
T: Constructed.
Stand up. Good. Read.
S: Roads are pathways constructed on path for the passage of people, vehicles, and animals.
T: Clap for yourselves!

(Mrs Oga, Primary 1 Teacher)

Mr Obi had a similar approach in his classroom with reminders to be quiet and sit properly, interrupting the flow of the lesson. He seemed to focus on students' ability to pronounce words when they were reading:

T: Sit well and keep quiet.
Okay, what is our topic? [Teacher writes on the board]
Ss: Identification of sanse organs. [Mispronouncing 'sense' as 'sanse']
T: Again.
Ss: Identification of sanse organs. [One student is now pronouncing 'sense' correctly]
T; Okay, all of you here keep your mouth shut. This side here, what is the topic?
Ss: Identification of sanse/sense organs. [Mixed success]
T: Again.
S: Identification of science organs. [A new variation]
T: Okay, keep your mouth shut. This row…

(Mr Obi, Primary 2 Science Teacher)

After many attempts at pronouncing the word by the students, Mr Obi asks the class to keep quiet and repeat after him.

In Mrs Eke's lesson on the metric units of length, she expected her students to learn these units mainly by repeating after her a couple of times. She then encouraged students to study the units at home:

T: Metric unit of length. What are these metric units of length that we discussed in our last lesson?
S: 10mm make 1cm.
10cm make 1dm. [Students struggling with the word deli/decometre]
10 decametre make 1 hectometre.
10hm make 1km.
1000m make 1km.
T: I observe that you are not pronouncing this last 's' in all your sentence … Please, you must make sure that you pronounce what? This 's', you pronounce it so that it comes out because it is written in the tense … anything more than one you add 's'. This one has 's' and this one doesn't, it is because this one is 'one'. Do you understand? So, take that correction. Can we now close our books and not look at the board and say it, because I gave it to you as assignment? Oya, let's start. One, two, start.

(Mrs Eke, Primary 3 Science Teacher)

Copying from the Board

Writing on the blackboard was how the teachers shared their summaries of the topic or concept with students. Students are expected to copy these notes, and most times, the teacher collects their books at the end of the lesson and ticks or signs to confirm that the students have copied the notes. In one of the schools, a whiteboard was placed over the blackboard, giving the teachers the choice of which to use. Teachers instructed students when they wanted them to copy notes from the board:

S: Aunty, let us write?

T: No. Don't worry, I'll give you time to write, just listen first.

S: Okay.

T: Maybe what you'll get from my mouth is different from what you are going to write, so try to understand first before writing... this is double period, so I'll spend a lot of time…

S: Can we write?

T: No, we have so many activities, so when I say write, then we write.

S: Okay.

(Mrs Eke, Primary 3 Science Teacher)

Occasionally, teachers had to remind students not to write. Such notetaking typically occurred at the end of the lessons, and this could be the reason for the instruction to "*put everything away and fold their hands*" to avoid distractions.

Most of the teachers drew a vertical line on the board to make it look like a two-page spread. Teachers had to wait for students to finish writing, especially when they had written on both sides and wanted to erase one section. I noticed that this was a challenge as students copied at varying speeds. In some instances, teachers copied what was in the textbooks or workbooks as a way of supporting students who did not have their own copies.

Working from Textbooks

Textbooks are a highly valuable resource in Nigerian primary classrooms. Students are expected to have copies of these textbooks which are either purchased from bookshops or sold at the schools. Students also need to have copies of the accompanying workbooks, which contain the associated activities. Here, Mr Abok was checking who had which books:

T: You'll all have your workbook and textbook.

S: I don't have it, oh.

S: Uncle, I don't have it.

T: Wait, you have the book, there's no how you have the book without the workbook.

S: They came together.

S: Yes.

S: I don't have it.

T: Okay, if you don't have the Basic Science that is understood, but to have the Basic Science only the book and no workbook… Kai! Okay, apart from you, who else?

S: I don't have it.

S: Uncle, even me.

T: How come? Who else?

Teachers assign classwork or homework from these workbooks. Teachers mark the workbooks and review the answers during whole-class discussions.

7.3.3 The End of the Lesson

Typically, towards the end of the lesson, the teachers would review the content covered by asking whether the students had any questions. However, this mostly just required a Yes or No:

T: So, that vehicles can pass, machines can pass, bus can pass. Is it clear?
S: Yes.
T: Any question?
S: No.
T: No question?
S: No.
S: Yes.
T: Any question?
S: No.
S: Yes.
T: Is it well understood?
S: Yes.

(Mrs Oga, Primary 1 Teacher, Lesson about Roads)

S: I hate this kind of tick because it means you are marking your book.

T: Any question at this level? Any question?

S: No.

T: Is there any one you don't understand how to measure?

S: No.

T: Is it clear?

S: Yes.

(Mrs Eke, Primary 3 Science Teacher, Lesson on Measurement)

In these interactions, the questions and responses did not provide opportunities for elaboration or in-depth interaction. Teachers seemed to just progress with their lessons regardless of student understanding. Based on my initial observations, most of the teachers did not probe further even when the student admitted not understanding.

7.4 Reflection on the Theme: Interactions in a "Typical Lesson"

The classroom interaction described in the narrative above formed one of the key themes that emerged from the transcribed and analysed data. I used these data to classify the interactions observed in a typical lesson. I further subdivided this theme into *procedural* and *pedagogical* interactions.

Procedural interactions were the instructions teachers gave students expecting them to be carried out. This includes operational rules about how things are done in the classroom, the teacher's behavioural expectations of students, and classroom management strategies. Examples of these may include decisions about how materials would be collected or packed up for safety reasons. These interactions were more commonly noticed at all stages of classroom interactions where students were asked to do this or that. Students mostly obeyed these instructions, but at times when they did not, teachers reminded them of the possibility of being punished.

Pedagogical interactions are the deliberate choices of words and/or actions by the teacher to generate a response in words and actions by students that relate to the learning process (Churchill et al., 2018). I observed teachers making discourse choices about the pace of learning experiences, rarely asking probing questions and mostly providing explanations of learning tasks.

In the typical lesson, I noted a limited range of such pedagogical interactions. When they did occur, teachers asked questions that stimulated low-level or simple responses from students, often single words or lists. Students were expected to provide the exact answers teachers had previously told them. Teachers missed opportunities to develop students' understanding by progressing their lessons to note-taking and assigning tasks or homework from workbooks or textbooks.

7.4.1 Communication Patterns

The classroom interaction patterns described above provided an insight into the nature of the learning environment. The nature of these interactions may support or hinder collaborative learning. The findings from my initial classroom observations prior to the PL sessions revealed that all teachers utilised a 'teacher talk' approach in their interactions, with little or no opportunity for students to interact with one another. The interaction was instructional, with students asked to '*be quiet*', '*fold their hands*' and '*put their things away*'. Even when pedagogical interactions occurred and classroom interactions progressed, these exchanges involved students providing one-word or short responses to teachers mostly closed-ended questions or repetitions of what the teacher had said. These observed interactions are consistent with the findings of studies on classroom discourse in Africa, and more specifically, Nigeria (Archers & Hardman, 2001; Dembélé & Lefoka, 2007; Hardman et al., 2008).

It is interesting, though, that from the questionnaire results discussed in Chapter 5, teachers claimed that they valued both whole-class and small group interactions, with a majority indicating that they used these approaches. However, from the classroom interactions I observed, whole-class interactions did happen but were mainly teacher-dominated, and I did not see any instances of small group or peer interaction before the PL sessions. When students interacted with their peers, it was mostly frowned upon by the teachers, and students were reprimanded to "*stop making noise*". All the teachers surveyed believed that teachers should ask questions of students and that students should be encouraged to ask questions, too. I witnessed this in the PAR phase, where teachers would ask "*any question?*" However, this kind of questioning and responses did not stimulate deep thinking or elaboration. This mismatch between what teachers say they do or believe and what they actually practice is consistent with the findings of research by Pontefract and Hardman (2005) on the pedagogical approaches of Kenyan teachers, who claimed they applied certain strategies but when observed, they did not use such strategies.

Some of the patterns of interaction I observed are congruent with what Scott and Mortimer (2005) refer to as an 'interactive/authoritative communicative' approach. In this model, teachers ask instructional questions with opportunities for varying answers with the end goal of arriving at one correct answer. In most cases, I saw non-interactive/authoritative communicative approaches where the teacher talked about the science concepts and students listened, presenting one specific point of view. The key aspect here is that these patterns of discussion were present irrespective of the content of discourse or sequence of the science lessons, as described in the narrative above. Although there is a place for explicit instruction and for the teacher to '*explain*' scientific concepts and terminology, the teacher's voice does not dominate in contemporary science teaching and learning classrooms (AAS, 2017a; Bybee, 2014). Instead, dialogue is encouraged as a way to negotiate meaning (Aguiar, 2016).

The questioning patterns I witnessed are also consistent with questioning approaches in a traditional, teacher-structured lesson, where closed-ended questions are asked with the goal of evaluating what students know, producing shallow and lower-order thinking that arrives at a predetermined answer (Chin, 2007). Students' responses are either correct or incorrect, without probing further to find out why they think the way they do. The teachers' comments or answers are not questioned or challenged but accepted by the students. This conflicts with contemporary discourse approaches.

Contemporary approaches in science teaching and learning advocate for the active participation of students in classroom discussions (Harlen & Qualter, 2018; Owolabi et al., 2014; Watters & Diezmann, 2016). Although the literature does not give a specific example, student involvement in the classroom interaction process is crucial for developing deep learning and understanding and may go through several phases. Mortimer and Scott (2003) suggest that meaning making is constructed through dialogical processes and suggest a framework for analysing classroom interactions (Table 7.2).

Table 7.2 Classroom communication patterns (adapted from Scott & Mortimer, 2005)

	Interactive	**Non-interactive**
Dialogic	Interactive/Dialogic	Non-interactive/Dialogic
Authoritative	Interactive/Authoritative	Non-interactive/Authoritative

Classroom interactions are thought to have the potential to improve students' intellectual development and increase their interest in science (Scott & Mortimer, 2005). The communicative pattern in a science class could be classed as *interactive*, if more than one person participates in discussion, or *non-interactive*, where others are excluded. It could also be *dialogic* where more than one point of view is offered or *authoritative* where there is only one point of view. Scott and Mortimer (2005) proposed adopting a combination of communicative patterns described above depending on the concept and lesson sequence, with the belief that:

> There will be times in the development of a sequence of lessons when the teacher needs to make an authoritative statement of the school science point of view. There will be other times when the teacher needs to allow time and space for the students to talk through and to use these scientific ideas for themselves. In this way, we believe that the rhythm of the teaching performance should be consequent upon changes in the communicative approach. (Scott & Mortimer, 2005, p. 404)

Teacher questioning is important in evaluating the discourse that occurs in the teaching and learning of science. The types of questions teachers ask have the potential to stimulate higher thinking and responses from students, thus developing their understanding. Contemporary approaches to teacher questioning in science suggest that teachers should ask open-ended questions that elicit students' ideas; students then justify their responses and are encouraged to ask their own questions (Chin, 2006; 2007; Skamp, 2018).

The description of the Nigerian Basic Science and Technology curriculum (see Section 1.2.8) revealed that the nature and structure of the curriculum is prescriptive and opportunities for dialogic interactions are limited. The findings described above also revealed that the teachers did not refer to the curriculum directly but used the prescribed textbooks that were designed to adhere to the curriculum content and format. In the students' workbooks, students' activities are described with a corresponding teacher's guide textbook listing the activities teachers should implement. In the teachers' guide textbooks were descriptions of practical activities to be carried out, but these were more demonstrations and had the character of 'following a recipe'. The practicals in the teachers' guides did not encourage students to make predictions or provide opportunities for questioning or interactions that could stimulate deeper thinking. It is important for students to engage in critical and intellectual thinking during these practicals; otherwise, they become merely 'hands-on' activities without 'minds-on' (Llewellyn, 2014).

During these classroom interactions, I also began to observe and consider the knowledge and skills that teachers were demonstrating in their teaching.

7.5 Teacher Expertise

My interest in the teachers' knowledge and skills, as demonstrated in the classroom observations, gave me some sense of their level of expertise. Teachers' expertise refers to how a teacher skillfully utilises their repertoire of knowledge and skills to support student learning (Loughran, 2010; 2011). The Nigerian Primary Science Curriculum and the Nigerian Professional Standards for Teachers (NPST) both link teacher expertise to the degree or extent of content knowledge (CK) and pedagogical content knowledge (PCK) teachers bring with them to the teaching and learning process. These standards also consider the teaching and learning philosophy and practice of teachers and how they blend their content and pedagogical knowledge to make learning comprehensible to their students (Shulman, 1986; 1987). Thus, 'expertise' encompasses teachers' knowledge of '*what*' and '*how*' to teach, and, equally important, the '*why*' to teach the content explored (Hattie, 2012; Hattie & Yates, 2014; Hattie & Zierer, 2018). Hattie (2012) puts it well when he says expert teachers differ from experienced teachers based on how they organise and use their knowledge. Therefore, keeping in mind the '*why*' and being able to effectively merge the '*what*' and '*how*' characterises teaching expertise.

From this research and the NPST, I developed a framework for this theme to analyse the observations more thoroughly. This framework included the following sub-themes: *content knowledge*; *knowledge of students and how they learn*; *knowledge of teaching strategies*; *knowledge of how to assess student learning*; *classroom management*; and *opportunities for teacher development*. These subthemes are drawn from Shulman's descriptions of PCK and are supported by the NPST and the Australian Professional Standards for Teachers (APST; with both documents stipulating the knowledge and practice teachers need to have and demonstrate (Australian Institute for Teaching and School Leadership (AITSL), 2017; TRCN, 2010). The APST provided a lens through which I reviewed the NPST.

It was interesting to note that the categorisation of what counts as teacher expertise is very different in these two documents. For example, the Nigerian Standards focus on a teacher's educational qualifications, while the Australian Standards base expertise on the teacher's cognition, growth and development in the key elements that represent teacher quality (AITSL, 2017; TRCN, 2010). Each of these sub-themes would be illustrated and how they occur within a typical lesson.

The themes in this framework can be used to shed some light on the second research sub-question— *How do science teaching and learning practices within a Nigerian cultural context reflect contemporary pedagogical approaches to science education?* —by providing examples from my observations, interactions, and reflections with the TPs.

7.5.1 Knowledge of Science Content in a Typical Lesson

Having a sound knowledge of the subject or content area to be taught is vital to enable the teacher to understand the goal and focus on what is important for students to learn. In the Nigerian primary school classrooms I visited, science was taught by ‘specialist’ teachers. These specialist teachers were teachers at the school who either had a science degree or had been teaching for longer periods and felt comfortable to teach science. However, only one of the six TPs (Mr Dachung) had a science background and a Bachelor of Science Degree (see Table 7.1). This notion of having ‘specialist’ primary science teachers is the schools’ way of meeting the recommendation in the NPE to have teachers who have specialised science content knowledge to teach science (see Chapter 2; FME, 2014).

I observed that these ‘specialist’ science teachers utilised a transmissive mode of interaction with their students. Several other studies have also noted such transmissive teaching approaches in Africa (Abiemwense, 2017; Afolabi, 2013; Aina & Olanipekun, 2015). This is illustrated by examples from my observations, such as:

> *T: of course, these are the temporary changes we are talking about, but coming to permanent change… you see the temporary change is reversible… yes, temporary change is reversible. That’s just what I've just explained that temporary change is reversible in the sense that, like, I gave illustration using iron. When we heat an iron rod, it can change its shape, but when you want to reverse it can come back to its original shape. I hope you are getting me. So temporary change is reversible. Then coming to permanent change, once the change has taken place, it cannot be reversed—you cannot change it back to something else. For example, some trees we see around our environment. Some are used to make planks, tables, and chair to sit on and write on.*
>
> *(Mr Abok, Primary 3–5 Science Teacher)*

The difference between experience and expertise is elucidated further below.

7.5.2 Knowledge of the Curriculum

Most teachers were aware of the curriculum content based on the textbooks their schools had chosen. Figure 7.1 shows a sample of the textbooks and the key themes and topics to be taught as derived from the national curriculum.

Based on the NPST, teachers are expected to know the curriculum area for the subject they teach and to be "conversant with other relevant sections of the national curriculum other than just the content of the subject they teach" (TRCN, 2010, p. 26).

Teachers did not use the national curriculum documents directly but instead used the textbooks and the stipulated teachers' guides to develop their lesson plans. This unfamiliarity with the curriculum mirrors the findings of the questionnaire, where about a third of the teachers indicated that they did know the curriculum. These teacher guides were developed in line with the Nigerian curriculum content for each year level. Teachers write their schemes of work (lesson plans) based on these textbooks and present their lesson planning books to be signed by the Head Teacher or Principal before teaching. In the sample lesson plans in Figure 7.2 below, we can see how the teacher maps out the progression of the lesson. A typical written lesson plan begins with a list of objectives, although these are not necessarily explained to the students. The lesson would progress by asking students to define the term explored, after which the teacher gives the definition that students should know and repeat. Students may then engage in some form of demonstration depending on the content explored, guided by the teacher. This is usually followed by students doing activities from their workbooks or copying notes from the board. Teachers then assign tasks as homework, either from the textbooks or by writing tasks on the board.

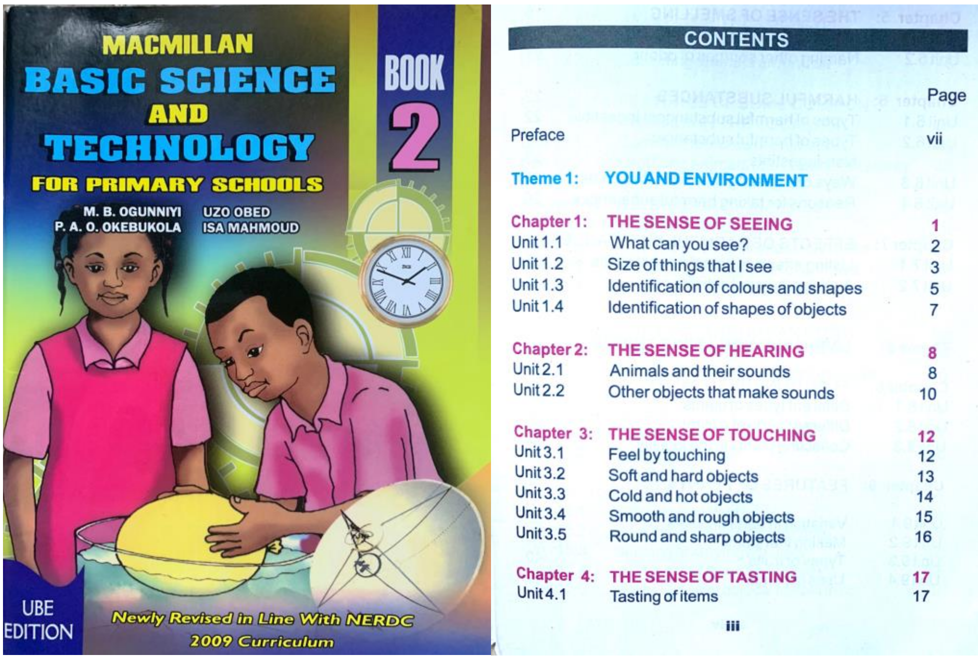

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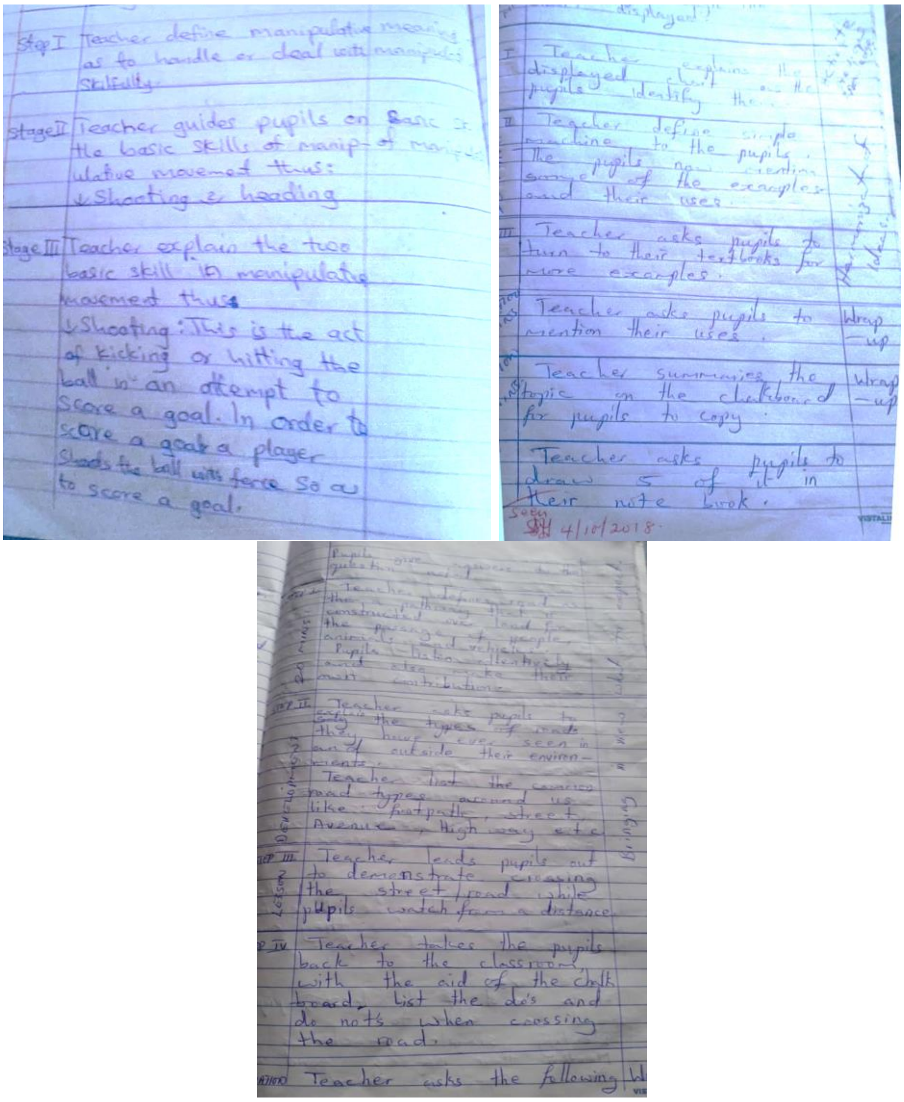
Figure 7.1 Sample textbook content


Stage I Teacher define manipulative meaning as to handle or deal with manipulat skilfully.

Stage II Teacher guides pupils on Basic the basic skills of manip- ulative movement thus:
i. Shooting & heading

Stage III Teacher explain the two basic skill in menipulative movement thus:
i. Shooting: This is the act of kicking or hitting the ball in an attempt to score a goal. In order to score a goal a player shoots the ball with force so as to score a goal.

displayed

I Teacher explains the displayed chart and the pupils identify them.

II Teacher define simple machine to the pupils. The pupils now mention some of the examples and their uses.

III Teacher asks pupils to turn to their textbooks for more examples.

Teacher asks pupils to mention their uses. Wrap-up

Teacher summarizes the topic on the chalkboard for pupils to copy. Wrap-up

Teacher asks pupils to draw 5 of it in their note book.

Seen 4/10/2018

Teacher define road as the pathway that is constructed and used for the passage of people, animals and vehicle. Pupils listen collectively and also take their contribution.

Step II Teacher asks pupils to explain the types of roads they have ever seen in and outside their environments. Teacher list the common road types around us like footpath, street, Avenue, High way etc.

Step III Teacher leads pupils out to demonstrate crossing the street/road while pupils watch from a distance.

Step IV Teacher takes the pupils back to the classroom with the aid of the chalkboard, list the do's and do nots when crossing the road.

Teacher asks the following

Figure 7.2 Sample lesson plans

7.5.3 Knowledge of Students and How They Learn

Developing a positive relationship with students is important to a teacher's ability to support students to achieve a goal and to teach them effectively (Churchill et al., 2018; Skamp, 2018). The teachers displayed such knowledge during my classroom observations:

> *T: So, there are many things, food items in the refrigerator. Okay, now listen, this is what aunty wants you to do… Listen. I know some of us cannot do this one, so we would not do this activity now. Is that clear? But maybe by the end of the term, when we are doing revision, by then you know how to read, then we would answer this page. Are we clear? Good.*
>
> *(Mrs Sambo, Primary 1 Teacher)*

This teacher displayed knowledge of her students' ability, acknowledging that some of them could not carry out a task at that moment because of their inability to read. She was demonstrating an awareness of their intellectual development. What I found interesting was that the teacher did not consider other ways to meet the needs of these students but opted to review the material at the end of the term. This was an opportunity to extend students in her class who could read and possibly to provide a different task for students who were still learning to read.

In another example, Mr Dachung realised that a student's seating position affected her ability to see the board well and to copy the notes even after providing what he considered ample time for the completion of the task:

> *T: Are you done with this part of the board?*
> *S: Yes.*
> *T: Inuwa, Zainab, Keya. You are still writing?*
> *S: I'm done, sir.*
> *T: Okay, what about Keya?*
> *S: No.*
> *T: Okay, Keya, I'll not wipe this side, just keep your book away, later you finish*

it. Fold your arms. Keep your biros away and fold your arms. Keya, you are too short, you are supposed to be in front.

S: She sits in the front, that's her seat.

T: Move back to your seat.

The TPs demonstrated the ability to identify their students' needs. In the latter case, that meant a physical re-arrangement. In the former, it called for a different strategy of identifying the student's cognitive ability and how to support that.

7.5.4 Pedagogical Knowledge and Skills

Based on the skills stipulated in the NPST (TRCN, 2010), all the teachers began their lessons with a plan of what they intended to teach. Looking through their lesson plans, as shown in Table 7.3, and during classroom observations, most teachers seemed to have a goal for what students should be able to do. However, these goals seemed to concentrate on students' ability to define terms or list examples.

Table 7.3 Sample lesson plan content

Lesson plan on 'The Road' (Primary 1 Teacher)	**Lesson Plan on 'Measurement' (Primary 3 Teacher)**
Objective: By the end of the lesson, students should be able to:	
Mention the do's when crossing the road Mention the do not's when crossing the road	List the types of balances State the metric units of mass

Although these objectives were stipulated in teachers' lesson plans, they were not clearly written or explained to students. Based on teachers' lesson plans, most had a clear sequence of how they would teach a concept. However, the sequence of activities focused more on teachers 'telling' students about the content or topic throughout the lesson, providing explanations about the concepts with little or no opportunity for students to engage in that process:

> *Okay, now, measurement. Whenever you want to know the distance from one point to another point, the only way for you to know the distance is to use measurement. Now, we have those that construct the road, they have a kind of tape to measure distance from one point to another and that tape has certain measurement number. Okay? It is with the use of that tape that they will know that from point A to point B is so, so, so km. For example, from point A to B is 1km from B to C, 3km from C to D, 4km. They don't just indicate km's off [the top of their] head. No, they must use that instrument, and it is a measuring tape. Very long.*
>
> *(Mrs Eke, Primary Science Teacher, Year 3)*

Within the timeframe of this study and in the classes I visited, I did not observe the TPs using strategies such as excursions, projects, or problem-solving techniques, as some alluded to using in the questionnaire. Some did mention that they would have taken their class on excursion outside the school premises but that for safety reasons (see Chapter 6), they had to carry out those lessons in the classroom. However, I did observe teachers utilising pedagogical approaches such as questioning, demonstrations, repetition, and making connections to students' cultural and social backgrounds.

Questioning

The TPs mostly asked questions at the start of the lesson, mainly whether students remembered the topic of the previous lesson. TPs also asked students if they had any questions at the end of lessons. Some of the teachers used questioning as a way of reviewing students' learning. These tended to be closed-ended questions that required a yes or no or a one-word response. The example below shows the nature of questioning in most cases:

T: Even some non-living things change because let's say for example, iron. When iron is heated in the fire, you can change the shape, isn't it? Am I right?
S: Yes.
T: Now let's look at ourselves, like humans… some are short, some are tall, some look young, some look old. Why? It's because of what? Yes…
S: Change.
T: So, 10 years ago, you were not like this, am I right?
S: Yes.
T: How many senses do we have?
S: One.
T: Who is saying one?
S: Five.
T: Five. We have five senses, and all these senses function on different areas. The sense to hear is different from the sense to see, isn't it?
S: Yes.

(Mr Abok, Primary Science Teacher, Years 3–5)

Demonstrations

Some of the teachers used demonstrations to engage students and to illustrate the content explored. At times, students were invited to participate in these demonstrations, enabling them to think about the process, although most of the time they were merely spectators watching the teacher explain the demonstrations:

T: This is our street, the one we have in front here, and Salim wants to cross the road.
Salim, come. Come and stand here. You are coming from Mista Ali [suburb], right, and you want to cross the road and there's vehicle, and the vehicle is facing this way coming from this side. Are you people watching us?
S: Yes.
T: Salim wants to cross the road, what will he do? Yes, who can tell us?

(Mrs Oga, Primary 1 Teacher)

T: Is there any ball here?

S: Yes.

T: Good. Don't worry, it would help us a little bit. Children, you see this ball?

S: Yes.

T: The shape of the world, of the earth is like this.

S: Ah. [sounding surprised]

T: Though not completely round.

S: Not small like that.

T: Yes, not that it is small. Look, just watch me then, eh, now there is no torchlight, I'll use my set [mobile phone] as torchlight.

(Mr Abok, Primary Science Teacher, Years 3–5)

Collaborative Group Work

Most of the teachers tried to engage their students during class discussions. I observed that most of these conversations were student-teacher conversations; whole-class discussions and demonstrations were used, but in none of the classes visited were students given a chance to work in small groups or for peer interactions to occur to explore the content. These discussions were mainly between the teacher and a few students giving chorus answers:

T: Now this one that we can mould we say is what?

S: Clay soil.

T: Clay.

S: Soil. [x3]

T: Be quiet. The one from our farm we say is what?

S: Clay soil.

S: No.

T: This one?

S: Sandy soil.

S: Loamy soil.

T: I don't want a chorus answer. Think before you put your hand up, okay?

(Mrs Oga, Primary 1 Teacher)

Although some of the teachers seemed to frown upon students giving '*chorus'* responses, the nature of their questioning encouraged and, in some cases, demanded such responses from students when they asked them to '*repeat after me*'.

Repetition

All the teacher participants would ask their students to repeat statements in a bid to check their understanding:

> *T: A temporary change is that type of change okay… that can go back to its what?*
> *T & S: Former form.*
> *T: Or it's that type of change that is reversible. That is what?*
> *S: Reversible.*
> *T: When they say something is reversible, that means it can go forward and come back. Okay, something that is reversible from where it is can come back to its former self… that's what we mean by what?*
> *S: Reversible…*
> *T: So temporary change is that type of change that is easily reversible. That is easily what?*
> *S: Reversible.*
> *T: Temporary change is that type of change that is easily reversible. [x2] Okay, that can go back to its former self... to it's what?*
> *S: Self.*
>
> *(Mr Dachung, Primary 4–5 Science Teacher)*

In these observations, students repeated what the teacher said or explained, often finishing the teachers' sentences when invited to by the intonations of the teachers. Students crammed these definitions as teachers tested them on their ability to recapitulate them, orally or in written tests.

Connecting Learning to Students' Cultural and Social Backgrounds

Most of the TPs attempted to connect learning to students' cultural and social contexts by presenting examples. Teachers gave examples and explained these connections to students. Students participated by answering closed-ended questions teachers asked:

> *T: You all know what is candle now?*
> *S: Yes.*
> *T: And then even the cock. You know the cock?*
> *S: Yes.*
> *T: In the olden days, our forefathers use the cock. When the cock crows, it means the day is about to break, isn't it?*
> *S: Yes.*
> *T: Up till today the cock crows. When you hear the cock crow, you know that the day is about to arrive.*
> *S: Uncle, in the morning, I used to hear chicken sound.*
> *S: Early in the morning.*
> *T: Yes, that is the cock. When the cock cry, it is a sign that the day is about to break.*
>
> *(Mr Abok, Years 2–5 Science teacher, Year 3 Lesson on Measurement of Time)*

> *T: We said the gully erosion is a kind of water erosion where the channel has been created deeper in the soil by a certain depth that water has washed, and I gave an example of the road path to the market like the Mista Ali market there. Okay, when we follow through Garba dawo at the back there, eh? Have you seen or observed that?*
> *S: Yes.*
>
> *(Mr Dachung, Years 4–5 Science teacher, Year 5 Lesson on Water Erosion)*

These connections though, focused on teachers telling students about how the concepts taught relate to items or examples in real life. Teachers could have inspired students to make such investigations and connections themselves.

7.5.5 Knowledge of Student Assessment Strategies

I saw a limited range of assessment strategies being employed, including asking whole-class questions at the end of the lesson, such as "*Do you understand?"* or "*Is there any question?"* Most students responded "*yes*" or "*no*":

> *T: So, you measure the teacher's table from the leg up, the length is on top, that is the flat surface of it. This one said we should measure the height. Do you understand me? If you are told to measure my height, where are you going to start from?*
> *S: From your leg.*
> *T: From my leg. Correct. You start from my leg and go up. So, if you want to measure the length of your teacher's table, you start from the down. Do you understand?*
>
> *(Mrs Eke, Year 3, Measurement)*

> *T: Okay, those are things around our environment.*
> *S: Okay, there's water.*
> *T: Where? Inside the office, right? Okay all these things make up part of our what? Our environment. Are we there? Are we there?*
> *S: Yes.*
> *T: Any question?*
> *S: No.*
>
> *(Mrs Sambo, Primary 1, Exploring the Environment)*

Teachers would then inform students of the next topic to be explored. Other assessment strategies included testing at the end of the topic:

> *T: Okay, let me go through it. Pay attention because I'll give you a test, and if you fail that test, you have punishment since you are not paying attention.*
>
> *(Mr Dachung, Primary 4–5, Erosion)*

7.5.6 Knowledge of Classroom Management

There were, on average, 25 to 30 students in most of the classes I visited. This number is rather small and manageable compared to the large number of students in public school classes in Nigeria (Ayodele et al., 2014; Okedeyi et al., 2013). Students were typically seated in rows and kept their bags with them as there were no lockers provided. This seemed to influence the nature of classroom management, with teachers often reminding students to be focused:

> *T: So, I want all of us to sit upright. Fold your arms, your biros and writing materials down.*
> *I said, fold your arms. I don't want you holding your bags where you are sitting. Keep your bags by the side. Okay, some of you are battling with your bags. Keep the bags by the side. Okay, then sit comfortably.*
> *S: Shekina.*
> *T: Shh! Keep your biros and pens away and sit upright. Stop opening your bags… keep your bags away. Just keep the books inside your bags. Glory, can you keep your bag aside? Good! Okay, can we settle down... Keep your biros and fold your arms. Keep your books and biros down and fold your arms. Fold your arms. Breathe in… out... Fold your hands… Ayo put your pen down… Ayo!*
>
> *(Mr Dachung, Primary 4–5 Science Teacher)*

The exception to the row seating plan was seen in the one class where students had individual cubical-like desks called 'offices.' At times, the teacher would ask them to bring their chairs and seat in rows in an open space towards the front of the classroom for whole class discussion. There were only about ten students in this class, and this arrangement seemed to result in the teacher having to give more reminders to be quiet during group sessions when the students would bring their seats out of their 'offices' to the front of the room.

The classroom management strategies TPs used to address challenging behaviour included reminders for students to be quiet, changing students' seats and threats of punishment.

7.6 Reflections on the Theme: Teacher Expertise

In this section, I engage with the literature on teacher expertise to consider what the teacher participants' practices, as seen in my initial classroom observation, revealed about their expertise in teaching science. I compare these data with the initial questionnaire results presented in Chapter 5. Further, I discuss the relationship between the observed teacher expertise, the Nigerian BST curriculum, and contemporary science teaching and learning practices.

7.6.1 Teacher Knowledge of Content, Curriculum and How Students Learn

Based on the findings above, the TPs seemed to know the '*what'* of the subject/area they taught and did not seem to struggle with the content they were teaching. One of the teachers explained that she was "*comfortable with the science at this level*", meaning that even though she did not have a science degree, she felt confident that she understood the content. This was a similar finding to the questionnaire results, where all the teachers believed it was important to have sound content knowledge and most feeling confident to teach science. However, one of the six TPs in this phase commented that not having "*specialised*" science knowledge may be the reason for their teaching "*theoretically*" and not "*practically*"; he believed that science learning should be done practically. His comment did not imply that he lacked the content knowledge, but he seemed to be referring to the difficulty in the *how* of teaching Primary Science. This could also relate to the inherent difficulties associated with running practical sessions and the lack of experience and confidence in the epistemology of science.

Although TPs at times seemed to know their students' needs (physical and emotional), they did not seem to demonstrate a knowledge of their students understanding of concepts or of how students learn science. Opportunities were not provided for students to offer their views and critically reflect on learning. The TPs observed practices revealed the need for teachers to understand and explicitly teach the nature of science to support students' development of scientific literacy and knowledge (Harlen & Qualter, 2018). This links to Hattie's idea that teacher expertise is characterised by how they teach more than what they teach. Scholars advocate a learner-centred approach to teaching to support students' development (Harlen & Qualter, 2018; Skamp, 2018).

Learner-centred is not a new term in education (see section 3.6), and it is used interchangeably with *student-centred*. However, I use the term *learner-centred* here to refer to both the teacher and the student. From my observations, the TPs did not seem to position themselves as open to learning with and from their students. Instead, they seemed to adopt an attitude that they were the sole source of knowledge and should not be questioned. This poses a challenge to the application of *learner-centred* pedagogies in the Nigerian context. It is also contrary to the role of the science teacher as described in contemporary literature (Loughran, 2007).

Framing the *Teacher as Learner* (TaL) may seem rather strange in Nigerian society for cultural and systemic reasons. However, when teachers begin to see the need for their own learning even within their classrooms, they may begin to change their mindset and their practice (Skamp & Preston, 2018). Again, I stress here the importance of the teacher having sound content knowledge, however a class where the teacher does all the talking, imposing their ideas and basically doing everything in the classroom, even if the content is relevant to the students, that class is not *learner-centred* and is thus inconsistent with contemporary approaches to the teaching and learning of science (Fitzgerald & Corrigan, 2018; Skamp, 2018). In contemporary science teaching and learning, learner-centred pedagogical approaches of inquiry have been advocated (Harlen et al., 2015; Harlen & Qualter, 2018; Skamp, 2007; Skamp, 2018). Such approaches recognise that the student brings prior knowledge to their learning. Identifying the different ideas students bring to the table and determining how to support them to develop an authentic understanding of the concepts is the core of the *Teacher as Learner* model.

7.6.2 Observed Assessment Practices

Based on my observations, the TPs mostly employed testing to assess their students' progress. Although summative assessments are important, however, when utilising contemporary approaches to learning, the judgement of students' learning should not be solely based on these assessments. The assessment practices these teachers used seemed to ignore the value of diagnostic and formative assessment that seeks to determine students' prior knowledge and provides ongoing feedback to students on their learning, which seeks to track students' progress. The question that arises is whether formative assessments are seen as a valuable or effective way of assessing student learning in the Nigerian context. Sayed and Kanjee (2013) noted that although *assessment for learning* approaches are recommended in some sub-Saharan African education systems, there remain challenges in how teachers can implement them. Large classes also seemed to pose a problem and could also be part of the reason that many teachers resort to tests and exams that ask closed-ended questions.

My observations of assessment strategies confirmed the questionnaire results showing that assessing students' knowledge of science content was the predominant reason for assessments, with written tests and exams being the most utilised means of assessments. Students' failure or passing of tests or exams seemed to determine their understanding of the concepts in the minds of their teachers. These findings are consistent with those of other scholars about assessment strategies in Nigeria and other Africa countries (Abiemwense, 2017; Okoloeze et al., 2015; Sayed & Kanjee, 2013). Tests and exams have long been part of the education system of assessing student knowledge of content and may well continue to be part of the yardstick for assessing knowledge. However, in Nigeria, it seems that tests and exams are the *only* way of gauging student knowledge (Abiemwense, 2017). In as much as tests and exams form part of the assessment process, research suggests they should not be the only method, as they were in my observations (Harlen, 2013a; Panizzon & Keast, 2018).

Further, such approaches to assessment do not support the development of Nigeria's espoused educational goals (see Chapter 2). Historically, the Nigerian assessment system has progressed from having only one exam at the end of the school year to having multiple continuous tests throughout each term (Abiemwense, 2017). However, these continuous assessments are all summative, which is inconsistent with literature on science assessments and learning in which assessments are viewed as an opportunity for learning, not only by the students but also by the teacher, who uses different assessment strategies to understand and support students' learning (Panizzon & Keast, 2018).

The Nigerian BST curriculum includes an evaluation guide that suggests how teachers could assess their students. The guide encourages students to define terms, list examples, or sometimes to describe or demonstrate a concept (NERDC, 2017a). These descriptions in the BST curriculum are consistent with the early phases of learning in Bloom's Taxonomy, namely in the use of the terms '*remember*' and, in a few cases, '*understand*' (Marzano, 2007; Mayer, 2002; Nenty et al., 2007). The guide does not elaborate on how students can develop and demonstrate deeper thinking. These opportunities include being able to *apply* and *analyse* their knowledge in new areas and *evaluate* or *create* something new with this deeper level of knowledge. The teacher participants' assessment practices were only sometimes consistent with the evaluation guide in the curriculum.

It is important to appreciate in the Nigerian context that the exam- and test-driven model is probably a reason that teachers teach in such traditional ways. This is an important divergence from the model advocated in the literature, which promotes using a variety of modes of assessment, particularly formative and that questions in summative assessments should encourage deeper thinking and understanding of concepts. This suggests, therefore, that teachers need to be supported to develop expertise in their assessment practices. This may also go some way to addressing the prevalence of exam malpractice that is common in such education systems (Ndifon & Cornelius-Ukpepi, 2014; Onyibe et al., 2015).

7.6.3 Participants' Pedagogical Approaches

The teachers' process of implementation, the *how*, seemed to be the main challenge; it simply did not match the learner-centred approaches advocated in the literature. The question remains, then, why the teacher participants were teaching using the strategies they were using. Was it because they learned to teach in these ways? What teaching approaches were used during their pre-service training? If teachers were not exposed to any approaches other than simply learning theoretically, then it's little wonder that they would not make use of these theoretical approaches. Irrespective of teachers' areas of speciality and knowledge, there is a need for them to continue to develop their expertise to adapt to changing societal needs. Some scholars argue that teachers must experience the strategies they intend to employ before they can fully understand how to implement them in their practice (Brand & Moore, 2011; Harlen et al., 2015).

One of the teachers in this study mentioned how "*the management have been talking about these child-centred approaches*". It seemed they were aware, to some extent, of other models and were dissatisfied with the standard practice, but they were not shown how to implement them. Learner-centred approaches, such as inquiry-based learning, have been advocated as a constructivist way of supporting students in learning science (Llewellyn, 2014; Skamp, 2018). In teaching and learning science, techniques that support students' achievement help students in knowing:

> how claims are generated, judged, shared, and retained or rejected in this discipline, emulating what scientists do. Learners here are part of a larger, collective enterprise, where learning is equated with knowing how, when, and why to contribute and succeed, and knowing what success in applying scientific processes and concepts to real-world problems can look like. (Alteratora et al., 2018, p. 451)

Alteratora and colleagues (2018) suggest that teachers demonstrate expertise when they successfully guide, encourage, sustain, and challenge students' thinking and contributions through guided inquiry. In this study, the TPs seemed not to include these elements in their practice, which may have hindered their development of expertise. This explanation is in line with Loughran's (2010) idea that the development of expertise is a process, a process of ongoing reflections and adjustments.

This was a matter I considered further in the next PAR stage. The findings from the questionnaire also revealed that the teachers believed that science should be taught practically, and a majority indicated that they used hands-on practical and experimental methods. From the observed PAR phase, it seemed the students were deprived of opportunities to engage in understanding and making decisions on *what*, *why* and *how* of practical science learning. Scholars call the successful blending of these three elements as learning and teaching of science being *hands-on* and *minds-on* (Harlen & Qualter, 2018; Skamp, 2007).

Alteratora and colleagues (2018) argue that student participation in learning should be collaborative, with responsibility for the development of student agency and problem-solving skills shared between student and teacher. From the questionnaire results, the strategies teachers said they used least were scientific inquiry and problem-solving. Clearly, some of the teachers were aware of these strategies; otherwise, they could not have mentioned them. Small group activities and discussions, dramatizations, use of science quizzes and stories were other approaches used only by very few teachers. These results were consistent with my observations in the first PAR phase, in which I saw none of the TPs utilise any inquiry strategies such as problem-solving, small group activities or encourage students to represent their ideas in various forms.

In terms of student participation, all respondents to the questionnaire believed it was important for students to plan and carry out investigations, engage in small group discussions, and be encouraged to ask questions. Although most teachers surveyed thought that whole-class discussions, hands-on explorations, and students representing their understanding in various forms were important, a few disagreed (11.8%, 5.9% and 5.9%, respectively). These results are inconsistent with what I observed during the initial PAR phase, as none of the teachers employed these strategies. Students were encouraged to ask questions, but often it was in the form '*Do you have any questions?*'. The students mostly answered '*no*'.

The nature of the teacher-student relationship and the structure of the learning environment affects the implementation of teaching and learning processes. Therefore, insight into the nature of that relationship may shed some light on the extent to which students are actively engaged in their learning.

7.6.4 The Teacher-Student Relationships and the Learning Environment

The teacher-student relationship can either ignite or quench a desire for learning. Developing a positive student-teacher relationship is considered important for learning and supporting students' development and welfare (Claessens et al., 2017; Darling-Hammond et al., 2020). To this end, teachers need to make deliberate efforts and demonstrate care about developing positive relationships with their students in all aspects of teaching and learning.

The teacher participants seemed aware of their students' needs and responded accordingly to cater for these needs. One such instance, described in the observations, was recognising that a student was not able to copy the notes from the board as quickly as she should have because of her seating position. Overall, the teacher participants were kind and firm, but the teacher-student relationship was rather authoritarian, with students not really saying much unless they were asked a question—which, as discussed above, were mainly closed-ended questions. When students did talk in class, it was usually to ask questions about whether they should copy notes, which books to refer to, or whispering to the person sitting next to them in such a way as to avoid being caught by the teacher. They sometimes asked questions about the content, though these questions were usually closed, such as "*Do the driver and passenger wear the helmet?*" or "*Those that work with NEPA [the National Electrical Power Authority] do they need to be scared of electricity?*" This mimicked the questioning approach used by the teachers. It was good, though, to see that a student in one of the classes seemed confident enough to interrupt and ask questions about the content.

In contemporary teaching and learning of Primary Science, knowledge of the learner and what they bring to learning is important. The teaching and learning of science thus become a shared experience where students' backgrounds, ideas, and knowledge, along with the teachers', are used in the construction of shared understanding (Smith & Fitzgerald, 2018). To foster the co-construction of this shared knowledge, the classroom environment should be relaxed and safe so that students and teachers alike feel comfortable and encouraged to share their ideas and challenge the ideas of others (Smith & Fitzgerald, 2018). This shared understanding begins with interactive dialogue, as discussed in the section on classroom interactions above. For effective learning to occur, it is important for the teacher to be deliberate in developing positive relationships with students and to consider and create learning environments where trust and respect are assured and where diversity is valued, allowing everyone to express learning in a personally meaningful way. Through this process, an appreciation will develop for "diverse perspectives, intellectual collaboration, purposeful questioning and critical reflection" (Smith & Fitzgerald, 2018, p. 48).

The teacher participants seemed to have a firm and authoritarian relationship with their students, and the classroom environment did not encourage students' interactive engagement with their learning. The teacher participants expected respect from their students and expected students to be respectful of each other. Occasionally, teachers threatened punishment when students appeared to be distracting others. An exception to this rather rigid and non-interactive classroom environment came during a lesson on things humans had invented when one student interrupted the teacher and asked, "*What do they use to call the ones that don't have engines, but they use to push* *it? Like wheelbarrow?*" The student asked this question after Mr Abok had requested examples of inventions and then explained that 'automobile' "*means anything that involves engine and can move. Look at the cars that are parked. Can the cars move by itself?*" From this interaction, it seemed to me that this student was making some connection to his prior knowledge of things that were not automobiles. Mr Abok did not seem to understand the question at first and asked if anyone else understood. Another student confidently rephrased: "*He means that wheelbarrow that they don't use to use engine. What do they use to call them without engine?*" Mr Abok then explained: "*Okay, is that the question? Okay, they are not automobile, you can only say 'mobile'. Okay. They are not 'auto' you can only say 'mobile'. Thank you for that*." This interaction stood out for Mr Abok's supportiveness and for the confidence of the students.

The physical layout of the classroom, with desks connected to bench-like seats arranged in rows facing the board. Although two or more student shared this seating arrangement, opportunities for them to interact as part of their learning was not encouraged, and most times when students did interact, teachers would reprimand them to "stop talking, stop making noise." The classroom environment seemed tense as teachers talked, and students listened or answered questions when they were asked. This seems contrary to socio-constructivist approaches to teaching and learning science; the environment should be welcoming and flexible in catering to students, allowing them to engage and interact meaningfully with their peers to encourage collaborative learning that could support or enhance students learning (Chu et al., 2016a; Gengle et al., 2017). Such positive and safe environments promote respectful behaviour by and toward all, including the teacher.

7.6.5 The Case for Teachers Learning to Inquire into their Practice

My research suggests that teachers need to adopt an inquiry mindset, as captured in Figure 7.3, to build their expertise in science. Such an inquisitive mindset may help the teachers become more open to learning about and with their students and from others. They may become more reflective about their practices and more willing to try new approaches to improve their practices and student outcomes.

Figure 7.3 Teacher as inquirer

While most of the teachers had a clear idea of what they wanted to achieve in their lesson plans, students were not carried along in this process. Traditional teacher-centred approaches to teaching and learning were evident in my observations of the teacher participants' classroom interactions and practice. These observations are consistent with other research on African schools. Many scholars have identified that teacher-centred methods do not encourage active learning and participation from students but rather inhibit the development of critical and creative thinkers and the generation of student autonomy and agency (Afolabi, 2013; Ogunleye, 2009; Omotayo

& Olaleye, 2008). Hennessy and colleagues (2016), in their research on Zambian primary school teachers, also identified such didactic teaching approaches. The low rate of student interest and performance in science and negative student outcomes in Nigeria are also attributed to the ineffective strategies employed by teachers (Ezema et al., 2017).

From the literature reviewed in Chapter 2 and Chapter 3, which highlight the use of such teaching approaches and the revelation by these scholars about the negative outcomes of these traditional teaching practices, I began to wonder why such practices persist. The implementation of constructivist pedagogical approaches such as inquiry in teaching and learning science is complex and challenging, and even more so in an educational context that is driven by tests and exams, with a crowded curriculum, scarce resources, limited teacher PCK, and low salaries (Sayed & Kanjee, 2013).

Some scholars have argued that if teaching and learning is context-specific, it may be difficult, if not wrong, to apply learner-centred pedagogical approaches contrary to the traditional models already in use (Barrett, 2007; Tabulawa, 2003). Tabulawa (2003, p. 10) further argues that the drive towards such learner-centred approaches is mainly by aid agencies who have a political agenda and that "the interest of aid agencies in pedagogy is part of a wider design on the part of aid institutions to facilitate the penetration of capitalist ideology in periphery states, this being done under the guise of democratisation." He further argues that constructivist approaches may not be appropriate or relevant to the African context, where cultural norms such as respect for elders tend to hinder student's involvement in learning. Systemic and economic issues, such as scarcity of resources and funds, are also a challenging reality in many of these countries (Barrett, 2007).

Although there is no denying these contextual challenges exist and that teaching and learning approaches should be context-specific, research on building teacher expertise suggests that ongoing learning and adaptation should be a part of this process (Alterator et al., 2018). In the present study, I sought to highlight what the teacher participants were doing well in their current practices and to offer opportunities for them to reflect on how their students were involved in their learning and to challenge them to think and possibly learn new ways to encourage their students' active involvement in their learning process.

Further, Nigeria clearly has, as one of its educational goals, the "development of appropriate skills, mental, physical and social abilities and competencies to empower the individual to live in and contribute positively to society" (NERDC, 2013, p. 2). One of its objectives for primary education is to "lay a sound basis for scientific, critical and reflective thinking" (NERDC, 2013, p. 7). I wonder at what point this empowerment should begin. Should it not commence at the early stages of learning? The Council proceeds to recommend that, for the educational goals to be achieved, "educational activities shall be learner-centred for maximum self-development and self-fulfilment. Teaching shall be participatory, exploratory, experimental and child-centred" (NERDC, 2013, pp. 7–8). Although this is stipulated in the National Education Policy, from my observations, it does not seem to be fully translated in the curriculum and falls short of being implemented in classrooms.

There has been a call to have specialist teachers in primary schools, especially for mathematics and science subjects, to improve student outcomes (NERDC, 2013). This is based on the belief that generalist teachers are incapable of teaching these subjects adequately as such subjects may not be their area of specialisation, which leads to poor student outcomes (Osuafor & Okigbo, 2010). However, a study of more than

120 Primary 6 non-science specialist teachers in one state in Nigeria by Osuafor and Okoli (2013) revealed that these teachers were not uncomfortable with teaching Primary Science and did not think the subject was too hard for them to understand or teach. On the contrary, they had positive attitudes about science and science teaching. The teachers revealed other challenges as factors affecting how they taught science, such as inadequate resources and how to translate some scientific terminology in their students' mother tongue to help them understand.

My findings are consistent with Osuafor and Okoli's (2013) in that most of my TPs felt comfortable with the science content they had to teach. Their knowledge of the *what* was not directly from the curriculum but from the prescribed textbooks, which are developed in compliance with the curriculum (see section 7.5.2). Although the TPs appeared comfortable with the content they taught, the extent of their knowledge may have also negatively impacted the ways they taught. Harlen and colleagues (2015) posit that, due to the exploratory nature of science at the primary school level, teachers may find it more challenging to make connections between the ideas developed in classroom activities and their wider application and may therefore limit how they support their students in developing these understandings. These challenges are not limited to primary school teachers; even secondary school specialist science teachers may face challenges in teaching certain areas of science that may not be outside their specialisation (Harlen et al., 2015). This strengthens the argument for ongoing PL to continue to bridge the gaps and further develop the big ideas in science and how to support students to develop an understanding of their ideas.

All the teacher participants seemed clear on the *why*, judging from the 'rationale' sections of their lesson plans, but this did not necessarily mean their students understood it. Students understanding the *why* is important for learning to be meaningful, rather than simply a matter of listening or completing an activity (Faulconer, 2017). This relates to the relevance of the curriculum to their lives and the need to link the learning of science to phenomena students can relate to for them to consider the meaning and significance to their learning (Tytler, 2017; Tytler et al., 2013). Constructing their own understandings through problem-solving skills and meaning-making abilities are essential 21st-century skills to develop (Bybee, 2010d). Although sometimes teachers referred to the *why*, the learning intention or goal of the lesson was rarely made explicit to students, and in some cases, it seemed like the goal was for them to be able to remember the lists of items or definitions mentioned in the lesson only because they would be tested. It seemed students needed to: "*Pay attention, because I'll give you a test and if you fail that test, you have punishment since you are not paying attention.*"

Research suggests that it would have been more beneficial for students to understand the reason for learning a particular topic and how it relates to their lives or other subject areas instead of learning just to pass a test/ exam or to avoid punishment. Such approaches contrast with constructive approaches such as inquiry-based science teaching and learning where there is an alignment between teaching and learning methods, intended learning outcomes, and assessments (Biggs, 2014).

7.7 Summary

My observations revealed a didactic, traditional approach to the teaching of Primary Science to be typical across all the classes. The TPs relied on frequent reminders to students to be quiet and on punishment to handle classroom management. The teachers relied on explicit teaching by telling students explanations. Although explicit teaching has a place in constructivist approaches to science teaching and learning, it should occur after students' ideas have been explored and students have been involved in the discussions to reinforce scientific concepts and develop familiarity with appropriate terminology. Teacher-student interaction seemed to be top-down, with teachers doing most of the talking and questioning. These questions were closed-ended questions that did not stimulate much response from the students. These approaches seemed incoherent with the more dialogical nature of classroom interactions advocated in the literature.

There were some aspects of the teachers' pedagogy that were consistent with the Nigerian curriculum, even though the teachers did not refer directly to it. Some of these aspects included the unidirectional interaction patterns, with students mainly providing one-word or short responses to teachers' questions. However, these interaction patterns were inconsistent with the approaches recommended to stimulate students' deeper thinking and encourage communication in the science literature.

An area of strength identified was the TPs' attempts to include demonstrations in their practice as a way of engaging their students. However, I also observed that most times, students just watched as teachers did the demonstrations and explanations. Although demonstration is a valuable teaching strategy, contemporary pedagogical approaches to teaching and learning primary science suggests that students should be supported to construct their learning in science. They should be supported and encouraged to be actively engaged in the process of developing their understanding through learning activities that are not just '*hands-on*' but also '*minds-on*'. Through relevant inquiry experiences, students are supported to think and carry out investigations about scientific concepts that support and/or develop their understanding of the world.

Teachers sometimes made attempts to make learning relevant to students' lives by relating the content to the area where students live or reminding students of how the context explored occurred in an area familiar to them. To support the development of the Nigerian educational goals of empowering students to be active and critical thinkers, the students could have been challenged and encouraged to make these contextual connections themselves.

The development of expertise in teaching means the successful blending of *what*, *why* and *how*. Scholars have advocated for the complementary rather than competitive nature of theory and practice, where teachers use their knowledge of their students, the content, and the context to decide on relevant experiences and teaching and learning approaches that will support and deepen student understanding of scientific concepts. The TPs were developing their expertise as they seemed knowledgeable of the science concepts and had reasons for their teaching and learning of these concepts documented in their schemes of work (lesson plans). These were not clearly explained to students, though, and the teaching and learning approach they utilised (the *how*) did not seem to support students in developing deeper thinking and understanding.

Although the TPs seemed knowledgeable about the science content, the ways in which they supported their students to develop their own understandings was limited. Their assessment of student learning was limited to summative assessments, which seemed consistent with the practice recommended in the curriculum. However, these approaches were inconsistent with contemporary models of science teaching and learning. Through the observations, some of the areas that TPs needed to be supported to continue developing their expertise became clearer to me. These areas included the development of student-teacher relationships and awareness of assessment strategies and pedagogical choices. Teachers need to be supported to develop expertise for the successful blending of *what*, *how* and *why*.

After these initial observations and consideration of how they relate to the Nigerian curriculum and contemporary approaches to science learning, it was important that I deepen my knowledge of the teachers' perceptions of their practices. The TPs' thoughts and ideas about science and their teaching approaches are detailed in Chapter 8.

Chapter 8
Identifying Professional Learning Needs Through Reflective Practice

In this chapter, I present my interactions with the teachers through a reflective process to better understand their beliefs and practices, as I had observed in the previous phase. Engaging in such reflections was an important step in identifying their professional learning needs before providing any PL as mapped out in Chapter 4.

8.1 Teacher Perception and Practice: Is there a Mismatch?

> *Science is an **interesting thing**, and the simple reason is that in science, you have to **discover things by yourself**.*
>
> *(Teacher participant, 2018)*

Following the initial observations reported in the previous chapter, I interviewed the teachers to inquire into their perceptions about science and science teaching and learning. Knowing more about the teachers' perceptions, I hoped, would provide some insight into how they think of themselves as teachers of science and what they see as some of the influences on their teaching practice. This should provide some answers to the third research question: *How do Nigerian primary teachers see themselves and their roles as science teachers?*

Using the semi-structured interview schedule described in Chapter 4, I had a discussion with each of the TPs. These discussions occurred after the first round of classroom observations, which allowed the TPs to teach as they normally would and reduced any potential pressure from my questions to adjust their practice before I had had a chance to observe it.

8.2 The Power of Reflection with a Colleague

During the interviews, I utilised a semi-structured interview schedule with open-ended questions to guide the discussion as the TPs elaborated on their practice. Each teacher participant reflected on one of the lessons that had been recorded, after which I (the RP) shared my reflections on their lesson and practice. The elaborations were not necessarily limited to what happened in just that lesson but also included their practice in general. The questions began with a review of what they thought they did well before progressing to what was challenging and what they felt they would like to improve on. Starting the reflections from a strengths-based approach enabled the TPs to identify and celebrate the things they did well, making it easier to identify and consider possible areas for adjustment (Ghaye, 2011). All the teacher participants appreciated the initial focus on what they were doing well, as this comment illustrates:

> *Oh, thank you very much. I am happy because at least someone has said you have done well here by doing this and this, that’s a very good encouragement. I really appreciate it.*

Nevertheless, individual teacher reflection can be challenging because teachers may not normally engage in such practice. The ability to reflect on one’s practice as part of a supportive network can be encouraging and may provide a different lens through which a teacher can view their practice. It offers others the opportunity to observe their colleagues' practice and provide constructive feedback (Farrell, 2015; Reed et al., 2002). In this study, my role was to provide supportive, constructive feedback to the TPs. I used an observation checklist (see Chapter 4) and took note of interesting occurrences in the classes and of the teaching process that was not necessarily on the observation checklist. I summarised my observations and discussed this with the TPs during the interview session after they had shared their reflections on the lesson. We also viewed the video recordings of the teaching sessions, which supported us in the conversations during the reflective process (Jewitt, 2012). The video footage was essential to stimulating recall for the TPs and me, given that the reflections could not occur immediately after the lessons. Further, the videos also highlighted other aspects of teaching practice that may not have stood out initially or that TPs wanted to focus on (Hollingsworth & Clarke, 2017).

In the following sections, I present the perceptions of five science teachers—one (Mrs Eke) had to pull out of the study (see Section 7.1.1). I present these as vignettes in relation to the nature and value of science teaching and learning and the teachers' roles and approaches to teaching Primary Science.

8.2.1 Mr Dachung

Mr Dachung is a Primary Four and Five science teacher with a science degree and more than 10 years' teaching experience. He also teaches Biology in the Secondary Section of Banke Academy. He enjoys science because it is a practical subject and believes his role is to help students understand the lessons. He shared his beliefs about science and Primary Science teaching during a reflective interview session:

> *Science teaching is a kind of way of making students to understand or get knowledge about some of the scientific principles and approaches that can help them to learn with time. Science is very important.*

He believed that the most important aspects of science teaching are the practical aspects: "*I think approaching it through practical is more understandable and the things they get to understand is more.*"

Mr Dachung further explained how he utilised practical approaches when he reflected on one of the lessons he taught in which he got soil samples to show the students while exploring the concept of soil erosion:

> *Well, I had some opportunity to get some soil samples because that one is easier. I could get it within [the school]. I told you from the beginning that approaches to science is very important and I think approaching it through practical is more understandable and they get to understand it more. For the other ones, I know I could not get the materials I used that time. I had intention to use it later on because I'll still do it, it is what I'll carry over with that class so that they would understand it better. But I think practical aspect is the most important in teaching Science.*

Mr Dachung believed that the use of practicals develops students' understanding. He also highlighted the challenges of obtaining the resources to carry out such practicals. In the lessons on erosion, he felt the lack of resources reduced students' understanding of the concepts and different types of erosion:

> *One of it is, eh, when I was teaching the different types of erosion, students were finding it difficult to understand the principle of the types. It takes them some time. Some of them I had to repeat it. Even with that, some of them could not get it still because the concept is what is giving them difficulty there. And the instructional materials that I used were not enough. How I wish if I had pictures, I would have gotten pictures to show them how the different types differ.*

8.2.2 Mrs Oga

Mrs Oga is a Primary One teacher with teaching experience of more than 15 years. She is a Head Teacher for the Junior Primary Section of her school. She believes that science is the study of nature and how things work:

> *Science is the study of living and non-living things, and it exposes one to nature and how those things behave in their immediate environment and how they are being made, how scientists put them together to become what they are. So, I believe science helps us to put things together and understand how they work.*

She believes that science is an important subject to learn because it develops our understanding of the world. She considers her role as being one that "*helps students understand the subject*." Reflecting on one of her lessons on safety in our environment, she explained that it is vital for students to be engaged in practical activities to develop their understanding of the concept taught:

> *As I said earlier, I want to take them outside the classroom because we are talking about the road, so that way they'll see the incoming vehicles and the ones moving the other way. The left and right that we are saying we should observe; I want them to see it. I think when they see it practically, they would understand more.*

However, she also alluded to the political unrest and national insecurity preventing her from taking her students outside. This insecurity was and remains a significant challenge in Nigeria now. It was evident that such insecurity had a significant impact on students' and teachers' attendance at school, can lead to school closures, and can affect teachers' practice. For example:

> *…the children, we were supposed to do it outside, this particular topic last session, it took place outside. But yesterday I looked at it if I should take them outside. Because of the security situation, it would not be safe.*

She also mentioned the financial challenges many parents faced, meaning they often failed to pay their children’s school fees or could not afford the required resources:

> *As you observed, each desk has two pupils and they have to share the textbooks because some of their parents, because of the economic situation and first term issues of paying school fees. And some can’t buy the textbooks.*

She also believed that lack of resources affects her ability to effectively teach science and other subjects.

8.2.3 Mr Obi

Mr Obi is an NCE holder with more than 10 years’ teaching experience. He does not have a science background. He teaches Primary Two Science and Agricultural Science in the Secondary Section of Banke Academy. When asked about what he believes science means and his role as a science teacher, Mr Obi responded:

> *Science teaching has to do with innovation, and it also has to do with creativity. Both innovation and creativity help in promoting learning that when it comes to what a child can do or the ability of a classroom. Secondly, when you talk about innovations as a teacher, you may not really know an area a child can excel in life, but through all this innovation and science of a thing, you discover that a child may figure out an area he can do best. So, it’s now left for you as a teacher to now cue into that area and see how you can help and mould him. So that is what science can at least bring about when we take it seriously.*

Mr Obi’s opinion of science teaching and learning is that it stimulates innovation and creativity. He sees his role as being to guide the students towards such innovations and creativity. He also believed that science helps his students to understand how certain aspects of their lives work and to understand some of the innovations they see around them as benefits of science and technology. He believes it is important to harness students' natural curiosity and to explore what students already know about a topic:

> *I believe that along the line, there are some of them [students] that have the eagerness, and they are—permit me to use the word—curious, they are so curious to use some of the ideas of things they know that has to do with the technology, so they were eager to, like, make sure 'let me say my own' [speak for themselves]. So, it shows that there are some of them that have the ideas of what the lesson or topic is all about. So that's enough to show that some of them have the idea already.*

Mr Obi believes that students' ideas about science concepts are valuable and should be taken into consideration when teaching, which is consistent with a constructivist approach.

8.2.4 Mr Abok

Mr Abok is a Primary 3–5 Science teacher with no science background. He believes that science is a practical subject and should be taught practically and by 'specialists':

> *It's the provision of materials for teaching because science is practical, it is more of practicals, and before you do practicals, you need some materials. In fact, that's one area we struggle with, especially like me.*
> *It requires specialists in it because it entails a lot of practicals, and apart from that, the theory is just a minute part of it, and it should be considered that way. But while you are not a specialist in that area, the only option is just to go by the theory.*

There was a correspondence between Mr Abok's statement and what I observed in many of the classrooms I visited where teachers resorted to a transmissive mode of interaction with their students.

He also explained how the lack of resources hinders his ability to teach practically. He also described how this non-specialisation makes teachers like himself resort to theoretical approaches, even though he thinks this should form a minor part of the science teaching and learning process. Further, in response to the question about what he thought worked well in one of his science lessons, Mr Abok referred to one of the lessons where he felt his students engaged with the lesson because they could make connections with the topic:

> *Like that topic 'Changes in Nature'. Why I want to talk about that one is that is something we experience. We as human beings, we experience it every day. No life is static, or no condition is static. Human beings are bound to develop from one stage to another and at a point in time go back to its creator.*
> *That very lesson, I enjoyed it, and as I observed the children too, they too, they participated enthusiastically because they know it is part of the life they are experiencing that we treated. And you could hear them talking about their parents, themselves at certain ages, and then they hope someday they'll get married, have children, become old.*
> *That topic is something that directly affects us.*

Here, Mr Abok suggests that he enjoyed teaching this topic, and his students seemed to have engaged with it, too, because it was relevant to their lives. Mr Abok's comments suggest that when teaching and learning is relevant to a real-life context, both the teachers and students can relate to it, which heightens their enjoyment and engagement in learning and thus leads to deeper understanding.

8.2.5 Mrs Sambo

Mrs Sambo is a qualified teacher with more than 16 years of primary school teaching experience but without a science background. She teaches Year 1. Mrs Sambo perceives science as being an enjoyable subject based on one's ability to "*discover things for yourself… that thing will stick to you, and you will never forget it*."

Although Mrs Sambo had perceived science as enjoyable because of this element of discovery, her teaching approach was quite the opposite, with many instances of her telling her students what they ought to know about the given topic:

> *T: Environment means the physical or condition or a place where somebody is. For example, we are in a class, eh, so we are in a class… so this classroom forms our environment, eh. This classroom forms our environment. If we want to know what is in our environment, we will now use our what? Our eyes because a scientist uses his ear, eyes, and even uses his hands, and sometimes he even uses his nose to smell, eh. Sometimes he will even use his tongue to taste. Yes, now… for example, if I have something or food and you don't know the type of food, you can see it, touch it, smell it, you may even taste to know, isn't it? It's all ways of finding out something. Is that clear?*
> *S: Yes.*

A challenge she identified to her science lessons was the nature of her student cohort. She had students with mixed learning abilities, with some from the city being more advanced in their learning than those from the village who had newly enrolled at the school:

> *The challenging aspects are, since I have too mixed children, some from the village and some from us that are here, okay, there are things the children may have said that made the other ones that are coming from the village not to understand. Okay, to me it was a challenge. Some were behind others.*

She also believed that having images would improve students' understanding of the concepts in subsequent lessons.

In summary, all the teachers viewed science as an important subject to be taught in Primary School and advocated for students to be taught through practical approaches. They all said that science is interesting and that students needed to be involved in their learning process. However, based on my initial observations of teacher's classroom practices as described in Chapter 7, there seemed to be a gap between these perceptions and their teaching approaches in the classroom. The teachers mentioned several constraints on their teaching, such as lack of resources. These findings are consistent with the literature (Fitzgerald et al., 2019).

Other unexpected challenges were mentioned, such as political unrest and the financial strain on families as inhibiting the attendance of students and their impact on some of the learning experiences teachers had planned. In discussing these difficulties with the teachers, I challenged them to think of how they could involve their students more to engage and deepen their learning of science.

8.3 Identifying the Teachers' Professional Learning Needs

This section describes how, in the interview sessions, through discussion and reflection, the teachers were able to identify some professional learning needs. Although this reflective process was carried out in a changing and challenging atmosphere due to the political tensions, I encouraged a strengths-based approach. Teachers were asked to describe what they thought they did well and identify areas where they could adjust in their thinking and practice. As a researcher participant, I provided feedback that led the discussion to highlight what they thought they had done well and any areas for possible adjustments.

I analyse these reflections below to explore their impact in the classroom, the school, and at a national level and to shed light on RQ 2: *How do science teaching and learning practices in a Nigerian cultural context reflect contemporary pedagogical approaches to science education?*

8.3.1 The Classroom Context

From the observations and interviews with teachers, the activities observed in their classrooms were jointly reviewed and discussed. All teacher participants demonstrated a passion and interest in teaching Primary Science. They all considered science a valuable subject that should be taught at primary school and were interested in supporting their students' understanding of the content. However, in the excerpt below, although Mr Abok demonstrated that he understood the content, as did the other teachers, he still resorted to 'telling' students about the content rather than involving them in ways that develop deeper thinking and understanding.

Some of the teachers demonstrated creativity in their use of the limited resources available. Their ability to improvise in some instances to support their students' understanding of the science concepts was a strength. An instance that stands out was when Mr Abok needed a globe to describe the earth's rotation around the sun but could not find one and instead made use of a ball to demonstrate:

> *T: Scientists, according to them, it is not the sun that moves; it is the earth that does*
> *S: Yes, the earth that moves, but slowly.*
> *T: We used to have the globe of the earth. I know we used to have one in the coordinator's office, but I don't know where it's been taken to.*
> *S: Staff room.*
> *T: Oh, that place is too far. Anyway, you know what, let me see… give me that… Is there any ball here?*
> *S: Yes.*
> *T: Good, don't worry, it would help us a little bit. Children, you see this ball?*
> *S: Yes.*
> *T: The shape of the world, of the earth is like this.*
> *S: Ah [sounding surprised]*
> *T: Though not completely round.*
> *S: Not small like that, oh!*
> *T: Yes, not that it is small, oh! Look, just watch me then, eh, now there is no*

torchlight, I'll use my set [mobile phone] as torchlight. Okay, you, let somebody come.

S: Uncle, uncle, me!

T: Okay, you come, hold it, just hold it, it would represent the sun, okay. The sun is stationary, and it doesn't move.

S: It used to move.

T: No, just look at the demonstration, stretch your hand. Everybody watch.. Now, this is the world. We have Africa here with a map of Nigeria. We have here America, here Asia, China, and the rest of them.

How all teachers could be supported to improvise and be creative and how they could encourage their students to do likewise was another area that emerged for consideration.

While most of the teachers felt their students understood the content, this question of how to make the learning of science more interesting was an area where the teachers felt they needed support. When asked how they gauged students' understanding, they said, *"based on the response of the* students" and that "*the topic is something they experience*":

That one was through my evaluation questions that I put across and their responses. It generally gives me the perception that most of them, not all of them but I know that they got most of the things I taught them. (Mr Abok)

The response above suggests that teachers valued their students' responses and that choosing topics and/or learning experiences that students' experiences can be chosen to connect with in their real-life promote better understanding. However, my observations showed that although most teachers claimed to value the responses of their students, during whole-class discussions, in practice, students were given little opportunity to expand or elaborate on their responses in whole-class discussions. Most questions teachers posed were closed-ended questions that are designed to generate a 'yes' or 'no' response. In instances where students provided explanations, such responses came from only a few of the students. Acknowledging this, the teachers felt that asking questions in ways that encourage students to think and respond beyond a single word was another area they needed to explore to engage students better.

One of the teacher participants was also sceptical about the use of formal summative assessments as a way of gauging students' understanding:

> *…and apart from that, even though I'm one of those who doesn't truly believe that writing a test can convince one much because a child who may not have an idea of what the question is all about might copy from his colleague and at the end you may judge them the same. So, I don't truly make use of that test of a thing, that is the written test, to be a yardstick for judgement, but I prefer asking them verbal questions so that each person can feel free and express himself. (Mr Obi)*

Although, there is a valid place for summative assessment in the learning process, research indicates that they should not be the only method used to assess students' learning (Corrigan et al., 2013; Harlen, 2013a). Many opportunities exist during the learning process to conduct formative assessments that could give valid information about student learning. However, all the TPs relied on summative assessments to judge their students' understanding. In the discussions, the TPs expressed a wish to be supported in developing their awareness and use of other assessment strategies for monitoring students' progress.

The conversations that occurred within the classroom allowed few or no organised opportunities for students to discuss the content being explored with their peers. When students had discussions amongst themselves, even if these were related to the content, teachers considered this 'noise-making', and often reprimanded students to be quiet. The teachers suggested that providing opportunities for students to interact amongst themselves to discuss or explore the content could be a means of channelling the 'noise-making' into positive interactions that contribute to deeper learning.

8.3.2 The School Context

Throughout the teachers' reflections, cultural practices, safety, funds and resources, leadership, and security were the key challenges they identified for their practice. Regarding cultural practices, one of the teachers mentioned that "*listening is one [part] of our culture, where children are not supposed to ask too many questions*." Because of this, balancing expectations about students not talking with their ability to ask questions in class remains a challenge.

Financial hardship also hindered many parents in paying school fees on time, leading to students being excluded, missing valuable learning. This financial difficulty also meant that some parents could not afford to purchase the prescribed textbooks. The teachers believed that the provision of instructional materials and facilities was the responsibility of school leadership which they felt was insufficient for effective teaching and learning.

Another area that most teachers commented on was the lack of professional learning opportunities. Apart from one teacher who had attended a PL workshop, none of the other teachers had done any PL. This is consistent with the findings of the questionnaire, in which most teachers indicated that they had not engaged in any PL. This further highlights the need for schools to provide in-service training, as mandated in the NPE (NERDC, 2013).

8.3.3 The National Context: Political Tension and Uncertainty

Teachers identified insecurity, some cultural practices, unreliable electricity supply, lack of government funding and resources for schools, and the structure of the national curriculum as impediments to teaching and learning:

> *We were supposed to do this particular topic outside, but yesterday I looked at it, if I should take them outside because of the security situation, it would not be safe.*
>
> *Some of the challenges, too, that we have not highlighted is lack of lab equipment, so if the school can also provide lab equipment, it would be helpful. Also, the government can support the schools with funding.*

The national insecurity occurring at this time had a significant impact, not just on citizens, schools, and the teaching and learning processes, but also on my research (see Section 6.2.6).

Local Government Elections

LGA elections had been scheduled throughout Plateau State for 10 October 2018. However, due to security concerns, it was announced that the elections would only take place in 13 of the 17 LGAs, as three were then highly volatile. As election campaigns intensified, there were rumours of unrest in various parts of the state.

Due to these growing concerns, the principal called a staff meeting on a Thursday afternoon to inform teachers that the school would be closed on the day of the elections, which was the following Wednesday, and that re-opening depended on the outcome of the elections. She encouraged teachers to listen to the news and be in contact with each other.

With this new information, I had to re-think and reschedule the first PL session. After consulting with the principal and the teachers, we agreed that the session could take place straight after school the following Monday and Tuesday. Most schools in Jos, including the two schools I was working with, decided to close for election day as a precaution because such previous elections had been marred by violence, protests, and the death of innocent people.

These instances of political, religious, tribal, and environmental unrest cause a huge disturbance to the life and progress of any society. This is the national context that teachers in Jos and, indeed, many parts of Nigeria have to face. It makes me wonder how teachers are expected to work under such challenging conditions. The tensions encountered during this period of the research meant that I had to make changes to the nature of the PL session to ensure the safety of the participants involved in the study. During the reflective sessions, teachers were challenged to think about this question: '*What is in your power to change?*'

8.4 Reflections on Nigerian Primary Teachers' Perceptions and Practices

In this section, I will discuss the teacher participants' perceptions about their roles in the teaching and learning of Primary Science. I will highlight the role of self- and peer reflection and the systemic and cultural issues that affected their teaching and learning processes.

8.4.1 Teachers' Reflective Practice

I encouraged the TPs to adopt a simple model of reflection on their practice by asking: "What did I do? What aspects worked well? What challenges did I face? What area could I modify or improve if I teach that lesson again or in my next class?" This simple reflection model was necessary to support the teacher participants in their own reflections as this was not a practice that they had previously engaged in or were used to. Having a colleague observe their practice was similarly unfamiliar. The TPs were also encouraged to create time to support each other, especially when one of them mentioned time as a limiting factor. Reflective practice with the support of another colleague or small cluster group is a collaborative approach that aids in developing a community of practice in which ideas are shared and are more likely to be sustained within a school (Mphahlele & Rampa, 2015).

I will now discuss the sub-themes that emerged from these reflective discussions: the TPs' perceptions of science and their confidence to teach it; of students' understanding, engagement, and explorations; and of the challenges affecting their practice.

8.4.2 TPs' Perceptions of Science and their Confidence to Teach It

A positive attitude towards science means that teachers will be more likely to adopt sustainable science teaching practices (Van Aalderen-Smeets et al., 2012). However, this is not always the case, as some researchers have found that many primary school teachers may have had negative experiences with science during their own schooling, which may affect their confidence to teach it (Appleton, 2003; Cahill & Skamp, 2003; Goodrum, Hackling, et al., 2001).

All the teachers in this study seemed to have a favourable view of science with the belief that it is an essential subject; they suggested that learning science helps students understand the world they live in. In the interviews, most of the teachers said they were confident to teach Primary Science, but one out of the six believed that science should only be taught by those who had a science background and perceived their lack of a science background as significantly reducing their ability to teach science.

Interestingly, though, the one teacher who did have a science background taught in very similar ways to the other five teachers. The findings from the observation phase showed that a teachers' high-level knowledge of particular subject matter does not necessarily guarantee that they can teach it effectively. This was consistent with the questionnaire results, where teachers with science backgrounds and higher degree qualifications did not necessarily describe different ways of teaching from those without these academic qualifications. The observations agreed with the idea that science content knowledge is only one factor in a teachers' repertoire and does not necessarily lead to more effective teaching (Adu & Olatundun, 2007; Hattie, 2012; Hattie & Yates, 2014; Loughran, 2011). Hattie (2012) and Fitzgerald and Corrigan (2018, p. 14) propose that what matters is expertise as a teacher:

> *this is not to infer that engaging with science and building your scientific understanding and knowledge along with your students is not essential, but it is your role and expertise as a teacher rather than a scientist that will be brought to the fore through your practice and burgeoning identity.*

The TPs demonstrated a sound science content knowledge and had many years of teaching experience. The question that arose for me, however, as the researcher, was how the TPs would be able to develop their expertise to teach science as required by the curriculum and/or as advocated in the literature. In other words, does the Nigerian educational context actually support them to teach in a way that ensures their students:

> *understand the purpose of their activities, explore new objects of phenomena informally and 'play with ideas' as a preliminary to more structured investigation, make links between new and previous experience, work collaboratively with others, communicating their own ideas and considering others' ideas, present evidence to support their arguments, engage in discussions in defence of their ideas and their explanations apply their learning in real-life contexts, and to reflect self-critically about the processes and outcomes of their inquiries. (Harlen et al., 2015, pp. 49–50)*

This is a difficult outcome to achieve, even in western education systems. In a resource-poor system like Nigeria's, it is vital to ensure that primary schools are staffed by qualified teachers, with or without specialist expertise in science, and that they are given opportunities to improve their knowledge base and skills to effectively teach Primary Science, as mandated by the Nigerian PL policy (TRCN, 2010). Research suggests that teachers should and be supported to develop their expertise by using their sound knowledge of content and context to teach in ways that challenge students to think more deeply and critically about their learning and should create an atmosphere that encourages students to engage in their learning process (Alteratora et al., 2018; Traianou, 2006).

Through the interview and reflection process with TPs, I designed the PL to support them in considering ways to further develop their expertise in terms of the impact of teaching on student learning and, more specifically, how they could encourage their students to be actively involved.

8.4.3 TPs' Perceptions of Students' Understanding, Engagement, and Explorations

The teacher participants believed that students should have opportunities to explore their environment. This was evident in some of their practices, where, for instance, one of the TPs took her students on a walk around the schoolyard while teaching the topic 'Exploring our Environment'. This exploration was a great opportunity for students to identify things in their environment, but throughout this exploration, the teacher asked the students only closed questions, such as "*Can you see those cars there? Can you see the people?*" with students responding "*Yes*".

In another instance, when one of the teachers took his students out to explore the phenomenon of erosion, he too did all the talking informing the students about how erosion may have occurred in that place:

T: Okay, look at this place, is this level with this one?
S: No.
T: Good. By the time the rain starts, at a certain ground level, if that a certain part of the ground is not strong enough, the water will start washing that part. Okay… As it rains, the water will start washing away that part. Simply because

that part is not strong, and that is why the washing away of that soil is what we mean by soil…

S & T: Erosion.

T: That is the soil erosion we are talking about. It happens everywhere, and it affects farmland very much.

The teacher participants thought that learning should be practical with students given chances to explore, but these explorations were simply another way to tell students what they should know. In response to their thoughts about their students' participation and engagement in the lessons, the TPs felt that their students were engaged and participating on the basis that they could answer the questions they had been asked. Often, however, as indicated above, these questions were closed-ended questions that demanded single word or phrase responses. Teachers' questioning approaches were a point of discussion during the reflection process, where we tried to explore how else to ask questions that support students to think more deeply and provide responses that show that level of deep thinking (Lee et al., 2012).

Research indicates that explicit explanations and instructions are important and have a place in science teaching and learning, particularly to support students' understanding of scientific terminology and to address questions/confusion that can arise in the exploratory phase (Bybee, 2014; Hackling, 2006). However, studies have also shown that explicit teaching should not be the only method, especially when the goal is to build inquiry skills in students. Instead, students should be given avenues to explore and reason through guided inquiry and to work in collaboration with their peers (Chittleborough et al., 2017; Darling-Hammond et al., 2020). These findings are consistent with research demonstrating that when teachers claimed to adopt practical approaches, they applied *hands-on* but not *minds-on* practices with a pre-dominance of explicit teaching and closed-ended teacher questioning (Fitzgerald & Smith, 2016; Harlen et al., 2015).

Overall, these observations and reflections revealed to me that the TPs needed support to explore and implement inquiry strategies to engage their students in deeper, critical, independent, and collaborative thinking.

8.4.4 Teachers' Perceptions of Challenges Impacting their Practices.

The teachers also mentioned some systemic and cultural challenges to teaching and learning in their context. All of them reiterated that the limited resources they had to work with posed a challenge, as did heightened security concerns (exemplified by the teacher feeling it would be unsafe to take her students outside to learn about crossing the road).

Although faced with these challenges, some of the TP's demonstrated the ability to improvise by using the resources that were already in class or by bringing materials for students to explore. This awareness provided another area for discussion in the PL sessions on how all teachers could face the challenge by improvising to compensate for inadequate or unavailable resources. The lack of teaching and learning resources is well-documented in the literature as a major challenge for many schools in Sub-Saharan Africa (Academy of Science of South Africa, 2010; Afolabi, 2013; Aina, 2012; Ezeudu et al., 2013). The findings of the questionnaire also attest to this challenge, which has sometimes led teachers to resort to teaching abstractly, with negative effects on students' interest and learning (Aina, 2013). Through this research, I seek to explore how teachers can be supported in their practice amidst these challenges.

8.5 Bridging Perceptions and Practice in the Nigerian Context

The teacher participants' perception of science and science teaching and learning was that science is a practical subject and should be taught practically. This basically meant providing opportunities for students to carry out experiments. This was not the approach they took in their practice, however.

The teachers' perceptions of science and science teaching and learning were positive, and they approached their lessons with a positive mindset. They also perceived science teaching and learning as a means of supporting students to be creative and innovative, but again, this was not revealed in their practice.

Research suggests that teachers need to be supported in the process of making these shifts and that the process is gradual due to pedagogical demand but also the time it takes in implementing change (Fitzgerald et al., 2019; Goodnough, 2018). As the researcher, I had to consider what I could realistically do to help them bridge this gap between attitudes and practices. I recognised that this bridge would have to be built gradually by supporting the TPs to try out new ideas and reflect on their practice. This process had to provide new and practical ways of thinking and to be based on the science learning and teaching theories and practices supported by the literature. Through the reflections, I supported the TPs in identifying gaps which led to more discussions during the PL sessions about how to bridge them.

Based on these gaps and the need to adequately support the TPs, I designed the PL sessions to be interactive and to model how an inquiry-based teaching and learning approach could be implemented in their practice. Furthermore, I modified my initial ideas for the content and structure of the PL to suit the needs we identified.

Judging from my discussions and reflections with the teachers, they did not seem to be aware of inquiry-based approaches or how to implement them. I realised that my initial plan (see Section 4.3) was too ambitious. I had intended to support science teachers to encourage more student involvement through inquiry by developing a lesson and possibly a unit of work using the 5Es model, implement it and then reflect on it. The observations, and most importantly, the reflective conversations, broadened my understanding and learning about where the teachers were in terms of their exposure to constructivist approaches to teaching and learning. Because of this, it was important to start at their level and focus on considering how they could implement inquiry-based learning in their context and to link it to their prior experiences.

This change in my approach is in line with the nature of PAR, which integrates uncertainty through the ability to reflect and the willingness to make changes in order to cater for the needs of TPs (Mills, 2016; Stringer, 2008; 2014). These changes made it a challenging but also an exciting and authentic research experience.

Subsequently, while I was updating the principal about the PL plans, she asked whether other teachers at the school could benefit from the session. To accommodate this, I needed to make further changes to my plans.

8.5.1 Putting the PL Plan into Action

On putting the plan into practice, I soon discovered that reflecting on their practice was not what the teacher participants were used to. Even more so, having a colleague observe their teaching and share their thoughts and ideas about a particular lesson was not common, though it was still something all the teachers appreciated:

> *I am very grateful for you to have observed my teaching. I think this is a privilege for me, because I think since I've been teaching, no one has ever come to my class and observe my teaching for me to see myself. I have never had an opportunity like that, truly!*

This was consistent with observations in the literature that teacher reflective practice in Nigeria is not common; this was even posited as a possible reason for the slow improvement in teaching practice (Agoro, 2013; Hyacinth & Mann, 2014). Reflecting on one's practice is in line with my *Teacher as Learner* approach, in which the teacher views themselves as a learner who, by adopting an open mindset of inquiry, is not only willing to provide opportunities for their students to carry out inquiry, but also willing to inquire into their teaching practices, to identify and implement effective practices that promote student learning.

When teachers adopt a mindset of inquiry, that may make it easier to model that mindset and to support students in adopting such a stance (Gillies & Nichols, 2015). A teacher's inquiry mindset may lead or can be linked to a growth mindset which can be a stimulus for ongoing learning (O'Brien et al., 2015). Adopting such a mindset requires a willingness to take risks, to learn along with their students and others, to try different pedagogical approaches, and to reflect on their own learning and practice by identifying areas of strength and areas needing adjustments with the goal of promoting or enhancing their students' learning. This draws on ideas of learning being practical, critical, and creative. Although this research advocates an inquiry mindset for both student and teacher, the application of this in the Nigerian context may be challenging due to the cultural and systemic issues identified earlier.

In the reflective conversations, I encouraged the TPs to think about what they could do differently if they were to teach that lesson again, and I also offered some suggestions. The focus was not on "*You or I did this wrong*", but more on '*this is what I did, these are areas that worked really well, these are areas I could modify or improve if I teach that lesson again or I could implement in my next lesson.*"

These ideas were to be applied in the project during the reflective cycles and are supported by the PAR methodology and research on PL. The teachers were encouraged and challenged to keep thinking about what they could modify or implement next time. The development of teacher expertise requires that they consistently reflect on their teaching practice and seek to enhance their knowledge and skills in specific areas. Many scholars advocate PL as a way of supporting teachers to achieve that (Alteratora et al., 2018; Berliner, 2004; Ericsson et al., 2006; Palmer et al., 2005; Winkler, 2001).

Therefore, through this learning process, I hoped to use research to support the teachers to experience inquiry-based teaching and learning of science in their classrooms, with the aim of helping their students to develop not only cognitive abilities but also other desirable qualities to function effectively in the 21st century. It was on this premise that I designed the PL sessions.

8.6 Summary

All the TPs had positive perceptions of science and considered it an important subject, supporting students' understanding of themselves and the world. Most teachers felt comfortable to teach science at the primary level. All the teachers believed science should be learned and taught practically, but this was not reflected in their practice as observed. Some of the teachers stated that their lack of formal science educational background made them resort to teaching science theoretically.

Further consideration of their perceptions and practice in relation to the classroom and school contexts revealed that the teachers did have sound content knowledge of the topics they taught. They felt their students were engaged in their learning, but they also realised that the level of participation was limited and that students were not given opportunities to engage and interact with their peers. The teachers indicated that the lack of resources posed a challenge to their teaching. Some, however, demonstrated creativity by improvising to support their students' understanding. In relation to the national context, the TPs felt that insecurity and uncertainty in Nigerian society harmed teaching and learning by forcing school closures and constraining lessons to the classroom.

My observations and reflections with the teachers helped develop my understanding of their perceptions and context. It became apparent that science teaching and learning was still dependant on rudimentary approaches where teachers taught science as a body of facts that needed to be known and not necessarily questioned or challenged. Despite this, the teachers demonstrated a willingness to consider how to incorporate other teaching approaches that would stimulate more of their students' thinking and participation.

With an awareness that some of these challenges were beyond the teachers' control, I challenged them to think about the question: '*What is in your power to change?*' This became the focus of the PL sessions, as described in the next chapter, where we explored how we could empower students to be active participants in their learning. The gaps identified also formed the basis of the discussions with the teachers about ways in which they think their students could be more involved in their learning process.

Chapter 9

Professional Learning Sessions: Exploring Inquiry Approaches in a Structured Context

In this chapter, I discuss the development and implementation of the PL sessions with the TPs in response to the issues identified in the reflective sessions described in Chapter 8.

Through the reflective process, the TPs became more aware of their practices and demonstrated a willingness to keep improving their teaching approaches. From the reflections, the teachers were able to identify areas they did well, as well as challenges and areas they could keep improving, especially related to student involvement and understanding. From the reflections, too, I became more aware of the needs of the teachers and the approaches they utilised.

Although advocated as a means of achieving the Nigerian educational goals as stated in the NPE, it was evident from these conversations that the TPs had not had opportunities to develop their understanding of constructivist approaches and how they could incorporate them into their teaching. This meant that I needed to rethink how best to support the teachers and had to modify my initial idea of offering and explaining the

5Es inquiry model (see Chapter 4) to supporting the teachers in exploring inquiry-based learning more broadly.

9.1 Designing the PL Process

The PL sessions followed on from the reflective sessions and provided an opportunity for the teachers and I to explore and consider the issues we had identified. The focus of the PL was on strategies that would encourage students to be more engaged and take more ownership of their learning and to explore more learner-centred strategies teachers could incorporate into their teaching.

After discussions with the principal, my original plan to work with the six 'specialist' science teachers was modified to include more teachers. Having primary and secondary school teachers meant the nature of the PL had to be broadened to consider how inquiry could be implemented at both schooling levels and, importantly, to ensure sustainable implementation and collegial support. Seventeen TPs attended the first PL session on the Monday, including two teachers from Guyip School. A second session was held the next day but with lower attendance (12) as some teachers had other commitments. Lunch was provided on both days.

Day one was a chance for all participants to get to know one another, to create a relaxed, collaborative atmosphere through games, and to continue discussions about some of the issues identified during the reflective sessions. We continued explorations and discussions on day two about *what is in our power to change* and how we can meaningfully engage our students. The findings from these two sessions also provided data relevant to the fourth research question: *How can Nigerian primary teachers be supported in order to enrich/strengthen their understanding of effective Primary Science teaching and learning approaches?*

At the end of the first reflective process, as discussed in the previous chapter, I encouraged the teacher participants to think and focus on '*what is in our power to change and how can we encourage our students to be more involved in their learning?*' This question sparked discussions during the PL sessions.

9.1.1 My Approach During the PL Sessions

I adopted a collaborative approach of empowering teachers and to model an interactive session where I facilitated the sessions by supporting and encouraging teacher participation and engagement. This meant that I was not providing all the answers but, through my questioning, challenged the participants as we developed ideas about the issues raised. Adopting such a role was consistent with my planned PAR approach (see Section 4.3.2) and the provision of effective PL for teachers (Bates & Morgan, 2018; Darling-Hammond et al., 2017). I hoped this practical experience would be a collaborative model that TPs could understand and utilise in their classrooms. After the welcome address from the principal, we began with a game that would enable us to get to know each other a little more as a group:

> *RP: You need to think about an adjective. As you introduce yourself, think of an adjective that starts with the letter of your first name. So, I'll start, 'I am lovely Lois.' So, you say hello to the group and say, 'I'm lovely Lois.' So, when grandma [the principal] stands up, she would say something like 'Hello, lovely Lois,' then say her name with an adjective that describes her beginning with the letter of her name.*

After giving this explanation, I asked another TP to explain what I had said for the benefit of those who did not understand it the first time. In doing so, I was also modelling a strategy the teachers could use to assess their students' understanding of an instruction. This was also a strategy that TPs could use to give their students the opportunity to explain a concept in their own words to their peers. Such student explanations could be beneficial to other students, as they can support them to clarify their own thinking (DiGiulio, 2016). Here is what happened when it was the principal's turn to share her name (her pseudonym and real name both start with D) and an adjective:

Principal: Okay, good afternoon, lovely Lois. I am good grandma.
All: [clapping and laughter]
R: Thank you, and then the third person needs to say my name, grandma's, and their name. The last person is it!
P: Okay, good Damaris. Ah, I didn't say my first name.
R: Okay.. yeah, but Damaris starts with D. So, you need to look for something D.
P: Darling?
R: Yes.
P: Darling Damaris.
R: Yes, that works. Yes, darling Damaris. Okay, uncle your turn

The use of titles and respect for authority and hierarchy is very important in the African and Nigerian contexts, as indicated by the principal referring to herself as 'grandma'. However, she spotted that she had not used her first name but the title (grandma) as she was referred to by everyone at the school. She demonstrated a willingness to be addressed by her first name to adapt to the rules of the game. Through this game, a more friendly and relaxed atmosphere was created, with sounds of laughter and chatter amongst all participants. Although I believe respect is a highly valuable attribute, this approach provided an avenue to model how to create a relaxed atmosphere for teaching and learning (Churchill et al., 2018).

9.1.2 Teacher Participants' Role

I encouraged the TPs to adopt an active role throughout the sessions and to engage individually, in pairs, in small and whole group interactions and activities. The TPs not only took part in identifying challenges but in recommending solutions to involve students more in their learning process. My intention was to model to the TPs that for the sessions to become meaningful, authentic, and *ours-centric*, they needed to know and understand their roles throughout the process (Darling-Hammond et al., 2017; Hunzicker, 2011). This was a strategy I hoped they could adopt in their classrooms as they supported and encouraged their students to identify and understand their roles and the need for active engagement.

9.2 Explorations on how Nigerian Teachers can Support Students to Develop 21st Century Skills

As part of the explorations in session one, we watched a video clip of a presentation by Strive Masiyiwa, founder of Econet, one of Africa's largest telecommunication companies, called 'How do we skill up our children for tomorrow?' The video was meant to stimulate our thinking and discussions about what constitute 21st-century skills and how we as teachers can harness our unique roles in supporting our students to develop the knowledge and skills to function effectively in this century and beyond.

The TPs worked in small groups and identified creativity, problem-solving abilities, working collaboratively, critical thinking and being able to share their ideas effectively as skills needed now in the future:

T: In our group, we had creativity because creativity is one of the skills that is needed by our students so that they can develop their mind in creating something new, either in the class and even if they can learn to be creative in their thinking may also bring out some things that are new. Then we also looked at problem-solving; when you have a problem, you look for a solution. You go into more research and also find out. And then finding self-solution to a problem, so when you are confronted with a problem, you start asking questions and look for solutions. Why is that? What is happening? Asking questions to find solutions to your own problems. After finding the problem, then you create means through innovations to solve the problems.

Another group explained their thoughts:

T: For us, we talked about creativity, working together. Today, in any job, you must work together.
R: Yes, so, how can we support our students to work together?
T: Give them group tasks.
R: They need that collaboration.

These interactions led to more discussions about what it means to '*find out*', explorations of various strategies we can utilise to support our students to find out, and various forms of communication and representation of ideas.

9.2.1 The Concept of Inquiry

Through the discussions described above, I followed up on one of the group's responses on the need to '*find out*' as a means of supporting students to take on more active roles in their learning of science and be supported to develop these essential skills. We discussed the fact that students have a natural curiosity and desire to inquire or find out. I then challenged teachers to think about and explain what they thought inquiry meant. After setting the task, I asked if any of the TPs could explain it in their own words, with the same dual purpose as in the first task:

T: You asked for us to think about what inquiry is, and then it does not mean that we should write it down, but we should use an image to represent what we think inquiry means. So maybe think of a picture and then pen it down, and then once everyone is done, we'll explain what we've drawn.

The TPs then drew representations of what they thought inquiry meant and explained them (see the assessment section below).

9.2.2 Collaboration

Throughout the sessions, the TPs had the opportunity to work individually or collaboratively in small groups. Another such instance of collaborative work was when teachers discussed the challenges of doing inquiry in their specific contexts.

The teachers identified *cultural underpinnings*, *safety*, *curriculum*, *assessment*, and *lack of funds and resources* as some of the challenges to teaching Primary Science and teaching in general within the primary school. On day two, teachers continued explorations in small groups to discuss the question '*What is in your power to change as a teacher from the challenges identified*'. The conversations below capture some of the challenges and solutions that teachers shared during the PL sessions.

9.2.3 Cultural Underpinnings

The TPs identified cultural expectations, such as the nature of adult-child relationships and religious and ethnic biases, as possible challenges to teaching and learning science. Some teachers suggested a need to embrace culture while others thought there was a need for cultural reorientations:

T: I see biases as a challenge to inquiry-based learning in the sense of religious and ethnic receptions. It would affect students' objectivity. Now, when you pose a question, instead of being objective, or academical, they may bring up religious or ethnic explanations/views which can affect their understanding.

(Mr Abok's group)

T: Okay, in case of culture— we said that, as a teacher, we use the way of life of those people; you have to value the same things so that you can go along with them. So, you have to be part of that culture, because if you bring a different thing, they may not understand.

(Mr Abok's group)

T: We also had cultural reorientation. We know there is beauty in diversity—Nigeria has different cultures and art—but people need to know at a particular level, culture shouldn't be taken into some aspects of our institutions.

(Mr Peter's group)

T: We said enlightenment of parents and students because they may tell you that science and culture may clash, but one should not affect the other.

(Mrs Obi's group)

TPs suggested the need to embrace and incorporate cultural knowledge and practices into science teaching. They believed that could be done by obtaining culturally appropriate resources that can support students' understanding of science and by engaging parents who have knowledge of cultural practices to share. They further suggested that students and parents could be encouraged to consider how science and culture could complement rather than oppose each other.

Although there is no clear-cut way to address this challenge, it is important to incorporate cultural expectations and indigenous knowledges into science based on the concepts explored (Chen & Tytler, 2017; Ezeudu et al., 2013; Harlen & Qualter, 2018). One of the TPs suggested inviting others in the community with indigenous knowledge and skills to share and work with teachers and students. Inviting specialists in relevant scientific fields could also be beneficial to deepen students' understanding. Being open to parents attending these sessions could help break down these barriers and promote further collaboration (Harlen & Qualter, 2018).

9.2.4 Safety

Safety was another factor the teachers identified as affecting science teaching and learning. The TPs considered safety risks in two categories: natural hazards that could affect students' explorations and the other the national insecurity that restricted the kinds of experiences teachers could provide their students for fear of being trapped in an outbreak of violence:

> *So, I'll think of their safety because of snake or scorpion bites in areas where they collect the soil samples.*
>
> *(Mrs Oga)*

> *You could be on your way to a particular area, and then gunshots can scare you away. How would you achieve your aim?*
>
> *(Mr Abok)*

Teachers discussed some possible solutions, such as:

> *Then, in terms of safety, if you are taking the students for a visit somewhere, then we should ensure we revisit the place by the teacher to find out what are the things that are there before taking the students to ensure that it is safe.*
>
> *(Mrs Sambo's group)*

Some saw video-based learning (VBL) as an alternative to taking students outside:

T: We talked about safety. One of the solutions there is video-based learning. Now we can have videos in our class of instead taking the kids outside to come and see the things outside because when we have the video from there, it can be possible to visualise it and learn.
T: So, something that when students watch others do it, the kids would be interested and then see how it works.

(Mr Bayo's group)

Other teachers felt using videos was also challenging to achieve due to the erratic electricity and internet. Although this is beyond the teachers' immediate scope of influence, they suggested being mindful that students not be exposed to such dangers and the need for safety precautions such as checking the area or equipment before carrying out explorations or experiments. They also recognised a role for improvisation when explorations such as excursions outside of school could not occur for safety reasons. The insecurity of the country had a significant impact on this project, with the length of the PL sessions affected by the curfew and subsequent observations truncated by school closures.

9.2.5 Curriculum

The crowded nature of the curriculum was another area the TPs identified as a challenge to teaching and learning. Teachers believed, however, that this was an area within their power to adjust in their implementation:

R: Anything else within our power to change?
T: Curriculum. As a teacher, when you have a topic and you look at the curriculum content, you now break it down to the level of the children.
R: Narrowing down the curriculum. Yes, let's write it down. Any others?
T: Also, in terms of curriculum, we said the curriculum should be broken down into simpler forms.

(Mr Dachung's group)

The teachers identified the need to '*break down*' or simplify the content to increase student understanding. Another suggestion was to create opportunities for subject integration, and we considered how to achieve this:

R: Maybe other ways of narrowing down the curriculum could be through integration. What does that mean? Integration of curriculum?
T: Join together?
T: To put together.
R: Yes.
T: Integration means bringing all and picking things that connect.
R: Yes. I observed some science lessons where we are looking at measurement. What other curriculum areas could that link with?
T: Maths.
R: So, how can the links be made?
T: Maybe talking with the maths teacher to incorporate some of the measurement ideas from science?
R: Yes, students could be challenged to solve a scientific issue with measurement skills they have learned in maths, or vice-versa.
T: Or even in English.
R: Yes, even English. How?
T: You can ask students to write about their experiences of measuring items
R: Yes, that could be an assessment piece right there. Finding ways to naturally integrate, not trying to force it to connect, but you may find that some content area just connects easily with other subjects, and that is one way to cut back all the expectations for each of these subjects. Let's collaborate.
T: Yes, collaborate.
R: And it actually makes learning more meaningful to the students because they see the value of it.

Through such discussions and growing awareness, the teachers identified the need for integration to fulfil the curriculum requirements. We discussed strategies to achieve this. Apart from narrowing curriculum demands, such integration supports students' deeper or more holistic understanding of concepts explored. Integration strategies not only aid teachers to narrow the curriculum and collect assessment samples but supports students to see the relevance of their learning in other aspects of their education and daily lives (Berry et al., 2018; Fitzgerald & Smith, 2016). This agrees with current research on the need for 'epistemic insight', which is to do with the interaction between different disciplines to develop students' understandings (Berry et al., 2018).

9.2.6 Assessment

Assessment was another challenge identified, and the teachers suggested that having smaller classes would minimise the pressure it imposed:

> *In terms of assessment, we said it is always a problem, and some of the problem that go with this is large population [large classes], so in that case, classes should be reduced, the number of students in the class should be reduced to a minimum size so that assessing them becomes easier.*
>
> *(Mr Dachung's group)*

From this suggestion, I challenged the teachers to think about their class sizes, which were reasonably small with an average of 25 students, except when two classes had to be combined. I asked them to think about ways to make the assessment process easier. As already indicated, most of the assessment strategies I observed were summative tests and exams at the end of terms or years. Teachers were encouraged to think about ongoing assessment strategies. Throughout the PL sessions, I modelled the use of ongoing assessment in my questioning and data collection process. One such instance was when I asked teachers to draw a representation of what inquiry means to them (see Figure 9.1).

Figure 9.1 Sample of teacher representations of what inquiry means

The teachers explained their drawings and how they represented inquiry to them. I explained how such representations could serve as authentic assessment pieces within the classroom by encouraging students to share their thinking.

Most of the teachers thought inquiry had to do with finding out and that this could be one of the solutions to engaging students. The teachers used words like *curiosity*, *finding out*, *asking questions, discovery, uncertainty*, and *problem-solving* to explain their representations of inquiry:

> *Inquiry is to get something you don't know. Maybe you've seen something, and you want to know what that thing is. First of all, you have to think, how will I get it? I have a drawing of a stick man who has seen a box on the ground, and he wants to know what is in the box? And through the process of inquiry, he uses his eyes to see, and then he is now thinking, what thing should I use? That's the process of inquiry.*

Another formative assessment strategy I shared was the Y-chart (see Figure 9.2). Using this, teachers identified what they thought their science class '*Looked Like*', '*Sounded Like*' and '*Felt Like*'.

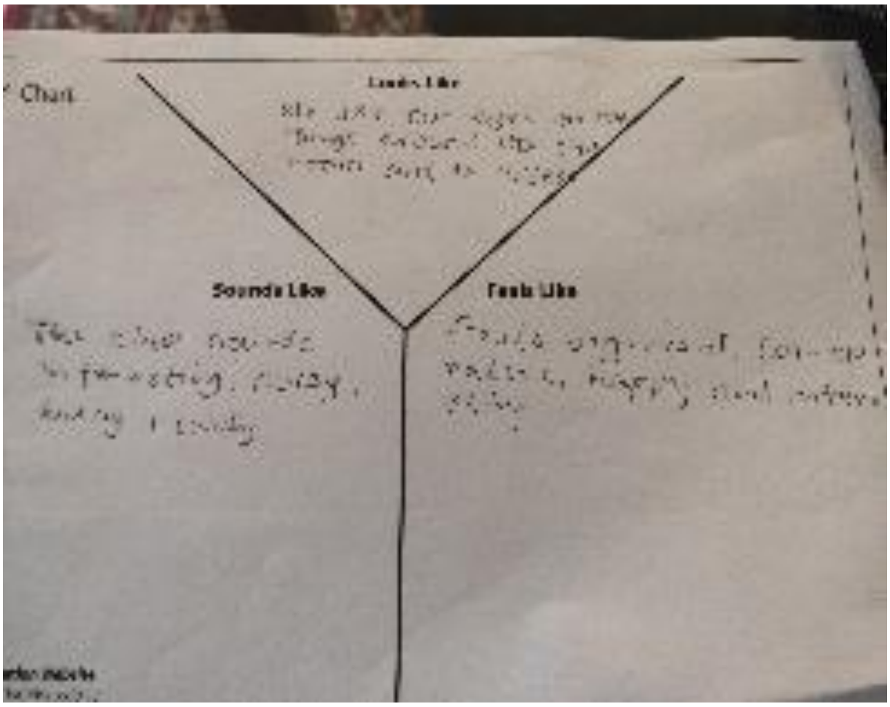


Figure 9.2 Use of a Y-chart

I proposed the Y-chart as a diagnostic assessment tool for discovering what students know or think about a topic or concept. Another assessment strategy that we discussed and utilised during the session was the TWLH chart— 'what we *Think* we know, what we *Want* to know, how we've *Learned* and *How* we know.' I introduced and demonstrated the TWLH chart when I asked the teacher participants, '*How do you think you can do inquiry within your classroom?*' After explaining to teachers what each section meant, I challenged them to write their suggestions of how they thought inquiry could be implemented. I encouraged them to give their students opportunities to make predictions about the topic or concept being taught because when students make such predictions, it gives an indication of what they already know and think.

We also explored the use of observation checklists where teachers can tick off their students' achievements or progress against the assessed criteria.

9.2.7 Funds and Resources

TPs highlighted the challenge of inadequate resources and funding. They believed that to effectively carry out any practical activity required the provision of resources and funds:

> *T: Then secondly, the practical approach sometimes demands funds, so if we don't have funds to get some certain materials, then you can't effectively do your work, and all these are challenges to inquiry.*

Teachers recognised improvisation as a possible solution:

> *T: So, we said we should employ some kind of improvisation within our local environment.*
> *T: We suggest putting pressure on the school to provide lab equipment. I think it would be helpful.*
> *T: We had to group the students in small sizes to work with the materials and then share.*

Some considered the option of asking students and parents for support in the provision of certain materials, such as recyclable items needed for a lesson. Some of the TPs were already doing this, and all were encouraged to keep doing so or to incorporate it into their practice.

After exploring the levels of inquiry and having further discussions on how we could carry out inquiry in our classes, the teachers worked in small groups to present a short role-play depicting how they were going to implement any of the inquiry strategies in their classes. Each group had a chance to present and receive feedback from the other group members and me. This was another way of modelling student-generated representation of their understanding, as well as peer feedback as an authentic assessment strategy.

At the end of day two, I asked the TPs to consider what strategy they wanted to try implementing during their next lesson with their students.

9.2.8 Teacher Reflections on the PL Sessions

After the PL sessions, teachers provided their thoughts about the process by completing a short evaluation form that focused on the relevance of the PL to their practices, what they found useful, what they planned to implement in their lessons, what other areas of professional learning they wanted to explore, and suggestions on how to improve future PL sessions. A copy of the evaluation form is attached as Appendix K.

In summary, the TPs found the sessions highly relevant, although a majority indicated that they were somewhat familiar with some of the ideas presented. The feedback showed that the TPs had probably heard about these approaches but had not had opportunities to fully engage in seeing how they could put them to use. This is consistent with one teacher's comment that the school's management had wanted them to adopt more student-centred approaches. All the teachers found the sessions helpful, with many hoping to implement strategies such as group work, more open-ended questioning, encouraging student thinking and participation through role-plays, and using TWLH assessment strategies.

The teachers all indicated that they would like to attend more sessions to further explore inquiry-based strategies and hoped that I could conduct them. They also hoped that the sessions could be extended.

9.3 Researcher Reflections on Collaborative PL

In this section, I discuss the key ideas from the PL sessions described above and consider their impact on the TPs. This discussion considered what constitutes effective Professional Learning and literature on contemporary approaches to IBL in general, with a focus on science teaching and learning. I further discuss the systemic problems the TPs identified as affecting their practices, as well as how I encouraged the teachers to consider '*what was in their power to change*' as a way of navigating or working within these constraints.

9.3.1 Theoretical Basis of the Professional Learning Sessions

From the initial classroom observations and reflections, it was apparent that the teachers had heard about the need for a more student-centred approach to teaching and learning but were not aware of how to implement them. Although I had a plan of what I thought we could cover during the PL sessions, I was open to redesigning the sessions based on the observations and reflections, which clarified the teachers' needs and how I might support them to implement a more learner-centred approach.

Consistent with the existing research, the structure of the PL sessions was interactive, and this was mainly to model to the TPs how they could involve their students more in their learning. I adopted the role of facilitator, which allowed me to guide the discussions but also meant that the teacher participants were actively involved in identifying and deciding how inquiry-based learning could fit within their immediate context. Garet et al. (2001) advocate for such active and collaborative processes that encourages participants to take ownership of the learning process in PL. Other positive aspects of the PL structure were that it was conducted in the teachers' environment and that ongoing classroom support was provided as the teachers tried to implement the new approaches they had chosen. Traditional workshops and PL sessions outside the teachers' environment have been criticised for not providing the time, and support teachers may need to increase their knowledge or implement change in their practices (Bates & Morgan, 2018; Garet et al., 2001). Such traditional workshops may have been what the few teachers that said they attended PL from the questionnaire experienced as their attendance of PL did not seem to impact their practice. Adopting a mentoring approach to PL has been found to support teachers in making connections with their classroom teaching methods that are sustainable in the longer term (Ajani, 2018b).

Guskey (2002) argues that the effectiveness of teacher PL is linked to the evidence teachers feel they obtain on the impact of the PL on their students' learning. As reported in Chapter 10, this was evident in my study, where teachers commented on the positive outcomes the new strategies they were implementing were having for their students. The positive student outcomes were a motivation to keep trying these same strategies.

9.3.2 Mirroring the Nature of Science and Scientific Inquiry

Although the nature of science is broad and varied, the definition I adopted for this study (see Sections 2.5 and 3.6) reflects that science exists in everyday life and culture and that this awareness leads to the development of scientific knowledge, derived from observations, experimentation, and creativity, not just from following procedures. It is the realisation that scientific knowledge is not absolute but subject to change and, in some cases, is unpredictable (Bartos & Lederman, 2014; Lederman et al., 2013). It is a process of scientific inquiry that seeks to find answers to questions. It begins by acknowledging the prior knowledge and beliefs of individuals and involves problem-solving, imagination, creativity, perseverance and working collaboratively to generate explanations from the evidence gathered (Bartos & Lederman, 2014; Llewellyn, 2014). Throughout the PL in this study, my goal was to model the nature of science while supporting teachers in developing IBL strategies they could use in their teaching contexts.

9.3.3 Identifying and Addressing Teachers' Needs

The initial phases of observation and reflection revealed the needs of the TPs. During the PL, it was important to review the strengths and challenges identified. During this process, all TPs at the PL sessions had the opportunities to discuss the strengths and challenges they faced in their practice and, most importantly, to come up with strategies to address the challenges. The purpose of the PL was to model the need to commence inquiry by identifying the needs of the students (*what*) and the purpose of learning (*why*) and to make these clear to students. Students are then involved in investigations (*how*) to find solutions to the issues identified. This process of identifying the '*what'* is consistent with the literature, in that every student has some pre-existing knowledge or ideas and that learning needs to commence by eliciting what these ideas are to detect the need or gap (Llewellyn, 2014; Skamp, 2018). The process of elicitation of students' ideas may further reveal the alternative conceptions the students and teacher may hold that may need to be addressed. The identification of pre-existing ideas also aligns with the NoS, which seeks to support students to understand that:

> science is about people and how they have investigated our world using particular processes and methods… like scientists, they can make claims about what they observe and be encouraged to collect evidence to support their claims and discuss their interpretations with their peers and teachers. (Skamp, 2018, p. 79)

9.3.4 Breaking Down Barriers: Creating a Positive Classroom Environment

The high value of respect and the hierarchical nature of classrooms in Nigeria, where the teachers are viewed as sources of knowledge, was apparent in my observations and reflections with the teachers. Therefore, at the start of the PL, it was important to model a less didactic classroom environment to encourage the TPs' participation, engagement, and learning (Darling-Hammond et al., 2017). The PL commenced with a game involving all participants, including the principal. This was an opportunity not only to stimulate cognitive thinking but for the TPs to share about themselves in ways that reduced the hierarchical constraints and encourage mutual respect (Llewellyn, 2014). The TPs participated in another ‘warm-up’ activity in small groups on the second day of PL, and this was another chance to demonstrate the need for a positive classroom environment that was not only relaxing but also stimulative of thinking. TPs were encouraged to make a deliberate effort to create a positive, trusting classroom environment where students feel safe and encouraged to freely share their ideas (Skamp, 2018).

9.3.5 Teacher and Researcher Participant Roles

Through asking open-ended questions such as ‘*What does inquiry mean to you?*’ or ‘*What is in your power to change?*’, I challenged the TPs and provided them time to think through, create and share their ideas. As a researcher participant, I had the opportunity of going around to chat with the TPs about their ideas as they wrote or drew representations before they shared them with the whole group. I adopted a facilitator role and modelled how, in the processes of inquiry, the TPs could take on this role in their classrooms (Chen & Tytler, 2017).

Involving the student more in their learning process commences with the recognition that the student knows something and has something to offer, identifying gaps and providing experiences that bridge them. This agrees with Vygotsky’s (1978) Zone of Proximal Development, which specifies that learning experiences should be within what students can achieve independently and things they can do with support from their teacher and/or peers. Throughout the PL sessions, it was important for me (the RP) to support the TPs to think through and share their ideas on the different topics explored in the sessions, focusing on their practices and exploring what would work in their context.

Such interactions demonstrated that, in the classroom, the active participation of both the teacher and students as learners is crucial, with the teacher demonstrating a real desire to know what their students know and to support them to develop their ideas to enhance their learning (Bybee, 2014; Skamp, 2018).

9.3.6 Questioning and Assessment Strategies

All the TPs asked questions of their students during my observations, but they were almost exclusively closed-ended questions. Although it may be impossible to completely avoid closed-ended questions during classroom interactions, such questions typically foreclose on answers that reveal or require deep thinking. Instead, it is necessary to have a balance in the use of closed and open-ended questions (Harlen & Qualter, 2018). I deliberately designed the PL sessions to demonstrate the importance of asking open questions to encourage more active participation. Questions such as: '*What does your classroom look like, sound like or feel like, what does inquiry mean to you, or how can we create an environment for inquiry?*' These types of questions prompted TPs to think, then share and discuss their ideas. TPs were encouraged to think about how they could change the structure of their questions to provide students with the time to think and respond meaningfully.

Challenging students to ask their own questions was another way to support students' active involvement. As observed and discussed with the teachers, when students asked questions, it was mainly about processes, such as whether they could write, copy notes, or what book to use. The TPs did ask whether their students had any questions during their lessons—such as by asking "*are we clear?"*, which students answered in the affirmative, or, at the end of the lesson, "*any questions?*", which they typically answered ‘*no*’. Encouraging students to ask questions is important, not just for participation but to support their understanding of the content explored. I modelled how to encourage such questioning in the PL using a graphic organiser such as the TWLH chart. The TPs were encouraged to write questions they may have about IBL. Through this modelling, TPs were supported with a practical way to actively encourage and invite students to ask questions.

This shift in thinking is potentially very significant, as it may be seen as contrary to the cultural dynamics of adult–child or teacher-student relationships in African, and more specifically, Nigerian contexts. As one of the teachers put it: “*listening is one of our culture, where children are not supposed to ask too many questions*.” However, while embracing these cultural norms, it is also important to consider students’ natural curiosity, as the TPs also identified (Harlen & Qualter, 2018; Skamp, 2018; Smith & Fitzgerald, 2018). TPs suggested that they would harness this natural curiosity and encourage students to ask questions by giving them more time and encouraging them to be respectful.

Assessment practices used by the TPs were mainly summative, which is consistent with the systemic nature of tests and exams in the Nigerian educational model. The closed-ended questions on their tests and exams mainly demanded students’ recall and recapitulated what they had learned without elaboration. The use of formative assessments did not seem to be highly valued, and these approaches were not used. This summative assessment practice seemed contrary to the documented policy considering that one of the goals of Nigerian Basic Education is to “*lay a sound basis for scientific, critical and reflective thinking.”* The place of formative assessments then needs to be prioritised as it is through such assessment strategies that teachers are able to support students in the learning process through ongoing interactions and observations (Harlen

& Qualter, 2018; NERDC, 2013, p. 7; Panizzon & Keast, 2018). Through these formative assessment processes, students are encouraged to take ownership of their learning through self and peer reflections on their progress and learning. During the PL sessions, I modelled formative assessment strategies such as the TWLH chart focusing on the 'LH'—what we '*Learned*' and '*How we know*'. We also modelled peer assessment strategies when the teacher participants provided feedback to other groups after the role-plays they presented. Further, the TPs engaged in representing their ideas in various forms through drawings, writing, role-plays, and discussions at different times during the sessions. These strategies for representing their ideas are supported by the science literature as ways to support and improve student learning (Kenny & Cirkony, 2018a; Waldrip & Prain, 2017).

9.3.7 Collaboration

Throughout the sessions, it was essential that I support the teacher participants to see the value of students working and learning with their peers. This was necessary based on the observations and reflections with the teachers about how students could be more involved in their learning. Again, this meant a shift in the teacher's role from the sole source of knowledge to the facilitator, one who creates an avenue for conversations to occur and challenges students' thinking, supporting them in their exploration of deeper learning (Hume, 2016).

We explored strategies on how grouping could occur. One approach we used was dividing the participants into small groups modelling how students could be grouped based on mixed ability (teachers of science with teachers of other subject areas) or similar ability (teachers of a particular grade or subject area). At different moments in the PL, teachers teaching the same specialised area worked together to discuss how they could incorporate IBL. Then, teachers were regrouped so that teachers teaching different subject areas shared their ideas. We also explored random groupings, such as TPs being counted off into four groups. During the sharing of ideas, I suggested that the TPs could choose one person to share on behalf of the group but mentioned the need to sometimes assign roles to students to clarify who was responsible for certain aspects of a task when working in a group (Aubusson et al., 2019; Skamp, 2018).

During the sessions, we also used the *Think–Pair–Share* (TPS) strategy to encourage active, collaborative engagement. Through some of the questions explored, TPs thought and wrote their responses, discussed their ideas with the person next to them and then shared their ideas with the whole class. Working collaboratively during the sessions enabled the TPs to explore peer learning by challenging them to view teaching and learning not just as a teacher-student interaction but also to consider how students' learning can be enhanced through interaction with their peers (Panizzon & Keast, 2018). This model is represented in Figure 9.3 below.

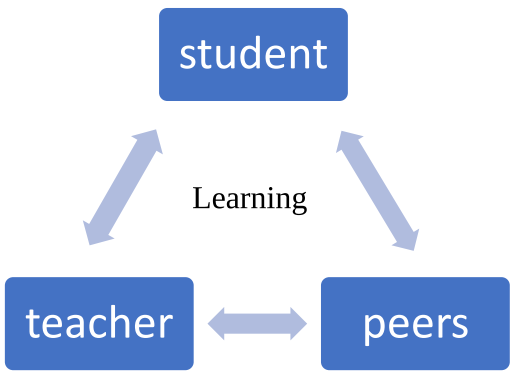


Figure 9.3 Teacher-student–peer learning

9.4 Summary

The PL sessions spanned two days, with teachers from both schools in attendance. The sessions were straight after school, so food and drinks were provided. Establishing a positive environment for interaction was necessary to break down barriers, so we began each session with a game. The teachers worked individually, with a partner, or in small and whole-group arrangements to discuss their ideas about '*what was in their power to change*' as they considered how students could be more actively engaged in their learning process and better supported to develop inquiry skills. The TPs considered what inquiry means and how they could apply inquiry-based learning approaches in the Nigerian context.

Over the two PL sessions, the TPs and I identified challenges to implementing inquiry approaches in the Nigerian context and, more specifically, within their immediate context and suggested strategies to overcome or circumvent them. Some of the challenges were national insecurity, the crowded nature of the curriculum, and the clash between students being encouraged to ask questions and their traditional cultural position of merely listening.

After identifying these challenges, I encouraged the TPs to think about '*what was in their power to change*' within their teaching practice to implement inquiry.

Some of their solutions included incorporating cultural knowledge and practices, curriculum integration, improvisation, use of diagnostic and formative assessment, and sourcing recyclable items for practicals, including from students and parents. The TPs believe that it is vital to support students' natural inquisitiveness to ask questions while encouraging them to be respectful. I further challenged the TPs to consider what strategy they wanted to trial in their next lesson.

The TPs' willingness and engagement during the sessions were positive and encouraging. They actively participated in discussions, which often continued until I (as facilitator) moved the session on due to time constraints. They were eager to try the new approaches in their classes as soon as they could. The challenges the teachers highlighted were familiar to me from facilitating the PL sessions, including unreliable electricity, lacking a sheltered place for the generator, heavy rainfall, and political unrest. The lack of resources was also something I had to deal with during the sessions and meant that I needed to think on the spot, make changes when things were not working, and improvise. It made me empathise with the teachers even more in their task of implementing inquiry-based learning under such conditions. These experiences during the sessions also made the learning authentic, as the TPs, despite these challenges, felt empowered and ready to trial at least one approach.

At the beginning of the PL and throughout the sessions, I urged the TPs to think of a specific area or strategy shared in the PL that they could implement. Chapter 10 describes those experiences.

Chapter 10

Professional Learning Outcomes: Small Shifts in Thinking and Practice

In this chapter, I discuss the second cycle of the PAR phase. I present my observations and a summary of my interviews with the four Science teachers and one Social Studies teacher. Each had chosen to implement at least one inquiry-based strategy from the PL sessions in their classrooms. One teacher, Mr Abok, had to pull out. I will present these findings as vignettes for each teacher.

A summary of the range of inquiry strategies the teachers chose to focus on, which included collaboration, student investigations, questioning, and demonstrations, is presented in Table 10.1. I supported each of the teachers during the lessons and afterwards as we reflected on positives and areas for improvement. These vignettes show the small but meaningful shifts the teachers made in their thinking and practice.

Table 10.1 Teachers and Chosen Inquiry Strategy after PL

Teacher	**Inquiry Strategy Chosen to Implement after PL**
Mr Dachung	Collaborative group work and student investigations
Mrs Oga	Collaborative group work and student investigations
Mr Obi	Questioning
Mrs Adamu	Questioning
Mrs Laraba	Demonstrations

10.1 Collaboration and Student Investigations

Two of the teachers, Mr Dachung and Mrs Oga, decided to focus on collaboration and student investigations as the aspects of inquiry they planned to implement.

10.1.1 Mr Dachung's Lessons

I observed Mr Dachung's lessons in two different classes, one his Primary Four and the other his Primary Five.

Primary 4 Lesson

Mr Dachung began his lesson on measurement for his Primary Four students by reminding them of their previous learning on measurement in Primary Three. He then explained how that day's lesson would build on what they already knew. He informed the students that they would carry out some simple measurements using rulers that he had asked them to bring the previous day. Some did not have their rulers, but they were able to share and participate in the activities.

He told the students that they would work in groups and reminded them how to do the measurements. Mr Dachung spent a lot of time talking about how to measure using the ruler, with the students repeating some of the steps he had explained. He still focused on students folding their arms and watching him as he demonstrated how to measure with the ruler.

After the explanations, he told them again about the group work. He then explained that they would move seats and started telling them to turn their seats around to be in groups of four. At this point, I asked if he wanted me to help with the arrangement.

I assisted the teacher in helping the students to move their desks with their integrated seats, which were heavy.

Figure 10.1 Students working in small groups.

The process of rearranging the classroom was rather rowdy as the students were excited to help with moving the desks. Eventually, though, Mr Dachung explained the task:

> *T: Okay, so every group should get a copy—one piece of paper. Get a volunteer. Get only one piece of paper. Sshh! Write the names of the members of the group from the beginning. Shhh! Bring out the piece of paper for recording. Good! Now, only one for your group. Why are you making noise there? Shhhh! Then get someone who will be writing from your group. You are making noise; I don't like the noisemaking. Alright, shh… All those that are writing for you are secretaries, but you will also participate in what you are going to do. So, who is your secretary here?*
>
> *S: Edu.*
>
> *T: Who is the secretary here?*

S: Abi.

T: Who is the secretary here?

S: Anyanwo.

T: Fold your arms and stop making noise. I have not given you what to do. Fold your arms, keep all what you have down… keep them on the desk and then fold your arms. The secretaries, you write all the members of the group, write the names of all the members of the group.

The class continued being noisy as Mr Dachung gave his instructions, and he kept saying, "*Sssh, be quiet!*":

T: You are making noise; did I say you should make noise? Fold your arms. You are blocking your secretary; just be quiet, listen. I want us to do it fast and all of you must what…? Contribute. And you contribute to what you are going to do in your group okay. So, I'm going to give you the object that you are going to use. Shhh… you are making noise here… so we have, okay… make a title at the top of your paper. Write group A here. Group B write it there at the top of the paper. Group C, write Group C above your names. Group D, Group E, Group F, Group G. Okay, have you done that?

Once this was accomplished, he gave them various items, such as textbooks, novels, and the teacher's register book, and told them they were to measure the length and breadth of each one. He drew a table on the board to show them how he wanted them to record their results. He encouraged them all to participate, take turns carrying out the measurements, and do the measurements more than once until they were all in agreement before the group's secretary recorded the results.

Most of the students were able to carry out the tasks, although, in some groups, some of the students did not seem involved and just watched the others. Mr Dachung gave reminders and asked them to allow others to do the measurements to confirm the result. Throughout the task, Mr Dachung was concerned about the noise levels, even though the students were doing as they were told and talking only about the task:

T: Don't allow one person to measure throughout. Make sure the measurement is in agreement with all. Make sure you contribute. Are you listening? Quiet here. Ask the members of the group: is it okay? So Serina, how many centimetres is this? All of you should deliberate and have an agreement. All of you should agree together. Shhhh! No noise… Not one person; don't allow it just for one person. All must participate. If you measure the length, the other person will measure the breadth. Are all of you agreeing? You must agree, oh!
S: Yes, sir.

When the students had finished, he invited each secretary to submit their paper with the measurements recorded and to return the books he had given them. He then asked the students to return their desks to how they were arranged earlier in rows. He did what seemed like a roll call of the students' names in each group and then asked them to clap for themselves in the special way that he had taught them:

T: Okay, can we clap for ourselves?
S: [clapping]
T: Okay, this clap is not enough! Okay, I'll do it group by group, okay?
S: Yes!
T: When I say 'Group A', all other groups should clap for Group A. Group A members should not clap because I'm thanking them for doing well. Group A, clap for Group A!
S: [clapping]
T: Okay, pam pampa pam, bravo! That's what I want.
S: Pam pampa pam, bravo!
T: Group B!
S: Pam pampa pam, bravo!
T: Group C! Now all of us should clap for ourselves.
S: [clapping] Bravo!

I did not have a chance to discuss the lesson with Mr Dachung straight after he had finished this lesson because he had another lesson with his Primary Five students. However, I made a note to have a reflective conversation about the lesson at a time that was convenient for him. It was clear from the lesson that his focus was to encourage his students to work in small groups to measure the items he had gathered and to record their findings.

Primary Five Lesson

Mr Dachung's Primary five class had been exploring the topic 'Pollution', and this lesson was a follow-up on what they had started discussing. He did a review of the previous lesson by asking the students the types of pollution they knew and then explained that they would be doing some activities to explore the different types:

> *T: What are the different types of pollution we have as we learned that day? Peter?*
> *S: Air pollution.*
> *T: Yes, we talked about air pollution. Musa?*
> *S: Sand?*
> *T: Are you sure?*
> *S: Wind?*
> *T: Wind pollution. Charles?*
> *S: Water pollution?*
> *S: Sir?*
> *T: Yes, Nanpit?*
> *S: Land pollution?*
> *T: Okay... land pollution. Zainab?*
> *S: Noise pollution?*
> *T: Okay, we said basically we have four types of pollution. That's what we were looking at right in our last class. For mentioning the types of pollution, we have; can we clap for ourselves?*
> *S: [clapping]*

He explained that he was going to divide them into groups and wanted each member to participate:

> *T: So today we are going to do something in relation to these categories, alright? And listen to these rules.*
> *S: Eeeh! [Students make a loud sigh and looked excited]*

T: Sit upright and listen to these rules all of you. I am going to share you into groups. Listen, don't be making noise. I'm going to share you into groups and the groups you will be, all of you must participate. How do you participate? You are going to participate by observing what we are doing in the class and also thinking very well, and then you give contribution. In each of the group you have a secretary, there'll be a secretary for each group. Are you getting me?
S: Yes.
T: For each group there would be a secretary to write things and report what you are going to do in your group. Then, after that, again, whatever group you belong to, make sure you participate. Okay, you contribute the answers or whatever you need to report to your group. So, all of you should open your mind and learn. There are some you are going to do by observation and some of it you will reason to get it. Okay? So, I'm going to share you into groups.

When Mr Dachung began explaining that they were going to do something different and that he was going to divide them into groups, the students seemed excited based on the expression on their faces and the exclamation of *'Eeeh!!'* This could also have meant that they were wondering how this lesson was going to progress, as it was something that they had not experienced before. He encouraged them to participate, think and contribute to their group. He explained that they would be observing a few items, and they need to reason to decide where it belongs.

Mr Dachung asked them to number off from one to four and pointed to designated places where the groups of ones, twos, threes, and fours should go. He also asked them to turn their desks around. Once again, I assisted the students in forming groups and moving their desks so that they faced each other. Mr Dachung reminded the students to select a secretary responsible for recording the findings of the group. This choice went relatively smooth in this class as Mr Dachung went around to each group to confirm who they had chosen. He instructed the secretaries to write the name of their group (Group A, B, C or D) and the names of the members. Mr Dachung had drawn a table on the board showing how he wanted the students to present the results, which he asked the secretaries to copy onto their papers:

> *T: So, as I told you, you must contribute to your group. Make sure if the first person gives the answer, for the second activity, another person can give the answer. Let us continue that way; you must observe, and then you write your answer. So whatever activity we are going to be doing, some of the activities you may not be sure about, I'll mention their name, and you tell us where they belong to. So, make sure you record it. There are some of them that may belong to two. Some of them may belong to what?*
> *S: Two.*
> *T: Or even three. Okay, so, what you are going to do here is to only tick where a particular pollutant belongs to. Are we clear?*
> *S: Yes, sir.*

Mr Dachung consistently reminded students to stop making noise, to work in agreement and to stop arguing. I wondered, though, if this was limiting the students' ability to discuss among themselves and give reasons for their thinking. At any rate, the noise the students were making was caused by their discussions about the activity. I made a note to discuss approaches to managing student conversations in our later reflective session.

The class continued to observe and sometimes feel the pollutant samples Mr Dachung had brought to class to determine which category of pollution each pollutant contributed to. It was interesting to note how Mr Dachung had made a range of items available for the students to interact with: ashes, chicken dung, bathing water in a tub, and a drum (shown in Figure 10.2 below). He seemed to have taken safety precautions when he asked the students to smell some of the pollutants, which he carried from group to group.

Figure 10.2. Mr Dachung showing various pollutants

After observing about 10 different pollutants and placing them in the category of pollution they thought was right, Mr Dachung asked the students to go over the work and make sure they were "*in agreement*" before submitting their papers.

10.1.2 Reflection with Mr Dachung on Group Work

After the lesson, Mr Dachung and I had a chance to discuss his lessons and trial of group work. Mr Dachung felt that his students had been involved and had collaborated during the lessons:

> *T: Honestly, there's a zeal and a spirit of participation in the group by individuals, unlike the individual work that they are used to. So now they want to participate, and they are happy, and they are working together, and with that, most of them that are not even sure of themselves, they can easily learn from others because they are participating. Sometimes they are forced to do it, so they learn. So, I think that's what I have observed.*
>
> *R: Well done!*
>
> *T: Thank you.*

He further explained that it was a good opportunity to share resources that were sometimes not available to each individual student. His concern about the lesson was the noise in the class. He thought the noise levels increased, mainly because he thought students were arguing about who was to do what and about some not having a chance to participate. He also thought the rearrangement of desks and chairs made it noisy. He explained that he noticed that some of the students were a little reluctant to participate at first but later engaged with the activity. He hoped that to improve the lesson, he could encourage students to work more quietly and make changes to the group selections, as he could tell that some students' personalities were clashing.

Based on Mr Dachung's lessons after the PL sessions, with a focus on small group collaboration and the manipulation of resources by students, I observed the classroom being lively. Students were engaged as they chatted, and from the sounds of laughter and the smiles on their faces, Mr Dachung seemed to have established a positive environment compared to the rather rigid format they had been used to.

Throughout the process, Mr Dachung seemed to have struggled with the noise level, but the students appeared to me to have been discussing the tasks. After reflecting on these lessons, and based on our discussion, Mr Dachung and I agreed that one area to work more on was strategies to manage noise during group work activities, as well as how to smoothly transition from small group tasks back to whole-class interactions. I challenged Mr Dachung to think about the noise and to consider whether it was directly related to the tasks he had assigned. To manage the noise levels further, we discussed that he could teach the students how to use 'inside voices' when working in small groups. I explained the use of a visual prompt to help the students monitor their volume. Mr Dachung seemed excited about his trial of group work and was willing to incorporate the suggestions into his next lesson plans to further improve his use of the strategy.

Another area I mentioned to Mr Dachung was his review of content at the start of the lessons. I asked him what he thought about the process. He thought that it was good that the students could mention some things they remembered from the previous lessons. I encouraged him to give more opportunities for them to explain what they understood from the last lessons and used his Primary Four lesson as an example. I explained that since he had already taught them about measurement in Primary Three, I thought that a quick review should have been adequate, and the review could have been such that students explained what they understood instead of him telling them how to measure. This links to how he could use open-ended questioning to challenge them to share their ideas. He responded, "*Ah, yes, maybe ask, how do we use the ruler to measure?"* I agreed that such questioning would encourage students to show him what they understood, and he could assess and support their progress that way.

It was great to see that Mr Dachung had assigned some roles, but he felt that students were arguing about who would do what. We discussed that to minimise the arguments, he could assign more roles such that each student had a role they felt was significant. Through his own observations and through the reflections, Mr Dachung was able to identify strengths and areas to keep improving. I encouraged him to remember that this was a new experience for him and for the students and that they needed more practice working in groups to improve. I encouraged him to give himself and the students time to adjust to this new approach.

10.1.3 Mrs Oga's Group Work Lesson

Mrs Oga also chose to trial group work with her Primary One class in a lesson about the environment with a focus on soil types. This was part of the curriculum for that year level. Before the lesson started, Mrs Oga had asked the students to bring in some soil samples. When I got to the classroom, the desks with seats attached had been turned around, and students were sitting in groups. These groups were rather large, with about five to six students each. They were sitting facing each other, which was different from the rows they had sat in before.

After welcoming the class, she gave instructions for one person from each group to come and take some sand. Students rushed to her desk, trying to collect the soil samples. This instruction was rather general and broad for students at this age, where everyone would naturally want to be the one to go up to get the sand sample. Mrs Oga quickly realised this was a challenge and chose students from each group to come to her desk.

The students collected three different soil samples, and she asked them to keep them separately on the desk. Soon she faced another challenge:

S: Aunty, they are touching the sand.
T: Just leave it there, alright? All stand! I don't want you to touch it, okay?
S: Yes.
T: Sit down.

Mrs Oga called the students' attention by asking them to stand and gave instructions for them to stop touching the sand until they were told to. It was only then that Mrs Oga seemed to realise that she had not taken safety precautions or explained it to her students. I made a note in my journal to discuss this with her during our reflections. After this, though, the students waited patiently to explore the soil samples (see Figure 10.3).

Figure 10.3 Students collected soil samples before exploration

Mrs Oga continued the lesson by asking where they had fetched or collected the soil sample from. Students gave a variety of descriptions of where they had done so with some saying from their farms, from the road and the garden:

T: Last week, I asked you to bring these sands, so who can tell me, where did we get these sands from? Yes, where did you fetch them from? Yes?
S: From farm.
T: From your farm?
S: Yes.
T: He said he fetched it from his farm. Yes, who else? I said you should fetch three types. Where did you get the other sands from? Yes?
S: Outside?
T: Where? Outside your house?
S: Yes.
T: Good.
S: On the road.
T: Yes, the same with outside. Where else do you fetch this one?
S: Garden.

Mrs Oga gave students opportunities to examine the soil samples, and she moved around the classroom, engaging in conversations with each group based on the tasks she gave them.

Figure 10.4 Mrs Oga interacting with the whole class and with small groups

Mrs Oga continued the lesson by telling the students that she was going to add water to the soil samples, and they were going to mix it and tell her what they thought about it. This seemed like a fun exploration for the students; they were all excited and wanted to mix. Soon after the soil mixing had started, though:

> *S: Aunty, he poured water on his face!*
>
> *T: Allow one person to mix. Is it all of you that are mixing? I said you should allow one person to mix it. Just one person. Have you done that?*
>
> *S: Yes.*
>
> *T: Now I'm going to pour water to the rest. [goes around pouring water] Remove your hand.*
>
> *S: Allow one person to mix.*
>
> *S: Aunty, see these children?*

It was after the muddy face incident and similar reports that Mrs Oga instructed the students to allow one person at a time to do the mixing. This showed that Mrs Oga had not explained the safety precautions the students needed to comply with while examining the samples; matters Mrs Oga and her students could have identified and agreed on as a class (Wilcox et al., 2015). This classroom experience also highlighted the challenge of carrying out small group activities when teachers do not have the help of other adults.

It was great to see Mrs Oga adjust her practice to encourage group work. I observed, however, that although students sat in small groups and interacted with the soil samples, the conversations that occurred were still between the teacher (Mrs Oga) and the students. Students could have been provided opportunities to discuss their exploration amongst themselves. She could also have asked each group to share their findings, making it a collective process instead of asking individual students. This may have helped the students to feel more confident to share their groups' responses instead of just the one student, as Mrs Oga explained:

> *T: So, what is the difference between that one and the one you fetch from your farm? Look at it very well and tell me. Observe it and tell me. This one and this one; what is the difference? What can you say about it? Eh? Look at it very well. I'm not talking to only one person; all of you look at it. Are they the same?*
> *S: No.*
> *T: Stand up and tell us how? Which one is not smooth?*
> *S: [points]*

Towards the end of the lesson, one student wanted to wash their hands, but Mrs Oga directed the class to wait and commiserated with them by showing them that her hands were dirty, too. Soon all the students were saying, "*Aunty, see my own?*" pointing to their dirty hands. She assured them not to worry and that they would all wash their hands soon. Mrs Oga did not just instruct and watch her students touch and manipulate the sand to mould it; she took part in the process. This helped the students to continue the learning process; they were in it together, dirty hands and all.

Mrs Oga then reviewed the types of each soil sample by pointing and asking students if they remembered the names. In this discussion, some students were still unsure what the names of the soils were. When a student finally gave the correct answer, she would ask the other students to repeat the name a couple of times.

Mrs Oga proceeded to write the topic ‘Types of Soil’ on the board and asked the students to read it. She asked how many soil types there were. Some students answered “*three*”, and some said “*four*”. She then asked them to count the samples they had on their desks. Some said “*four*” because they had moved some of the soil from the original pile as they were touching and moulding it. They ultimately agreed there were three, and she wrote that on the board, then asked them to tell her the names of the three types. As students mentioned them, she wrote the types on the board and asked the students to clap for themselves.

10.1.4 Reflection with Mrs Oga on Group Work

Talking with Mrs Oga about her lesson, she said excitedly that the lesson went well, and she thought the students participated well:

TP: I think the students participated really well, as they were the ones that brought all those items. I also think that being able to touch and feel the different soils helped them to describe them.
RP: So, in terms of your focus after the PL, what can you say about?
TP: Well, I was focusing on group work and how the students can be involved more. So, in that aspect, I think it went well. As you notice, there were some that were like the leader, so you use that skill as they support their other classmates.
RP: What would you do differently next time?
TP: Well, I think I could use the colour of the soil to support students, because the next part of the syllabus is ‘Colour Identification’.
RP: Okay, so in terms of your focus on group work and getting students involved, what would you do differently?
TP: Well, I’ll divide the class; you see, there were two classes merged, so it was really hard. So, if I have like 20 children, I could group them into five or so. It may make it easier.
RP: Thank you so much for your responses. You did really well.

Mrs Oga thought her students engaged well with the lesson and that being able to collect and manipulate the soil samples made the learning more authentic for them. She felt the large class size was a challenge, as she had to include another Primary 1 class because their teacher was away.

I commended Mrs Oga for her efforts in implementing group work and mentioned some of my impressions of the lesson. I commended her movement and interaction with each group as they shared their thoughts with her. The way she participated in touching, moulding, and exploring the sand also helped the students feel more comfortable. I asked her what she thought about how the students had all rushed to the desk and how some had gotten the soil on their faces. She felt she could have made more safety rules. I agreed with her and suggested how she could involve the students in developing the safety expectations, which would make them more likely to comply with them.

The smiles and sense of delight on the faces of the students said it all as they touched and manipulated the soil samples and expressed their thoughts and ideas. This experience created a positive and relaxed environment for the students to learn in.

10.1.5 Critical Reflections on Student Collaborative Learning

Two of the teacher participants (Mr Dachung and Mrs Oga), during three different lessons with Primary 1 (Exploring Soil), Primary 4 (Measurement) and Primary 5 (Pollution), focused on how to embed collaborative learning in their lessons to encourage more peer support and interactions. There were similarities and differences in how they did this. I will discuss these in line with the observed changes and reflections with the TPs on the shifts they made and challenges they encountered implementing these newer strategies below.

Small Shifts

Both TPs made physical changes to the seating arrangements in their classrooms to suit collaborative learning. The difference lay in how they chose to make those changes. In one case, the classroom was already set up by the teacher when the children arrived. In the other class, students were involved in moving their seats. This was interesting, as it demonstrated the TPs' thinking and knowledge of their students. It made sense to involve the students in Primary Four and Five in making the change to their seating arrangements but not the Primary One students because of the heaviness of the desks and the disruption to their routine. These traditional old-fashioned desks were probably not designed to suit such activities, so they present a physical impediment compared to lightweight modern alternatives.

Both teachers explained the reason for the change in seating arrangement to their students and encouraged them to work together in their small groups to share their ideas. Mr Dachung used a random grouping approach, and this provided students with the opportunity to work with members of the class other than those they typically sat next to. Once the students had formed their groups, he encouraged them to choose a secretary who would report the results of their investigations. This was a positive approach, challenging students to make decisions on who would represent their group. However, moments of tension arose as students in some of the groups found it hard to decide, leading to arguments. It may have been better if Mr Dachung had assigned the roles, especially given this was the first time the students had done group work (Llewellyn, 2014).

In reviewing their previous lessons, Mr Dachung seemed to be reminding the students of what they had done instead of giving them a chance to explain or demonstrate their prior knowledge. Mrs Oga adopted a more exploratory stance and commenced her lesson by asking students to collect the soil samples they had brought to class from her desk and then describe where they had found them. These differences highlight that change in practice takes time and begins with a shift in thinking and mindset (Sedova, 2017).

Both teachers thought their lessons went well and were excited to have tried the strategy. They both thought their students participated well. Although it was a new experience for the students, the teachers felt their students had embraced it with excitement, and they were mostly able to collaborate to carry out the assigned tasks.

The TPs also felt their students had developed more understanding of the content, especially when they were supported by their peers. The TPs thought that student engagement and understanding were enhanced by their manipulation of the items provided and their small group discussions. This is consistent with the literature, which suggests that collaborative learning in small groups supports all students, especially those who may be reluctant to engage in larger, whole-classroom experiences (Harlen & Qualter, 2018; Llewellyn, 2014).

Challenges

Upon reflection, Mr Dachung felt the noise levels in his class were a challenge. Together, we reflected on what the students were discussing, and he appreciated that the noise was not necessarily a bad thing, especially because the students were excited, and they were mostly discussing the task assigned. There may be an assumption that a quiet class is a well-controlled and fully engaged class. While such a class may appear well-controlled, the level of student engagement, learning and understanding remain questionable (Garrett, 2015). Mr Dachung and I discussed strategies to encourage students to minimise noise by teaching them to use inside and outside voices and encouraging them to consider the impact of the noise level on other groups. I suggested and explained the use of a visual noise level monitor/reminder, which he hoped to trial. I encouraged both TPs to remember that this was a process of adaptation for them, as well as for their students, and to expect a little more noise than usual as students learn to work at a more manageable noise level. This again suggests that change in pedagogical approaches takes time, involves everyone in the class, and calls for creativity in implementing and supporting it (Guskey, 2002; Kenny et al., 2020).

The teachers mentioned large class sizes as another challenge for group work. This was especially challenging for Mrs Oga, who had younger students, and although interacting with sand did not seem harmful, safety issues arose during the lesson. Through the reflections, she thought that having a smaller class would have been easier to manage. Large classes are a challenge in many Nigerian classrooms, especially in public schools and sometimes in private schools when a teacher is absent for a longer period and classes need to be combined. Mrs Oga having to cater for students from an additional class for two weeks due to a teacher's absence was difficult.

Teacher absenteeism has been identified as a problem in Nigeria and in Africa more broadly, with negative effects on students' learning (Ejere, 2010; Obiero et al., 2017; Ugoani, 2016), and has been attributed to dissatisfaction with salaries, lack of resources, poor systemic support for teachers and, interestingly, the lack of autonomy and dignity attached to the primary teacher role (Humphreys et al., 2015; Ugoani, 2016). Although most of the absenteeism occurs in public state schools, it also occurs in private schools, where it may be approved by school authorities. There are minimal or inadequate processes in place to cater for students during such teacher absences.

Both schools in this study had teachers absent during my time there. One case led to the merging of the two Primary 1 classes, which meant that Mrs Oga would be teaching about 50 students for a fortnight because of her colleague's attendance at university exams. Mrs Oga felt that the larger class reduced her ability to teach effectively. Another instance involved a teacher taking on the additional responsibility of teaching Science to students in Primary 3, 4 and 5 because their usual teacher had been hospitalised. Mr Abok highlighted that this was an extra workload and explained on several occasions that he was only filling in for this teacher and sometimes did not feel prepared or was not available for a particular lesson due to clashes with his regular timetable.

Relief or substitute teachers were non-existent. These teachers are registered teachers who may be called upon to teach when the regular class or specialist teacher is absent (Lunay & Lock, 2006; McCormack & Thomas, 2005; Nicholas & Wells, 2016). Previous research has shown that the main coping strategy for teacher absenteeism is to have a rotation of administrative staff who are free to supervise the affected children (Ejere, 2010). Sometimes parents or any other available adults are organised to supervise the students. This supervision usually means that students are doing random activities, such as singing and revision of content that is mostly below the students' level. Another approach was to split students among various classes. This resulted in additional classroom management challenges, increased workload, and, in many instances, it being impossible to deliver the appropriate curriculum content (Ejere, 2010; Moletsane et al., 2015).

Students were often left unattended to do something quietly, such as reading or revising their previous work. Instead, however, students would often be chatting or wandering around the school grounds. My findings are consistent with the earlier research cited above, showing the negative effect of teacher absenteeism on teachers and, more importantly, on students. Teachers may have legitimate reasons for being absent from school, so the utility of having a systematic arrangement in place to provide substitute or relief teachers cannot be overstated.

10.2 Questioning

Questioning was an inquiry approach we explored and demonstrated throughout the PL session by challenging teachers to develop and ask more open-ended questions that would stimulate students' thinking and elicit responses beyond a 'yes' or 'no'. I will use the lessons of three teachers, Mrs Oga, Mr Obi, and Mrs Adamu to illustrate the resulting change in practice. I will also discuss their thoughts about the lessons and my thoughts in a reflective conversation I had with them.

10.2.1 Mrs Oga's Primary One Lesson

In Mrs Oga's lesson on soil types with her Primary One students, she modified her style of questioning to encourage more thinking and participation. She aimed to ask open-ended questions to encourage her students to share their ideas:

T: What can you say about it? Yes, what can you say about the sand, the one from the farm?
S: It is smooth.
T: Are you sure?
S: Yes.
T: Touch it again. So, what is the difference between that one and the one you fetch from your farm? Look at it very well and tell me. Observe it and tell me. This one and this one, what is the difference? What can you say about it?
S: So, what can you say between this and this? Yes…
S: This one is soft and that one is rough.
T: The soft one and this one is rough. Yes, this one has what?
S: Stones.
T: Did you hear them? Yes, break it and feel it.
S: See Samantha.
T: Hello. Look at what I mean. Break it this way and feel it, okay? What can you feel?

Mrs Oga encouraged her students to describe the difference between the soil samples by asking, "*what can you say about that one?*" Throughout, she used prompts such as "*break it, feel it. What can you say?*" to encourage more responses.

After the students added water to each sample and identified the one they could mould, she asked, "*Since we can mould it, what are some things we can use it to mould?*" Mrs Oga provided opportunities for her students to explain their reasoning by asking, "*why?*":

T: This one is sandy soil, right?
S: Yes.
T: Why did you say it is sandy soil? See, tell me why did you say this is sandy soil?
S: It is not smooth.

She encouraged the students to look at the three soil samples and decide which one they thought was from the garden. She went around the small groups and listened and looked at the ones they pointed out as being from the garden. At this point, Mrs Oga accepted all responses and encouraged students by asking them to clap for themselves. She then identified which soil sample was from the farm and then asked students to touch the sample for the garden, which she called the "*black soil*", and to describe what they thought it felt like.

As Mrs Oga probed further for the students to describe the soil samples, there was confusion as to which sample they were describing. She then had the students do a comparison of the soil samples to aid them in their description:

T: So, what can you say between this and this? Yes.
S: This one is soft, and that one is rough.
T: The soft one and this one is rough. Yes, this one has what?
S: Stones.
T: Did you hear them?
S: Yes.

T: This one has what?

S: Stones.

T: What of this?

S: Not smooth.

T: Why?

S: Because there is stones inside.

T: There are stones inside… it is what?

S: Rough.

T: Good. Now the last one. Yes, feel it also and tell me the difference.

S: Not smooth.

T: Not smooth.

Mrs Oga asked her students to describe the soil samples now that water had been added to them and specifically asked them which one they thought they could mould. After the students touched and took some of the wet soil and tried to press it together in their hands, they pointed to the ones they thought they could mould. They also identified it as being from their farms or gardens. She then asked them to think of things they could mould from that kind of soil:

T: Look this way. Now, this is the only one that we can mould, right?

S: Yes.

T: Am I right?

S: Yes.

T: This the only one you can mould. Do you have it there? This one?

S: Which one?

T: This one. This is the only one you can mould. So, this one what do you think we can use it to do?

S: To mould?

T: To mould what?

S: Flower?

S: No.S: Chin-chin?[5]

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[5] *Chin-chin* (see https://www.allnigerianrecipes.com/snacks/chin-chin/) is a traditional fried dough snack.

She then asked them the name of the type of soil that is used to mould with. It was interesting and rather impressive that students mentioned some scientific names of soil types. Clearly, students were guessing from memory:

T: So, what do we call this one that we can use to mould?
S: Loamy soil?
T: No.
S: Sandy soil?
T: No.
S: Clay soil?
T: Clay.
S: Soil.
T: Hello.
S: Hi. [x2]
T: When you were in Nursery, they asked you to bring this type of soil so that you use it to mould, right?
S: Yes.
T: You say the name is what?
T & S: Clay soil.
T: Again.
S: Clay soil. [x2]
T: Clay soil.
S: Clay soil.
T: Again.
S: Clay soil. [x5]
T: So, this one that we can mould, the name is what?
S: Clay soil.

Mrs Oga's approach here shows the introduction of the scientific terms for each of the soil types after students had explored them by looking, touching, and manipulating the soil samples. This practice is consistent with a constructivist approach that could assist students in understanding the soil types.

Mrs Oga directed her students by pointing to the soil they had identified as being from the farm and asked them if they knew the name of the soil. One student shouted, "*loamy soil*", and the teacher asked the other students to clap for him and to repeat the name of that soil type a few times. They then continued exploring the remaining soil sample (from the school's compound) and identified it as "*sandy soil*".

Mrs Oga continued this revision of what the students had explored by asking them questions as she wrote on the board:

> *T: So, if you can find it in the garden, what do you use it for? Yes?*
> *S: Building?*
> *T: From the garden? When you went there to fetch the soil, what did you find there? What are they doing in the garden?*
> *S: Carrot.*
> *T: Carrot… So, what is carrot? Is it animal or plants?*
> *S: Plant.*
> *T: So, what do we do in the garden? I want you to think before you raise your hands. Yes, what do we do in the garden? Who fetched his own from farm?*
> *S: [some put their hands up]*
> *T: Eeeh hem! The farm is like garden—see the garden here that I showed you? The one at the back of here, the day you picked paper. So, what do you see that they do in that garden? Yes?*
> *S: Farm.*
> *T: So, in our garden, we can have our flowers, we can plant things. Different things.*

When students identified the clay soil, she reminded them that it was the soil type they could mould and revisited the question she had asked the students earlier about where they had fetched the clay soil from. There was still a bit of confusion on this point, but some students seemed to be following along:

> *T: Now, the one we can mould is the clay—*
> *S: Soil.*
> *T: Tell me, where did you find that clay soil?*
> *S: From the farm.*
> *T: Farm again? Yes.*
> *S: From garden.*

T: Garden? Yes.

S: From valley?

S: [students laugh]

T: Don't laugh… What did you say? Did you say valley? Clap for him!

S: [clapping]

T: Have you ever seen where they dig well?

S: Yes.

T: Rigiya?[6]

S: Yes.

S: River.

T: Yes. Who said river?

S: This one.

T: Clap for her. She said she got her own near the river. Near the riverbank you can find this kind of soil. Clap for both of them. Since we can mould it, what can we use it for?

S: For moulding.

T: Clap for her. Have you ever seen a clay pot?

S: No.

S: Yes.

T: Some of you, your grandmas have clay pots that you put water, eh?[7]

S: Yes.

T: Some have flower vase. Have you ever seen a flower vase?

S: Yes.

T: So, they make it with clay soil.

Through her questioning and discussion of the uses of each soil type, the teacher provided an opportunity for her students to make more real-life connections about how the soil types are used. Mrs Oga encouraged them to think about their lives and what they see around their homes to make these connections.

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[6] Hausa for 'well'.

[7] Many of the old women in the villages use clay pots to store their drinking water. The pots keep the water cool for drinking, as electricity and fridges are not available.

Towards the end of the lesson, another safety concern arose when a student, playing with the samples, got some soil in his eye. At this point, I would have expected the lesson to have been concluded due to the short attention span of students at this age, but the teacher gave a warning, asked them to stop playing, and carried on asking where each sample came from. Finally, she got the students to stand and to repeat after her as she read from the board. After this reading, she asked them if they had any questions. Students said "*no*," and she asked them to line up to wash their hands outside the classroom, where she had placed a basin of water and some soap. I helped with the clean-up process. After the students had washed their hands and returned to class, she asked them to get their science notebooks. Mrs Oga reviewed the lesson by asking students questions which formed the notes she wrote on the board. She then asked the students to write these notes in their books.

10.2.2 Reflection with Mrs Oga on Questioning

Mrs Oga felt that the questions she asked encouraged her students to think about the soil samples and their uses. She also attributed the development of their understanding of the content to the fact that students were able to collect the soil samples themselves and thought their touching and feeling further supported their comprehension. She felt that her main challenge was time, as she wished she had given more time for student responses.

I commended her efforts in adapting her style of questioning, especially how she stimulated her students' thinking and encouraged their responses by asking 'why'. I also commended the shift in the way she ended her lesson. Even though she still wrote on the board and expected students to copy the notes into their books, she used open-ended questions and students' responses to these questions to generate the notes. For each subheading she had on the board, students provided the answers, and these formed their notes. This approach meant that her questioning and notes became a form of review for the students, providing more authentic learning because the students understood what they were copying down.

I challenged her to think about how she could also encourage her students to ask questions. I observed that Mrs Oga asked students towards the end of the lesson if they had any questions, to which they said ‘no.’ However, I suggested she could encourage students to think about questions they wanted to find out about the soil samples. This could have occurred even at the beginning of the class, and students could also interact in their small groups to discuss what they wanted to find out. Mrs Oga said she hoped to try this approach in subsequent lessons.

10.2.3 Mr Obi’s Primary Two Lesson

After the PL sessions (see Chapter 9), Mr Obi chose to focus on how to use questioning to encourage student thinking and to provide opportunities for deeper responses and discussions. He tested this approach in his lesson on ‘The Human Body: The Eye’ with one of the Primary Two classes. After a review of the previous sense organ (the tongue), Mr Obi began:

> *T: So, today we would be talking about the eye. I’m very sure all of us can locate the position of our eye.*
> *S: Yes, we can.*
> *T: Now, all of you show me your eye.*
> *S: [points]*
> *T: Very good. Now let me see what is your eye for?*
> *S: To see.*
> *T: You use it to see everything?*
> *S: Yes.*
> *T: Are you sure?*
> *S: Yes.*
> *T: Mercy, what do you use your eyes for? To see something. What do you use*

your eye for? [students give more responses] Wow, watch cartoons and read! So, you see everybody has its own function for each of our eye. All these reasons you have given me or are mentioning, you are all right, because that is your personal view. Is that clear?
S: Yes.
T: All of you are correct, so, for that reason, clap for yourselves.

After the question, "*what do you use your eye for?*" Mr Obi provided students with ample time to talk about the uses of their eyes. His acceptance of all responses encouraged the students to participate. After explaining that the eye is one of the sense organs, he asked them to close their eyes and tell him what they saw with their eyes closed. Again, Mr Obi's question prompted a discussion:

T: Now, just imagine all of you close your eyes. Sit well and make sure you close your eyes very well, because I'm going to ask you a question. Now, can you see something while you are closing your eyes?
S: No.
T: Are you sure?
S: Yes.
T: If you say yes, it means your eyes are open.
S: My eye is not open.
T: Okay, when you are sleeping and snoring, do you use to see something?
S: No.
S: Yes.
S: I use to see my dream.
T: You used to see your dream? What do you see?
S: I used to see somebody pursuing somebody.
S: I used to see the film I watch.
T: You used to see the film you watched?
S: Yes.
S: I used to see the chair where I'm sitting down.
T: Okay, now, it's okay… now, for those of you that used to see the things that you have watched, that one we call it imagination. Say imagination.
S: Imagination.
T: Again.
S: Imagination.

T: Now, apart from that imagination, ideally, when you close your eyes, you are not supposed to see anything; the whole place will look dark for you, even if it is morning or night. Even at the morning time, when you close your eyes, the whole place would become dark for you.

Mr Obi then asked the students to repeat the title '*Eye*' and then talked about drawing a picture of the eye. Mr Obi started to write notes on the board about the eye for students to copy into their notebooks. He then drew a diagram on the board, which he expected students to draw in their notebooks. Although the goal of drawing the picture of the eye was to understand how the eye looked, the teacher seemed to have focused on how students drew their images.

10.2.4 Reflection with Mr Obi on Questioning

I did not have a chance to chat with Mr Obi straight after this class but made notes of my observations and planned to discuss these with him at a time that was convenient for him, which turned out to be the following day. He gave an overview of the benefits of his chosen inquiry approach of questioning:

T: Based on the previous discussions, I think one of those things I have learned, and I have tried to apply it in the lesson, is that inquiry skills. I discovered that truly it brings out ideas and even knowledge about what the child thinks and knows. Even though at times it might not be correct, but the idea for them to speak their minds and express themselves is even a joy for me. It gives me an idea that the child has little [some] idea about what I'm about to teach. So that inquiry basis is really helping me these days, not only on the lower classes, even the higher classes, I give them more opportunity and time to express themselves.
RP: Awesome! I guess also doing that helps you know how you can modify your lessons and gives you an idea of who knows what and provide support.
T: On a serious note, like J3,[8] I remember we were talking about crop movement. I just wrote the topic, and I allowed them to speak concerning the topic, and at

[8] JS 3 is Junior Secondary 3, equivalent to Year 9 in Australia.

the end, I discovered that most of them that feel they don't know anything about crop movement is because they don't want to express what they think they know. Which deep inside them, they feel that is wrong but not knowing that they have the idea. So, I just allowed them. After expressing themselves then, I now write them, and they discovered it is even what they thought [some form of reinforcement]. So, this is what it is like for the senior class; they are giving me rest from talking. While they do the talking, I do the summary… so that is one thing that I've really liked, I really appreciate that.
RP: That's good. Good to hear that!

Mr Obi seemed to have continued to implement the approach of asking open-ended questions by writing a topic and allowing his students to provide various responses. Mr Obi indicated that he continued this approach not just with his lower primary classes but also in his Junior Secondary Biology and Agricultural Science classes (Years 7–9). He continued with this approach because he considered it to have been successful, as many of his students were more engaged in the classroom discussions while he did more listening. Through this approach, he discovered what his students knew about the topic, and he was able to support them accordingly.

I commended Mr Obi for his open-ended questioning and for providing opportunities for his students to share their thoughts. We also discussed the idea of students drawing the eye in his Primary Two lesson, and he commented that he just wanted to see what they could draw and realised that this was probably beyond their abilities at this level. I commended him for his drawing of the eye on the board and said how having pictures, or a chart of the eye on the wall could also have helped the students as they explored that body part. At this year level, the teacher drawing a picture or showing an image of the eye probably would have sufficed.

Further, with reference to his question on what students could see when their eyes were closed and his comment about our imagination, I suggested that it may have been a good opportunity to discuss the eye and its relationship with other body parts. I encouraged him to think about how the open-ended questions may sometimes generate responses or more questions from students that may demand further exploration and discussion. I highlighted that it would be at this point when he, as the teacher, would decide how these could be beneficial to the topic being explored or could schedule time for further explorations. Mr Obi said he appreciated this feedback and hoped to incorporate these suggestions when he taught his next lessons.

10.2.5 Mrs Adamu's Primary One Lesson

Mrs Adamu was continuing her lesson on 'Things in Our Environment' with a focus on living things. She chose to focus on questioning as a way of understanding what her students thought about the topic.

She commenced the lesson with a review by asking, "*What did we say environment is?*" She gave ample time for students to think, then one said:

S: Environment is all around our environment.
T: yes, anybody else? Yes, Debo?
S: Environment is all around our place.
T: Yes, anybody else?
S: Environment is things around you.
T: These are all great answers! Clap for them!

Mrs Adamu progressed the lesson by asking students to list the things that were in their environment. Students were eager to respond. She then told them that they were going to be learning about "*living things in our environment*" and asked, "*what is a living thing?*" Students called out, "*A man!*" She then rephrased her question and asked:

T: When we say something is living, what do we mean?
S: Something that can walk.
T: Yes, what else?
S: Something that can run?

Mrs Adamu accepted all responses but soon provided a definition of living things: "*Living things are those things that have life.*" She asked the students to repeat this definition a few times, then asked:

T: What are some of these living things?
S: A cow.
T: Yes.
S: Dog and giraffe.
T: Yes, you?
S: Tiger.

Mrs Adamu wrote these names on the board. She then said, "*All these things you have listed, we can put them in a group, and we call them animals.*" At this point she could have encouraged the students to keep listing and then checked if they could identify how they would group the living things. As these were Primary One students, images could have helped them to do a sorting and grouping activity at the end. I wrote this as a point to discuss with her later. She proceeded to ask what other things are living, and students mentioned plants. She asked them to list the types of plants they knew, which she wrote on the board. Mrs Adamu then asked, "*Why do we say they are living things?*" This open-ended question linked back to the students' earlier responses, and they answered:

S: They can grow.
T: Yes, they can grow. Can animals grow?
S: Yes.
T: How?
S: They have babies, and then the babies become big.
T: Apart from growing, what else can they do again?
S: They can walk.

Mrs Adamu engaged me in the discussions, too, by asking, "*Aunty, we need help here. Do you think man is an animal?*" I responded by asking the class to share their ideas about the question. I repeated the question to the class, "*Is man an animal?*" I then asked the students to stand up and explain how to form a 'decision line' where those who said 'no' stand on one side, those who said 'yes' on the other, and those who were unsure in the middle. The teacher stood in the middle section as being unsure. I asked the students to say *why* they thought that man was an animal. Students said it was because man walks and eats like animals. One student who was on the 'no' side said he did not think that man was an animal because "*man can talk, and animals cannot.*" The teacher gave her reason for standing in the middle, saying she was confused as there were things that man could do that were like animals and things that were different. I then suggested that, from the decision line and their reasons, maybe we could conclude that man is a special form of animal with an ability to do certain things like other animals but can also do things other animals cannot do.

The nature of Mrs Adamu's questions encouraged students to share their ideas and engage in the class discussions.

10.2.6 Reflection with Mrs Adamu on Questioning

I chatted with Mrs Adamu straight after her lesson as the students were going for their break. I commended her efforts and asked her how she felt the lesson went. She excitedly shared how the students were all "*just wanting to talk*". She said, "*It really showed me what they know and that they do know a lot.*" She said she struggled to control the children so that they did not all shout out the answers but would take turns to talk. She mentioned how she appreciated the decision line strategy I used to demonstrate how students can explain their reasoning. She hoped to keep using these strategies.

I shared my thoughts about the lesson with specific reference to her questioning strategy. I agreed with her that because she asked more open-ended questions, the students were able to share their ideas and provide reasons for their answers. I explained the idea of encouraging deeper thinking from students by having them group the living things and give their reasons. I demonstrated the decision line as a way of encouraging physical movement while simultaneously engaging the students in critical thinking.

10.2.7 Critical Reflections on Questioning Strategies

Small Shifts

Three TPs (Mrs Oga, Mr Obi, and Mrs Adamu) chose to focus on questioning. Mrs Oga had a dual focus on collaboration and questioning, while Mr Obi and Mrs Adamu focused on questioning strategies as a means of inquiry and encouraging more student thinking and participation. These TPs demonstrated shifts by making their questioning more open-ended, which stimulated responses from students. For instance, Mrs Oga commenced her lesson by asking, "*where did we get these sands from?*" Through this, she encouraged students to share by inviting them to consider the colour and texture when determining the soil samples' origins. The nature of questioning here was progressive and built on students' prior knowledge, which is consistent with contemporary literature.

These teachers used further probing questions to elicit deeper thinking and responses to their initial questions. For instance, after students had mentioned where they had collected soil samples, the teacher asked them to touch a soil sample and said, "*What can you say about it? Yes, what can you say about the sand, the one from the farm?*" The use of questioning here provided students with the opportunity to describe the properties of the soil as they looked at and felt the samples. She further asked, "*So, if you can find it in the garden, what do you use it for?*" Such exploration encouraged deeper thinking and supported students in describing what each soil type could be used for. These questioning approaches also aided the students later in their comparison of the three soil samples and in the development of the big ideas about soil types and their uses; this is consistent with advocated pedagogical approaches to science education where new ideas are developed from earlier ones (Harlen et al., 2015).

Through their shift in questioning, these TPs also encouraged their students to provide reasoning for their responses. This was also evident in the lessons recounted earlier in this chapter. After the students had identified the different soil types by their properties and uses and introduced the scientific terms, Mrs Oga asked them to show her which soil was sandy, loamy, and clay. She further probed, "*See, tell me* ***why*** *did you say this is sandy soil?*" Students' responses demonstrated some deeper thinking when they said, "*It is not smooth, it cannot mould.*" Another instance was Mrs Adamu asking, "*Why do we say they are living things?*" Asking '*why*' meant the students needed to justify their reasoning, which provided an indication of their thinking irrespective of whether they were right or wrong (Tytler, 2017).

These teachers demonstrated an ability to use questioning to challenge students' thinking. Their open-ended questions and accommodation of all responses encouraged students to share their ideas without the fear of reprimand for being wrong. Through the discussions and explorations, the teachers guided their students towards more scientific perspectives. This gradual process of developing scientific explanations is supported in contemporary science education (Harlen & Qualter, 2018; Waldrip & Prain, 2017).

10.3 Student Involvement through Demonstrations

All the teachers at Banke Academy were encouraged by the principal to attend the PL session, even those who were not science teachers. One teacher, Mrs Laraba, who taught Social Studies, invited me to visit her class after the PL session as she excitedly said she wanted me to observe what her class was learning and her trial of some of the inquiry ideas she had learned from the PL.

10.3.1 Mrs Laraba's Primary Two Lesson

In this lesson with her Primary Two class, Mrs Laraba was focusing on demonstrations and student involvement. They were exploring the concept of culture. Before this class, she had asked her students to bring some traditional foods and costumes that reflected the part of the country they originated from.

When I arrived, students were already getting changed into their traditional outfits, and the atmosphere of excitement in the classroom could not be missed. The teacher allowed students some time to get organised, then:

T: Alright, can we settle down now? We are going to discuss culture. Is there anyone of you in this class that doesn't have a culture?
S: No.
T: We all have cultures. Isn't it?
S: Yes,
T: Okay, can somebody tell us what culture means?
S: Culture is our way of life.
T: Beautiful, please clap for her!
S: [clapping]
T: Culture is our way of life. We can also say culture is the total way of life of people. Isn't it?
S: Yes.
T: Yes. And culture includes what? The food we eat…
S: The dress we wear.
T: Yes… our craft. What about music? Yes! Let me see those that brought their cultural foods.
S: [students raise hands]
T: Okay, bring it out now.

In this interaction, the teacher began by asking a closed-ended question. She continued by asking a more open-ended question: "*Can someone tell us what culture* *means?*" After one student provided a satisfactory answer, the teacher did not give opportunities for more responses but simply read a definition from the textbook. While talking about what culture includes, more time could also have been spent encouraging students to share their ideas. I made a note of this to discuss with her during our reflections.

Mrs Laraba had a table set up where she asked the students to bring the food they had brought one after the other. After all the food samples had been placed on the table, she told the students that they would come to the front to describe what they had brought:

> *T: Before Europeans came and introduced their foreign foods to Africa, we had our own indigenous food, that is our native foods. Isn't it?*
> *S: Yes.*
> *T: It is otherwise known as our what? Local…*
> *T & S: Foods*
> *T: And our local foods differ based on what we are able to produce in our communities. Am I right?*
> *S: Yes.*
> *T: Yes. Okay, Eli come. Can you come and tell us the name of this local food?*
> *S: It is gawte.*[9]
> *T: Okay, tell us more about it. What tribe are you?*
> *S: Buji.*[10]
> *T: Okay, what did they make this food with?*
> *S: Pepper, cabbage, meat, water…*
> *T: Good, thank you. Who brought this one?*
> *S: Me.*
> *T: Okay, come, what is the name of your cultural food?*
> *S: Yam.*

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[9] Also referred to as *pate* by some Northern tribes, *gawte* is a porridge made of ground corn or rice, garnished with vegetables such as spinach, capsicum, tomatoes, and a variety of meats.

[10] One of the major indigenous tribes in Plateau State.

T: Okay, yam.[11] *From what tribe?*

S: Edo.

T: Do you know the name of yam in Edo language?

S: No.

Figure 10.5 Cultural foods brought in by the students to share

Mrs Laraba then invited the students who had worn their native attire to stand in front of the class and share what tribe they were from. Students shared the tribes they originated from mentioning—Ibira, Fulani and Buji.

Figure 10.6 Students dressed in traditional attire

[11] Yam is a popular root crop eaten in all parts of Nigeria. It can be boiled, pounded, or eaten in and eaten with different soup or made into a pottage.

It was great to see students move from their desks to the table where the food had been kept, and some were able to describe the food samples they brought, and some showcased their native attires. Some of the students who had brought food samples did not know the names of the foods, and the teacher highlighted this. At this point, though, a discussion about how students could learn more about the foods they had brought could have occurred. I noted that in my diary to discuss with Mrs Laraba later.

Mrs Laraba explained that traditional cultural foods are more nutritious than other foods and used the example of the *gawte*, which is made entirely from healthy ingredients. Throughout this explanation, Mrs Laraba did all the talking and would only ask the students, "*Isn't it, am I right?*" She went on to list more of the cultural foods, such as *tuwo da miya*, *masa*, *akamu* and *kosai*,[12] and encouraged the students to eat more cultural foods because "*it is good for our health.*" She also explained how culture is passed from one generation to the next so that it would not fade away. Mrs Labara went on to explain how the traditional ways of dressing and greeting differ between Nigerian cultures:

T: We have the Igbo attire. What kind of dressing does the Igbo person wear?
S: See the Igbo person here.
T: Where? Okay, come.
S: [student goes up]
T: Yes, they dress with a blouse and—
S: Skirt.
T: Or blouse and wrapper. Do we have Yoruba here?
S: [students come up]

[12] *Tuwo* (see https://cookpad.com/uk/recipes/10335771-tuwo-da-miyan-agushi) is mainly made from maize or rice and *miya* means 'soup with a variety', such as *agushi*, *kuka*, or *okro*. *Masa* are Rice cakes (see https://cheflolaskitchen.com/african-masa-recipe-hausa-masa/). *Akamu* (also called *ogi*, see https://en.wikipedia.org/wiki/Ogi_%28food%29) is a porridge made from maize or millet. *Kosai* (also known as *akara*) is a cake made from blended beans (see https://www.makeheritagefun.com/how-to-prepare-beans-cake-akara-or-kosai/).

T: Okay, we also have greetings as part of our culture. So how do Yorubas greet?

S: [student demonstrates by kneeling]

T: What do they say?

S: Ekaaro[13].

T: Ekaaro. What about the Buji?

S: Kukan.

T: They say what? Kukan. So, if our parents don't communicate with us in our local dialects, our culture will fade away. Our culture will what?

S: Fade away.

T: Okay, can someone sing a song for us in their language?

S: [student raises her hand]

T: Okay, come. Let's keep quiet and listen.

S: [student sings]

T: Beautiful! Please clap for her.

S: [clapping]

T: Because our culture includes our music. What tribe is that?

S: Igbo.

The interaction described above encouraged students to share and demonstrate how they greet in their native languages. When one student volunteered to sing in her native language (Igbo), it prompted more students to want to share songs they knew in their native languages, too. Mrs Laraba accommodated this, and students who had not dressed in their native attire had a chance to share in some aspect of the cultural exploration. Some of these aspects are captured in Figure 10.7 below.

Figure 10.7 Students demonstrating her cultural greeting (left) and another singing

[13]Ekaaro- Good morning in Yoruba

The teacher informed her students that people from other cultural backgrounds would come and taste the food they brought and explained the need to show respect for other cultural foods that may be different from theirs:

T: Every cultural food and attire is beautiful. Do we understand?
S: Yes.
T: Yes, it is beautiful, and we should respect other people's culture. When we do that, we promote what? We promote peace in our communities. Am I right?
S: Yes.
T: We promote what? Peace in our…
S: Community.
T: Okay, let's take down some notes quickly before we continue.

At the end of the lesson, after students had copied the notes from the blackboard, Mrs Laraba shared the food out, and the students got to taste it. I assisted, and while the students ate, I chatted with Mrs Laraba about the lesson.

10.3.2 Reflection with Mrs Laraba on Demonstrations

I began the conversation by commending Mrs Laraba's efforts and the idea of students bringing their costumes and traditional foods to share. It supported students' understanding of culture and the differences between cultural groups. I asked what she thought of the lessons. She thought the students did well, although she had hoped more of them would have brought something from home. She was still happy with their participation. Regarding what she could do better next time, Mrs Laraba thought she could get the students to share more about how the food is cooked or even invite the parents to come along and participate in the demonstrations and explanations.

I commended her for the positive classroom atmosphere that I witnessed, as students were excited to participate in the demonstrations. We discussed that the variety of artefacts provided the students with different ways of being involved in the demonstrations; those who did not dress up in their cultural attire or bring food still had a chance to demonstrate how they greet in their cultures and sing in their languages.

We discussed how having the students taste the cultural foods others had brought was an excellent way to support the development of respect and acceptance. We reflected on the need for further or deeper exploration where students could have been challenged to compare the cultures represented in their class. Such an approach may have generated a deeper appreciation of being different yet similar.

I encouraged her to consider the nature of her questioning and to ask questions that would prompt deeper thinking or responses from students. We identified instances during the lesson where students could have been challenged to think more deeply, such as identifying the benefits of cultural foods, what they wanted to know about culture and how they could find out, why cultures differ, how and why students think we can be proud of our cultures and the differences between them. Through her questioning and student demonstrations, I encouraged her that she could provide students with more opportunities to engage in deeper thinking and conversations about the concepts explored instead of simply agreeing with her or carrying out assigned tasks.

10.3.3 Critical Reflections on Student Involvement through Demonstrations

Demonstrations are valuable not only for engaging students but can be utilised in instances where, for example, a new experiment is being conducted, and especially where safety is a concern (Llewellyn, 2014). Using demonstrations was not new for most of the TPs as some of them employed this approach in their teaching, but when they had used demonstrations in the past, it was mainly in a ‘show and tell’ style. Llewellyn (2014, p. 115) refers to demonstrations that engage students as “demonstrated inquiries”, which not only give students a chance to partake in the process but could also spark more questions and inquiries. The teacher could have adopted a facilitator role and encouraged the students to think about questions they wanted to ask about culture and carry out further explorations instead of the teacher asking all the questions.

Small Shifts

From the beginning of the lesson, students were engaged by getting changed into their traditional attire or as they placed their food items on the table at the front. Through encouraging students to bring items from their cultures, the learning was made relevant and, in doing so, gave the students ownership of what occurred in the lesson. The teacher reminded the students about the topic by asking whether anyone does not have a culture, and then "*Okay, can somebody tell us what culture means?*" The attempt at a more open-ended question here suggested that students had the opportunity to give their varying ideas, but instead, only one student had a chance to respond. The teacher seemed happy with that student's response, but she missed the opportunity to hear what the other students thought and instead gave them a definition they were expected to repeat and write. Again, this highlights that the shift in practice is gradual and must be deliberately pursued (Darling-Hammond et al., 2020; Darling-Hammond et al., 2017).

Mrs Laraba invited her students to the front of the classroom and used guiding questions/prompts to encourage them to describe the food they had brought. Students were able to give the names and ingredients. Mrs Laraba used a similar approach when she invited those who had dressed in their native attire to the front of the class to show and share about their outfits. Students also demonstrated their customary local greetings with both words and gestures.

Encouraging their participation in the demonstration was a way for the students to understand more about their culture and to share it with their classmates

(Chittleborough et al., 2017). Having peers ask questions after each demonstration could have engaged the rest of the class more fully.

It was a positive experience for the students to share their cultures by bringing attire and food items. It was also important that Mrs Laraba used these experiences as an opportunity to promote mutual respect.

Challenges and Limitations

Mrs Laraba did not seize the opportunity to invite students to discuss *why* they were engaging in the lesson on culture. This would have been beneficial to developing more student reasoning and agency about the learning process instead of the teacher simply telling them why. Nigeria's diversity—with some 250 ethnic groups and more than 500 languages—means that the ways of life and practices vary significantly, and this is sometimes the cause of ethnic conflict (Kwaghga, 2018; Okoro, 2018). Therefore, the significance of teaching students at an early age about the need for respect and tolerance of cultural diversity cannot be overstated or rely merely on telling students what to do. Instead, students should be invited to actively consider solutions.

10.4 Summary

The second cycle of classroom observations and reflections provided an avenue for teachers to implement their chosen strategies from the PL sessions, to be supported in the process of implementation, and to reflect on how the strategy went. The teachers felt that they were largely successful, based on their students' apparent engagement and understanding of the lessons. Through further reflections and interactions, they identified areas they would include or adjust in subsequent lessons.

The different mode of engagement was not without challenges, such as how to control the noise level in the classroom, the need for extra adult supervision as students carried out explorations, and the relatively large number of students in some classes. Overall, the TPs spoke positively about the strategies they implemented and hoped to continue to refine them in future classes.

I had originally planned for a third cycle of PAR and more classroom observations and reflections with teachers. It would have been beneficial for me to provide them with more support, especially with how we could overcome some of the challenges we identified. Further, it would have been helpful to support teachers during the planning phase of their next lessons in thinking about how to incorporate more inquiry strategies. However, the political situation in Jos at that time remained tense, with more riots and demonstrations as local government elections neared and continuous violence and killings in villages by unknown gunmen led to school closures. Due to these safety concerns and interruptions, I could not conduct the third phase with the teachers and needed to return to Australia.

Stage Three: Personal Reflections and Recommendations

In the final chapter, I present a personal and critical reflection on the research. I will articulate what the study suggests about progressing teacher adoption of new pedagogical approaches in teaching and learning of Primary Science in the Nigerian context. This new knowledge will inform a series of recommendations for developing the expertise of Nigerian science teachers.

I will conclude by presenting my own reflections and adaptations through this PhD journey and the conclusions that can be drawn from the study. Further, I will discuss the study's limitations and offer some recommendations for further research.

Chapter 11

Personal Reflections, Conclusions and Recommendations

In this concluding chapter, I reflect on the research process and the challenges I encountered as a researcher. I consider how the methodological approach enabled me to better appreciate and adapt to the complexity of educational change and the foreseeable and unforeseeable contextual challenges that affected the research process.

After this background, I address the research questions and consider the contribution the study has made to understanding the needs of Nigerian primary teachers to develop their expertise to teach science. From these findings, I also consider the broader implications and make a series of recommendations in relation to curriculum development and in-service teacher training.

Given the widely recognised difficulties associated with systemic educational reform and the centrality of teachers to achieving it (Hargreaves & Fullan, 2013), these recommendations might be helpful to Nigerian education policy makers in achieving their espoused educational goal of developing “appropriate skills, mental, physical and social ability and competencies to empower the individual to live in and contribute positively to the society through a more scientific literate citizenry” (NERDC, 2013, p.

2). I close by discussing the limitations of this study and suggesting opportunities for further research.

11.1 Reflections on the Research Process

This journey began with my personal experiences and through explorations of students' voices in my previous research. My personal journey of learning has been one of many adjustments as a primary, secondary, tertiary student, a pre-service teacher, practising teacher, and now researcher. My epistemological stance on learning has been shaped as I have been empowered to consider what learning means to me, rather than seeing it just as something done to or for me as I learn with and from others.

This shift in thinking and practice was not without its challenges. As a pre-service teacher, I had to seek help to adequately search for and critique ideas to write my assignments. I was supported by the library staff and other classmates through this process. Through the tutorials and classes I attended, I was challenged by my lecturers to share my ideas and ask questions. This was not easy for me because I was not used to such learning approaches from my previous experiences in Nigeria and Kenya. However, the supportive environment, practising and being motivated enabled me to feel more confident to participate in this process. I emerged from these challenges stronger and more empowered, and for the first time, I felt that learning meant something to and for me. These challenges have sparked my pursuit of further learning.

The Nigerian students who participated in my honours research revealed a similar discrepancy between the teaching and learning approaches in Australia and those they had experienced in Nigeria, as well as the adjustments they had to make as migrant students. Through my teaching as a primary school teacher, I sought to provide my students with opportunities to question what learning means to and for them. This was not a process that I left to chance. Instead, through the learning experiences I provided and the classroom environment I created, I challenged my students to take ownership of their learning and promoted a social constructivist mindset.

This epistemological stance and my awareness of the pivotal role teachers play in students' learning led to this inquiry into how Nigerian teachers teach and to what extent they are empowering their students to take ownership of their learning, and how they can learn with and from others. This inquiry has been guided by an overarching research question:

In a globalised world, what are the key educational challenges facing contemporary primary school teachers in Nigeria?

I addressed this question within the context of science education using the following four sub-questions (RQ1 to RQ4):

1. What policies are advocated in Nigerian education?
2. How do science teaching and learning practices within a Nigerian cultural context reflect contemporary pedagogical approaches to science education?
3. How do Nigerian primary teachers see themselves and their role as science teachers?
4. How can Nigerian primary teachers be supported to enrich/strengthen their understanding of effective Primary Science teaching and learning approaches?

11.1.1 Responding to the Research Questions

I chose a case study methodology employing sequential mixed methods, which included an initial survey and PAR. This was an appropriate methodology as it enabled me to adopt the position of researcher participant and to learn along with the teacher participants. The questionnaire data gave me a broader sense of teachers' perceptions of the educational challenges facing Nigeria beyond the case study group. It also enabled me to identify a small group of teachers to work with in the PAR phases of the study. Throughout this process, I adopted shifting roles of observer, facilitator, and supporter—aligning with my social constructivist position. In the following sections, I specifically address each research question in turn.

RQ1: What policies are advocated in Nigerian education?

In phase one, I reviewed the literature to determine what constituted effective, contemporary science teaching and learning approaches. I also reviewed relevant literature about the Nigerian educational context and analysed key documents to gauge how they related to internationally recognised effective pedagogical approaches.

My analysis of the Nigerian curriculum revealed its history, nature, and structure and showed that there had been numerous shifts in its design over the years. A more recent focus is on adopting a thematic approach that is meant to better cater to the needs of students and society (Adolphus, 2019; Igbokwe, 2015; NERDC, 2017a). These changes were made in response to the changing societal context and needs and to be in line with international trends towards making learning more relevant by supporting students to develop the problem-solving, creative, critical, and communication skills needed for the 21st century.

As discussed in Chapter 2, I decided to focus on the context of the discipline of science because it has been recognised as a subject that taps into students' natural curiosity and supports them to develop an understanding of themselves and the world. Further, as part of STEM, science is globally considered a means through which personal, national, and international advancements can be achieved (Bybee, 2010a; Formunyam, 2020; NERDC, 2013; OECD, 1999; Tim, 2016).

The literature review suggested that effective science teaching and learning should support students in becoming scientifically literate. Science education research promotes the use of more student-centred approaches to teaching and, more specifically, inquiry-based approaches to support and develop students' scientific knowledge. Through inquiry approaches, students can also be challenged and supported in developing problem-solving, critical and creative thinking, collaboration, and effective communication skills. These are essential skills needed not only to learn science but to function effectively in the 21st century and beyond.

Research further indicates that the effective implementation of these approaches places significant demand on teachers and students alike, as discussed in Chapter 3. Some of the challenges of implementing inquiry-based approaches include lack of resources and time, an overcrowded curriculum, lack of teacher expertise and a lack of PL modelling such approaches for teachers (Barron & Darling-Hammond, 2010; Fitzgerald et al., 2019). However, when inquiry approaches are implemented effectively, with specific reference to guided inquiry, successful outcomes are possible, especially in enhancing students' knowledge and interest in science and science-related subjects (Ayodele et al., 2014; Chen & Tytler, 2017; Hackling et al., 2007; Harlen, 2013b; Martina et al., 2016). The stated demands and challenges of using inquiry-based learning call for the need to create a positive learning environment and for teachers to be supported to implement them in their practice. I explored opportunities to support teachers to implement IBL in their context during this study's PAR phase.

The objectives in the Nigerian Basic Science curriculum indicate that students will develop an interest in science and technology and acquire content knowledge, along with science process skills through problem-solving activities. The curriculum also aspires to equip learners with 21st-century skills and knowledge (see Section 2.8). However, a deeper analysis revealed the level of knowledge and understanding that students are expected to demonstrate in their actual lessons does not align well with these espoused educational goals. The curriculum details expectations of student learning limited to factual recall and demonstrating understanding through descriptions and sometimes explanations (NERDC, 2017a).

Further, the assessment structure in the curriculum is limited to remembering, naming, defining, listing and, in some cases, explaining. In the Primary 5 science curriculum on the theme 'Environmental Change', for example, with its focus on erosion, students are encouraged to "participate in a project to control erosion at the site" (NERDC, 2017a). This seemed to suggest that students could apply their learning on erosion to propose ways of controlling it. On reviewing the corresponding teacher evaluation section, the assessment task teachers were encouraged to use only suggested that students should be able to "state three causes, effects of erosion and three ways of controlling erosion" (NERDC, 2017a).

In contrast with the espoused aims, students were not provided with opportunities to analyse, evaluate, or create something new with their knowledge and understanding. Further, the curriculum did not seem to encourage teachers to conduct formative assessments. Teachers typically used summative assessments (tests and exams) instead (Owolabi et al., 2014). These limitations in the curriculum can have a direct connection to the nature of the teaching and learning approaches employed (Harlen et al., 2015).

There is also evidence of a lack of adherence to the curriculum. The teacher guides specifically state that: "a teacher of Basic Science and Technology is a professional instructor who facilitates, promotes and influences pupils to achieve the outcomes and objectives of the curriculum" (Olatunde, 2018, p. 3). However, a review of the literature indicated that teachers in Nigeria (or Africa more broadly) seem to adopt a traditional and didactic role, being 'informers' rather than facilitators of learning (Afolabi, 2013; Aina, 2012). Scholars have attributed students' low performance and interest in science to the use of these didactic approaches, as well as to other challenges, such as inadequate resources and a lack of qualified teachers.

The initial questionnaire provided a general overview of the science teaching and learning perceptions and approaches that Nigerian teachers claimed to utilise. The teachers believed science to be an essential subject and felt confident to teach it. They said they used discovery and hands-on approaches as ways of teaching science, which seemed to align with the curriculum and with contemporary science teaching and learning approaches. However, it was important to observe the teachers' practices to examine how they implemented these techniques because the questionnaire results contrasted with earlier findings which showed that didactic approaches predominated in Nigeria. The contemporary science teaching and learning literature suggest that the teaching and learning of science should be more than just 'hands-on'; it should be 'minds-on' as well (Oludipe et al., 2020; Tytler, 2002; Tytler, 2017; Tytler et al., 2013). I examined this aspect more closely in the second PAR stage of the study.

During the PAR phase, I became more aware of how systemic issues in Nigeria can affect teachers' practices. To explore this further, I reviewed the policy documents and Nigerian Teachers Registration Council documents to understand the process for becoming a qualified teacher in Nigeria and how teachers are supported to develop their expertise (TRCN, 2010).

These documents clearly state the need to employ qualified teachers and provide for those not qualified to upgrade their qualifications. They outlined the minimum entry qualifications to teach in primary schools being an NCE (see Chapter 2). These documents indicated that teacher in-service support is through workshops, conferences, and enrolling at the universities to upgrade their qualifications. However, studies have shown that unqualified teachers are employed in primary schools in Nigeria, giving further evidence of a disconnect between policies and outcomes (Fareo, 2013; Ogunyinka et al., 2015).

The literature also suggested a lack of in-service training for teachers and that when such training opportunities occur, they are in the form of one-off workshop sessions, which may have a minimal impact on teacher practices (Fareo, 2013; Ogunyinka et al., 2015). The findings from the questionnaire were consistent with existing research on this point, as most of the teachers surveyed reported that they had not participated in any science PL. Again, practice was inconsistent with the stated PL policy.

In summary, the goals espoused in the Nigerian curriculum had some alignment with contemporary goals for science teaching and learning as outlined in the literature. Both advocated developing students' scientific, critical, and reflective thinking skills to help them function effectively within society and called for teachers to utilise "participatory, exploratory, experimental and child-centred" (NERDC, 2013, p. 8) approaches. However, my investigation into the implementation of these goals revealed some areas of incoherence. In particular, the prescriptive nature of the curriculum and the limited range of assessment measures seem to promote recall and factual knowledge over the development of understanding and the application of learning in new and authentic ways. Such practices seem to focus mainly on summative assessments with little or no regard for formative assessment processes.

It is important to be aware of these discrepancies, as a lack of coherence can limit the effectiveness of policies (Kenny & Cirkony, in review; Magrath et al., 2019). Further, as the questionnaire results were based on self-reported data, it was essential to explore what was happening in the classrooms, as I did in the second PAR stage of the study.

RQ2: How do science teaching and learning practices within a Nigerian cultural context reflect contemporary goals of science education?

My initial goal in the PAR phase of the research was to immerse myself back into Nigerian culture. This was a useful opportunity to remind myself of things I may have forgotten and aided me in adjusting. In this phase, I visited the schools daily and attended various classes to simply observe the daily routines and occurrences. It was also a valuable time for developing a positive relationship with the TPs and for the students to get used to my presence at the school and in their classrooms. It was obvious that a few of the TPs were sceptical about my presence in the first few days, but most warmed up as time went by.

The initial formal classroom observations enabled me to see the TPs' practices and to understand their relationship to the Nigerian curriculum and effective science teaching and learning approaches. The TPs I observed seemed knowledgeable of the content they taught. However, they were still developing their expertise on *how* to successfully support students to understand *what* and *why* they were learning.

The communication patterns teachers utilised were formal, with teachers doing most of the talking and giving instructions. Their interactions were mainly top-down instructions with few or no interactions between students. Questioning was mainly from the teachers, and these were mostly closed questions that did not stimulate deep thinking and responses. It was interesting that when students asked questions, they were closed-ended questions, too.

The classroom interactions seemed to be consistent with the didactic approaches reported in the literature. The teaching practices I observed contrasted with the dialogical interactions recommended in contemporary science teaching and learning. They also contradicted the findings of the questionnaire, in which teachers said they valued such discussions and engaged students during whole-class and small group activities—I saw nothing of the sort.

The observed assessment strategies were mainly summative, with tests and exams at the end of a term or year. The teachers did not seem to be aware of diagnostic and formative assessment strategies. While this was consistent with the curriculum expectation, it was inconsistent with contemporary approaches to assessments in science teaching and learning. The teachers were sometimes observed using demonstrations, but most of the time, students were asked to just observe, and on few occasions, were invited to copy what the teacher had done. Although it seemed engaging to the students, it did not stimulate critical thinking or provide students opportunities to construct their own learning. This is also inconsistent with contemporary science teaching and learning approaches which suggest students should engage in 'hands-on' and 'minds-on' learning to construct and develop conceptual understanding.

In this PAR stage, although some of the teachers were a little sceptical of my presence at first, most were welcoming. Visiting the schools within the first few weeks was important to forming positive relationships with the teachers and gaining their trust.

This was important to be able to further explore the teachers' perceptions on their context, identity, and practices as science teachers, through a reflexive process.

The Nigerian cultural context, as reflected within the schools investigated, seemed to have a significant impact on the way teaching and learning occurs. My classroom observations revealed a very formal context, consistent with cultural expectations, with a focus on discipline and of students listening to teachers. Teachers sometimes invited students to talk by asking, "*is there any question?*" or "*do you understand?*" which usually resulted in a one-word response. When students interacted with their peers, they were often reprimanded to "*keep quiet*" (see Chapters 8 and 9). This rigid and very structured classroom environment meant that the teacher's voice was dominant, with few or no opportunities for students to express themselves. This showed a contradiction between the suggested dialogical nature of interactions as encouraged in contemporary science teaching and learning.

In summary, my observations went some way to answering the second research sub-question. They revealed that teaching and learning in Nigerian Primary Science classrooms still rely mostly on teacher-centred approaches. The findings generally corroborated the existing literature. There are aspects of the TPs' practices—such as their assessment approaches—which, while congruent with the curriculum expectations, were inconsistent with the contemporary goals of science education. Again, the lack of coherence in this policy area, particularly regarding the student's voice during learning and the assessments strategies, will need to be addressed, considering the Nigerian cultural context. Further interactions with teachers as they reflected on their practice reinforced my understanding of their perceptions about themselves and their roles as science teachers.

RQ3: How do Nigerian primary teachers see themselves and their role as science teachers?

To enable teachers to reflect on their practice, I used video recordings of the science lessons and a semi-structured interview schedule as springboards for discussion. Using the video recordings of their lessons as a reflective practice approach was a subtle way of tapping into teachers' perceptions of themselves and their roles as science teachers (Hofer, 2016; Hollingsworth & Clarke, 2017; Impedovo & Malik, 2016).

Through these discussions, the TPs were able to reflect on their lessons and provide further explanations about their context and practices. The TPs also identified strengths and gaps in their practice. They considered their roles to be highly significant, with the responsibility of helping their students understand the lessons. The TPs perceived themselves, as teachers, as knowledgeable and need to pass that knowledge on to their students. Therefore, they adopted a telling and lecturing style where students did more of the listening.

They all considered science an important subject and one that should be taught practically. They mostly felt comfortable and confident to teach science and thought their students understood the content based on their questions and responses. However, in further discussions about the nature of their questioning, teachers saw that their questions were not encouraging students to think deeply and critically about the concepts explored.

The TPs tried to provide some practical experiences but felt limited by inadequate resources and security concerns. The practical activities they did provide were demonstrations and exploration of the environment, and our discussions revealed that in many instances, the teachers were simply telling or explaining the ideas to the students as they watched and sometimes followed along. We talked about there being a place for explicit teaching and explanations, but that students could be encouraged to reason and develop their ideas through guided inquiry. The TPs gave their reasons for doing things a certain way, what they felt worked well, and the challenges of working in their context, and mentioned areas they might improve in their practice, especially to support their students to be more engaged in their learning. The reflections also helped me understand their practices and gave me a better sense of their PL needs and how I might support them in developing their expertise further.

The teachers appreciated this and mentioned that they did not have opportunities to engage in this form of reflective practice, which they attributed to a lack of time and resources. This revealed a further area of mismatch between policy and implementation (Magrath et al., 2019). The Nigerian professional standards for teachers clearly state, as part of the continuous professional development requirement, that "teachers [should] *continually reflect* on their practice and take responsibility for its development. Teachers are to be open to coaching and constructive criticisms and advice" (*emphasis* added; TRCN, 2010, p. 49). While this policy statement seems to align with what is advocated in contemporary literature about the need for teachers to continually reflect on their practices to develop expertise (Impedovo & Malik, 2016; Winkler, 2001), this requirement was not being met for these teachers. All the teachers commented on the lack of opportunity to reflect with another colleague and get feedback on their practice.

The professional standards-based qualification framework seemed to equate higher degree qualifications with greater expertise (Appendix A). Although having a Master's or Doctoral degree suggests a person's expertise in a particular area, it may not mean that they are more capable in other aspects of teaching than a teacher with an NCE- or Bachelor degree-holder. This categorisation affects how teachers see themselves and the science teaching and learning approaches they may utilise.

Irrespective of qualification but based on levels of proficiency and experience, all teachers should be held accountable for providing quality teaching and learning for all students. Teacher knowledge and expertise is a complex topic and goes beyond content knowledge (Hargreaves & Fullan, 2012; Kenny & Cirkony, (in review); Shulman, 1987). Therefore, determining ways to effectively support teachers to develop expertise is crucial and will be considered in responding to RQ4.

In summary, based on my observations and our reflective conversations, this group of Nigerian Primary Science teachers saw themselves as knowledgeable authorities within their classrooms. The reflective process and discussions with the teachers helped them to become more aware of their practices and identify their strengths, but also see areas they could improve, especially about empowering their students to take ownership of their learning. They identified their approaches as teacher-centred and seemed aware of the need to adopt more "*student-centred approaches that management has been talking about.*" While they recognised that their authoritative position seemed detrimental to students' meaningful participation and engagement, they did not seem to know how to change it. This presented an opportunity for me to offer support to the teachers through PL and in-class support that could possibly help them bridge this gap, as I will explore in more detail in the next section.

RQ4: How can Nigerian primary teachers be supported in order to enrich/strengthen their understanding of effective Primary Science teaching and learning approaches?

My reflections with the TPs enabled them to identify their strengths and areas for improvement and informed the design of the PL to support their use of effective primary science teaching and learning approaches. Although the policy documents recommend that teachers should engage in PL, most of the teachers surveyed in the quantitative phase of the study reported that they had not engaged in any science PL. Only one out of the six TPs involved in the PAR phase of the study had any sort of science PL. However, some indicated that they were attending classes at the local university to upgrade their content knowledge.

I designed the PL sessions for this study so that the TPs could engage in a process of inquiry to explore how they could use more learner-centred approaches within their classroom. This provided both the TPs and RP a way to explore the possibilities and challenges of doing inquiry within the TPs' immediate context. Structuring the PL sessions to model inquiry-based approaches made the learning authentic and relevant to the TPs and in line with recommended approaches for effective teacher PL in literature (Alteratora et al., 2018; Darling-Hammond et al., 2017; Preston et al., 2015).

The ideas and strategies in the PL were shared in a collaborative process in which the TPs took ownership of their own inquiry journey. Each chose an inquiry strategy they wanted to try. My reflection sessions with the teachers after the implementation trials also supported the TPs to keep thinking about their practices and how they could continue to identify strengths and areas for improvement as they strove towards greater expertise.

The messiness and uncertainty of the process was challenging, but the observations and reflections from the PAR phase suggest that there were shifts in TPs' thinking and practices, albeit small ones. The ability of the TPs and I to make changes and be flexible to work within these changing and challenging situations validated the nature of this action research process (Goodnough, 2018). The discussions and experiences the PL provided effectively supported the TPs to make these changes. The value of having a colleague to reflect with and to support the implementation of a new strategy was something the TPs were not used to but found beneficial. The teachers commented positively on the in-class support I provided as they trialled their chosen inquiry-based teaching strategies. This was different from the theoretical learning that some of the TPs were engaged in during the university courses they were enrolled in.

In response to RQ4, teachers' PL needs emerged from my reflections with the TPs on their practice. I designed the PL sessions to enrich the TPs' understanding of learner-centred approaches. The sessions were not theoretical, merely informing teachers but created opportunities for authentic learning where TPs shared and tested their ideas about ways to encourage more student ownership of the learning process. I found modelling the approaches during the PL sessions to be effective. The interactive and collaborative approach I used gave TPs opportunities to experience the inquiry approaches they hoped to trial. Later, I supported the TPs during their trial runs and afterwards in reflection sessions.

This method was consistent with the cyclical nature of PAR and how this kind of support encourages teachers to persist with the new approaches they had tried. The teachers made small shifts in their thinking and practices as they implemented their chosen inquiry-based strategies. These shifts included a change in the physical arrangement of the classrooms to enable students to work in small groups, students engaging in more discussions with peers and teachers, and the teachers improvising by bringing and encouraging students to bring items for explorations. The teachers' questioning also shifted towards open-ended questions, and I saw the teachers utilise diagnostic and formative assessment as they listened more to what their students knew or thought about the topics explored.

Teachers did experience some challenges as they tried to incorporate these approaches into their practice. Some struggled with the rather noisy classroom environment from the increased levels of interaction. The lack of adequate resources also posed a challenge to their implementation. Other unforeseen challenges occurred that impacted the teachers' practices and the research process, as discussed below.

Unforeseen challenges

The teachers identified three categories of challenge: infrastructural (to do with a lack of charts, books, computers, unreliable electricity supply, etc.), curricular (primarily the over-crowding of the curriculum), and social (as a result of political unrest). All of these forced them to modify their practice, reducing their ability to engage their students in their learning.

While working with them, I experienced similar challenges myself. During the classroom observations and the PL sessions, the sporadic electricity supply meant that a portable generator had to be used. Not only that, but I had to buy the fuel to run it so I could share my PowerPoint presentation and make photocopies. This became even more challenging on the second day of the PL when it rained heavily. We had to shut most of the windows, and the generator was cutting in and out because it was not properly sheltered from the rain. This meant that with the limited natural light coming in through the windows, I had to adapt. I suspended my presentation and engaged with the TPs in small group discussions based on an open-ended question while some of the teachers tried to organise a better shelter for the generator. Occurrences like this are common in Nigeria, and this provided me with a snapshot of the challenges teachers face.

A much more serious challenge, for me as a researcher, was the political tensions. These caused me to curtail my work with the teachers and affected my research plans. Again, I had to modify my plans in response to this messiness.

Despite these challenges, I found that Primary Science teachers in Nigeria can be supported effectively if their PL learning needs are identified and teachers are involved in finding solutions to problems. As the literature suggests, an effective strategy in supporting teachers is for PL to enable them to experience the practices they hope to implement. Further, providing in-class support while they tried the new practices empowers them and boosts their confidence to persist in using the newer approaches

However, as I experienced in a limited way, working in a developing country such as Nigeria presents challenges unlikely to be experienced in western countries. These included challenges arising from systemic educational, infrastructural, cultural, political, and communal aspects.

Overarching Question:

In a globalised world, what are the key educational challenges facing contemporary primary school teachers in Nigeria?

One of the key difficulties Nigerian primary school teachers face is the lack of support in understanding and implementing the nation's espoused educational goals. Although these goals and objectives for education in Nigeria are documented in well-intentioned policy documents that hope to support teachers, how they are structured, accessed and translated into practice posed a challenge for the teachers in this study. While the national curriculum is now (commendably) online, it is behind a paywall, and access is further limited by the country's relative lack of computers and internet connectivity. The development of teacher guides and student workbooks is also laudable, but again, accessing these materials, and the prescriptive expectations placed on teachers and students, limits the development of creative and critical thinking.

Further, the lack of teaching and learning resources, although well-documented in the literature, remains a challenge to effective teaching and learning practices in Nigeria (Afolabi, 2013; Aina, 2012; Aina et al., 2017; Ugwoke, 2018). I witnessed the consequences of these limitations throughout the research process. Although teachers and students are encouraged to improvise, there is only so far that can be expected to go before the quality of teaching and learning suffers.

The exam-driven nature of the education system also has a negative impact on the kinds of assessment stipulated in the curriculum. Diagnostic and formative assessments are not clearly mentioned in the curriculum. Instead, the focus seems to be on tests and exams as the main assessment procedure. This may contribute to teachers use of didactic approaches and their reliance on testing students' recall. This limits students' ability to be creative and to see the relevance of their learning as they are unable to apply it in new ways.

In-service teacher support is limited in the Nigerian education sector (Ajani, 2018a, 2018b; Ajani et al., 2018; Fareo, 2013), a conclusion this study bears out. Although mandated in the policy documents, the provision of and support for teacher PL is a challenge, with many teachers unable to attend PL conferences or workshops. Further, the nature and structure of these PL sessions do not cater to teachers' needs. This disconnect between policy and practice has been shown to be detrimental to effective teaching and learning outcomes (Kenny & Cirkony, in review; Magrath et al., 2019).

In addition, the political environment and tensions in Nigeria pose a real threat to effective teaching and learning. The impact of political unrest and insurgent attacks on the lives of Nigerians has been reported in the media, but the effect on education may be under-recognised. Teaching and learning are often interrupted by outbreaks of violence, and even when schools reopen, certain teaching and learning activities are ruled out due to safety concerns. Incessant attacks by Boko Haram (see Section 6.2.6) continue to destroy lives and impede teaching and learning.

11.2 Implications of the Research

In this section, I review my findings and make recommendations that could assist policy development, with specific reference to the curriculum, PL for in-service teachers, and support for science teaching and learning. I conclude with recommendations for further research.

11.2.1 Implications for Curriculum Development in Nigeria

The Nigerian policy on education has as one of its goals the empowerment of students to be creative and active citizens, and suggests, in the National Teacher Education Policy, that teachers should teach in ways that empower students based on a child-centred philosophy (FME, 2014). The goals of science education in Nigeria were broadly stated in an earlier version of the curriculum but not mapped out in the current curriculum. These goals should be clear and concise enough to be interpreted by teachers and all stakeholders.

As mentioned, it is impressive that the Nigerian curriculum is now online, but it can only be accessed with a paid monthly or annual subscription (NERDC, 2017a). It is not clear why this is the case. If the goal is to support schools and, most importantly, teachers, then the curriculum should be accessible at no cost to all teachers and, indeed, to all educational stakeholders.

Adopting a thematic structuring of the content in the Nigerian curriculum was a way in which the curriculum developers tried to make learning relevant to students, but the activities that students and teachers are expected to carry out are quite prescriptive and closed-ended. The assessment section of the curriculum outlines the expectation that students should be able to list and describe aspects of their learning, which does not necessarily allow them to demonstrate creative and critical thinking. Essentially, it does not provide opportunities for them to apply their knowledge and skills or to create something new. Because of this, the curriculum content and, more specifically, the expectations of what students should know and be able to do should be more congruent with Nigeria’s espoused educational goals.

The prescriptive nature of the curriculum does not encourage teacher agency and creativity, and neither does it encourage inquiry approaches. Instead, the goals should be described in ways that challenge students to use their new knowledge and understanding in new ways. Further, summative assessment strategies such as tests and exams should not be the only means of assessing students. These assessments should be reconsidered, as they only seem to test students’ recall which does not encourage inquiry. Formative assessment should be considered and recognised as a valid means of evaluating students’ learning. Teachers would need to be trained on how to use these types of assessments. This would foster a direct relationship between teachers’ approaches to teaching and their expectations.

The crowded nature of the curriculum was another challenge where teachers felt the burden of what it expected to be covered and may suggest why teachers resort to teacher-centred approaches that are didactic in nature. It is therefore important for the developers to continue to consider how curriculum content could be trimmed in ways that could make implementation more feasible and the curriculum more adaptable to inquiry-based approaches.

These challenges have implications for developing teachers' expertise. The provision of necessary funding and resources, as highlighted by previous research, is a matter the government should consider seriously as the curriculum cannot be implemented effectively without the necessary resources.

11.2.2 Implications for Teacher Professional Learning

The importance of PL cannot be overemphasised. In-service teachers need to continue to engage in PL, especially considering the changing times and the need to continue to hone in on knowledge and skills that will support their students' understanding, engagement, and educational growth in general.

Although there seems to be a well-documented PL policy, it does not currently seem to be effective as many teachers are unable to achieve the 130 credit units stipulated (TRCN, 2010, p. 58). Teachers are hardly aware of PL opportunities, and many are unable to attend even the annual conference of registered teachers due to a lack of funds. Finding time to allow teachers to be released to attend such workshops or conferences is a challenge. This need should also be considered in discussions of greater provision of in-school and in-class support to teachers.

Research suggests that the structure of PL sessions should promote TPs' voices and encourage them to take ownership of their learning and professional growth and expertise. This means taking their immediate needs and their environment into consideration and providing PL that supports them in meeting those needs. This could be achieved through a PAR approach to PL. A mentoring model should be used when providing PL as an effective way of sustaining the knowledge and skills teachers acquire in PL. This model allows teachers to work within their classrooms, which may be cheaper than releasing them (Jones et al., 2016; Kenny, 2012). The cost-effectiveness of such a model could be explored in future research.

The government and schools should invest in providing adequate funds and release of teachers to engage in PL experiences as described above to achieve continuous and sustainable development of teacher expertise. A relief teacher system is one the government and schools should consider. Such an arrangement will release the regular or specialist teacher to attend PL and ensure that students are catered for in their absence.

11.2.3 Implications for Science Teaching and Learning

The findings of this study revealed that the TPs were aware of student-centred approaches but were constrained in their ability to implement them. The findings further revealed that they still taught in ways that were more teacher-centred, mostly employing lecturing, explaining and demonstration. The utilisation of IBL approaches has been identified in research as an effective means of supporting students in developing necessary skills to function effectively in the 21st century. In specific reference to science teaching and learning, it means that students are supported to learn how to learn when they are encouraged to think critically, work collaboratively, provide evidence and explanations for their ideas, carry out investigations and be willing to change their ideas to more scientific ones.

The findings also revealed that after exposure to IBL during the PL sessions and through the TPs trialling some of the strategies, a more positive classroom atmosphere was created that encouraged more student participation. The TPs revealed how such engagement freed them and enabled them to take up a participatory facilitator role, one that encourages and challenges students' thinking and learning by providing constructive feedback.

This raises a cultural issue. In Nigeria and wider Africa, the teacher is considered all-knowing, and it is seen as disrespectful to question or challenge them. This is a serious barrier to participation that needs to be addressed if these forms of teaching are to be implemented. It probably also has implications for pre-service training, where teachers may need to learn to adopt the 'Teacher as Learner' stance and consider that, although teachers may be the more knowledgeable, students' voices should be prioritised.

When teachers adopt a TaL stance, they may be more open to the expertise and help of others in their teaching practices. This could mean deliberately planning and engaging with the broader school community, which could include inviting people with specific scientific knowledge, parents, or indigenous elders to share their knowledge and experiences with students. Engaging with the broader community could support students to see the relevance of their learning.

11.2.4 Implications for Further Research

The purpose of this study was to gain a deeper understanding of what constitutes effective Primary Science teaching and learning practices and to explore whether and how Nigerian primary school teachers are implementing such approaches in encouraging their students' deeper engagement in their learning process. Through a PAR process and a strengths-based approach, this exploration created opportunities to celebrate things teachers were already doing well and support them where we identified gaps. Although the findings from this small case study are very context-specific, with a limited population, and thus non-generalisable, they may be informative to understand what is happening and how to support Primary Science teachers in Nigeria more broadly. As a developing country, this research on Nigeria may also be useful for others conducting research in Africa or in other developing countries where resources, political tensions and culture may be important factors.

Further research could also involve follow-up interviews with the teachers to see if their practice has been altered in the longer term.

In addition, the research revealed the benefit of the PAR methodology in enabling me as the researcher to adjust my plans in response to unforeseen circumstances. Researchers need to be able to adapt plans for unforeseen circumstances by adopting methodologies that support them to deal with disruptions. This is not necessary only in developing societies, but in any society, especially given the present COVID-19 pandemic. Although it is important to have a plan, it is also necessary for researchers to realise the unpredictability of situations and to be prepared to modify those plans. An open mindset and trying to anticipate disruptions can help. Researchers should consider adopting a methodological approach that allows for flexibility. In this instance, PAR allowed this flexibility due to its cyclical nature (Altrichter, Kemmis, McTaggart, & Zuber-Skerritt, 2002; Corbett & Hill, 2018; Stringer, 2014). It created a flexible space in which to conduct research, releasing both the teacher participants and I from the pressure of 'fixing' problems outside our control and allowing us to focus on classroom practices that were in our power to change.

To the best of my knowledge, there has been no documented use of PAR as an inquiry approach and as a process of supporting teachers to improve their practice in the Nigerian context. It would be important to consider the use of PAR in further research as a way of identifying teacher needs, supporting them, and developing their confidence in teaching and learning of science and in the Nigerian educational context more broadly.

Finally, this research has only touched the surface of the challenges of doing research in developing countries and Africa in particular. That said, it does map out some strategies for dealing with cultural expectations and challenges, which may be beneficial to education researchers.

11.3 Contribution of this Study

This study contributes to the knowledge and understanding of Nigerian Primary Science teachers' teaching and learning approaches by revealing their perceptions and practices, celebrating their strengths, and identifying gaps as they strove to support their students to be active participants in their learning.

The sequential methodological approach incorporating the cyclical nature of PAR, enabled the TPs to be active participants in this inquiry. Reflection and identifying strengths, gaps, and challenges, as well as strategies to overcome some of these challenges, were processes the TPs were not used to. This conforms with previous research on overcoming such challenges in the Nigerian and broader African contexts. This study goes further by exploring how these teachers practice, but more importantly, by celebrating what they are doing well, identifying the gaps in their practice and empowering them to identify ways to improve.

Through the PAR phase of the study, I provided the TPs with further support in reflecting on their practice and in the implementation of the new strategies they trialled. The study revealed the benefits of providing one-on-one in-service teacher support and feedback for improving teacher practice.

This study has highlighted the pedagogical, cultural, systemic, and political challenges of teaching and learning in the Nigerian context. These challenges affected not only teaching and learning but also the research process. Through the affordances of PAR and working within the TPs' contexts, we were able to navigate the challenges and disruptions. I supported the teachers to make small shifts in their thinking and practice through an exploration of inquiry-based approaches to science teaching and their trial of some of these approaches. Their classroom interactions began to shift from mainly teacher-dominated interaction to the teachers seeking students' opinions. This was closely related to the open-ended and probing questions that the teachers started to use to encourage deeper student thinking and responses. Most importantly, the TPs reported the positive effect on student learning and engagement resulting from incorporating such approaches in their lessons, and they planned to continue to reflect on their practices.

Through PAR, participants were empowered to take the "construction and reconstruction of their social reality into their own hands" (Kemmis & McTaggart, 2000, p. 572) in a social setting and did that knowing that they were supported. The PAR process also increased my understanding of the need for further study on the impact of systemic and cultural factors on the research process.

11.4 Research Limitations

Although I conducted initial surveys about teachers' beliefs and practices in the quantitative phase across several schools, the sample size was rather small due to time and financial constraints, which means the findings cannot be generalised. The qualitative PAR phase of the study was limited to a case study of two private primary schools in Jos, Plateau State, Nigeria. Although it provided an in-depth understanding of the teachers' context and practices, it may not be generalisable either. I would recommend a study covering a broader geographical area, including government schools and possibly over a longer period, factoring in possible disruptions. The political and national unrest limited the research processes, causing erratic school closures and the consequent curfew shortening the PL sessions.

11.5 Final Reflections

Since embarking on this study, my journey of learning continues to evolve. I have been challenged and grown in my thinking and ability to work with and learn from others. Although the research focused on a small sample, it enabled me to work closely with the TPs and dig deeper to understand their practices and support them. As indicated in the TPs' reflections, I too emerged from this research empowered with a deeper understanding and appreciation of the passion that drives teachers to remain in this profession even with the many challenges they face. Their willingness to learn and trial a new approach and reflect on it was commendable, and that motivates me to continue to improve my own practice.

My curiosity and desire for ongoing learning mean that, through this research, more questions have been raised: I wonder how the Nigerian curriculum could be modified to better reflect ways to challenge students to apply their knowledge and skills in new ways and incorporate indigenous ways of knowing. How could a systemic approach to the provision of casual or relief teachers be implemented to deal with teachers being absent for PL or other reasons and for the continuous support of students' learning? Mentoring-type support for teachers was effective and beneficial in this study, and this leads me on a quest to discover how such mentoring-style in-service support could be provided within the Nigerian educational setup. Finally, I wonder if the government has considered how the incessant political and tribal tensions affect the education of its future leaders and what it is doing to address this.

Through the PAR cyclical approach in this project, I became more conscious of my role as a researcher. I learned more about the power of working as a team and being a coparticipant with the teachers. My adaptation to the cultural context was also important to the formation of positive relationships and openness with the principals and TPs involved in the study. Although I am a Nigerian national and had learning experiences in the Nigerian context, it was vital for me to re-immerse myself to gain trust, cultural awareness, and understanding of the school, the classroom culture, and teachers' practices. I also learned and witnessed how teachers' confidence can be boosted when they make decisions that change their practice, rather than just being passive recipients of knowledge; the TPs were more willing and eager to try solutions and approaches they had experienced for themselves.

Further, I learned that the process of change is indeed a slow one. The TPs took small steps to adjust their practices while I was present. Through an unsolicited email from Mr Dachung, I learned that I had had a long-term positive impact:

> *I am constantly using the knowledge to teach in my science class, and it is yielding better results. Your suggestions, most especially regard the participation of pupils/students during the class, is in use by me.*

In an informal phone conversation, another teacher, Mrs Oga, commented how she was still using the *Think–Pair–Share* strategy to encourage her students to share their ideas.

I was excited to hear that, two years since these PL explorations, at least two of the teachers have been empowered to maintain the strategies we explored and that despite the slowness and difficulty, positive change is possible and should be celebrated.

But the story does not end here because the development of expertise as a teacher and researcher is an ongoing process of frequent and thoughtful reflection on actions and inactions.

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Appendix A

Sample pages of Professional Standards for Nigerian Teachers

SECTION TWO
PROFESSIONAL KNOWLEDGE

The following are the sub-themes, standards and expected performances under Professional Knowledge:

STANDARDS	EXPECTED PERFORMANCE			
	NCE Teachers	**Graduate Teachers**	**Master Teachers**	**Doctoral Teachers**
Sub-Theme 1: Subject content				
(1) Teachers know the content of the subjects they teach.	Teachers' knowledge covers all the themes and topics stipulated in the subject curriculum issued by the appropriate curriculum authority. For instance, a teacher in a Basic School is expected to know all the subjects, themes and topics in the Basic School Curriculum issued by the NERDC.	The same. For instance, a teacher of Mathematics at Senior Secondary Education level is expected to know all the themes and topics stipulated in the curriculum of Senior Secondary School Mathematics issued by NERDC, JAMB, NECO, WAEC, and other relevant authorities at that level.	Teachers know their specialized teaching subjects and know all the relevant themes and topics prescribed by the Minimum Academic Standards for the subjects.	Teachers know all the themes and topics in their specialized teaching subjects prescribed by the Minimum Academic Standards and have advanced knowledge of these subjects based on recent theories and research findings.
Sub-Theme 2: Pedagogy				
(2) Teachers know how to teach subject content to their students and related assessment and monitoring strategies.	Teachers know the general and specialized methodologies and techniques for teaching, assessing and monitoring student performance in	Teachers know how to utilize several behaviour management strategies to empower learner growth and development.	Teachers have critical understanding of the strengths and weaknesses of the various strategies ones most suitable for specific situations.	Teachers know the innovations and global best practices in the methodologies for teaching, assessing and monitoring student performance in

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	their subjects.			their subjects.
Sub-Theme 3: National Curriculum equirements				
(3) Teachers know the national curriculum requirements.	Teachers are conversant with other relevant sections of the national curriculum other than just the content of the subject they teach.	Teachers know the assessment requirements for their subject and curriculum areas including requirements of the various national examinations.	Teachers know the sources of national and international statistical and related information needed to assess curriculum performance.	Teachers understand how to use national educational statistics and related information to accurately evaluate and improve curriculum implementation.
Sub-Theme 4: Literacy and Numeracy				
(4) Teachers know literacy and numeracy.	Teachers know basic reading and writing of English and their language of classroom instruction. Teachers know the basic operations of addition, subtraction, multiplication, and division as well have general quantitative aptitudes.	In addition, teachers have advanced ability to comprehend literature, grammar and syntax; know how to write essays, compositions, applications, feature article and similar assignments. Teachers have advanced quantitative aptitudes.	In addition, teachers have excellent understanding of written and spoken English and language of classroom instruction. Teachers understand the use of computer to develop data base of their students activities and reports and related assignments.	In addition, teachers understand written and spoken English and language of classroom instruction in international context. Teachers know how to use the latest statistical packages to analyse and present research findings and to draw inferences.
Sub-Theme 5: Information and Communications Technology				
(5) Teachers know the application of modern computer systems and communication technology.	Teachers know parts of a computer and basic computer operations; use computer software (e.g. Microsoft Word, Power Point); use of the internet; use of emails and other communications devices.	In addition, teachers know the use of projectors for lesson presentations; use of computer software to compute and store students' examination scores and personal data, etc. Teachers know the	Teachers know how to computerize most of their classroom activities; conduct academic research using digital libraries.	Teachers know how to maintain robust relationship with the international academic community using information and communication technology; Teachers know how to give their academic work maximum enrichment and

Appendix B

Ethics Approval: Human Research Ethics Committee, Tasmania

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
Fax: (03) 6226 7148
Katherine.Shaw@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

UTAS

08 June 2018

Dr Greg Ashman
Education
Private Bag 1307

Dear Dr Ashman

Re: FULL ETHICS APPLICATION APPROVAL
Ethics Ref: H0017300 - Let's learn together! Exploring the Pedagogical Approaches of Nigerian Primary Teachers in Developing Scientific Literacy

We are pleased to advise that the Tasmania Social Sciences Human Research Ethics Committee approved the above project on 07 June 2018.

This approval constitutes ethical clearance by the Tasmania Social Sciences Human Research Ethics Committee. The decision and authority to commence the associated research may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or review by your research governance coordinator or Head of Department. It is your responsibility to find out if the approval of other bodies or authorities is required. It is recommended that the proposed research should not commence until you have satisfied these requirements.

Please note that this approval is for four years and is conditional upon receipt of an annual Progress Report. Ethics approval for this project will lapse if a Progress Report is not submitted.

The following conditions apply to this approval. Failure to abide by these conditions may result in suspension or discontinuation of approval.

1. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval, to ensure the project is conducted as approved by the Ethics Committee, and to notify the Committee if any investigators are added to, or cease involvement with, the project.

A PARTNERSHIP PROGRAM IN CONJUNCTION WITH THE DEPARTMENT OF HEALTH AND HUMAN SERVICES

2. Complaints: If any complaints are received or ethical issues arise during the course of the project, investigators should advise the Executive Officer of the Ethics Committee on 03 6226 7479 or human.ethics@utas.edu.au.

3. Incidents or adverse effects: Investigators should notify the Ethics Committee immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

4. Amendments to Project: Modifications to the project must not proceed until approval is obtained from the Ethics Committee. Please submit an Amendment Form (available on our website) to notify the Ethics Committee of the proposed modifications.

5. Annual Report: Continued approval for this project is dependent on the submission of a Progress Report by the anniversary date of your approval. You will be sent a courtesy reminder closer to this date. **Failure to submit a Progress Report will mean that ethics approval for this project will lapse.**

6. Final Report: A Final Report and a copy of any published material arising from the project, either in full or abstract, must be provided at the end of the project.

Yours sincerely

Emma Field
Ethics Officer
Tasmania Social Sciences HREC

Appendix C

Approval Letter from Ministry of Education, Plateau State, Nigeria

PLATEAU STATE UNIVERSAL BASIC EDUCATION BOARD

PLATEAU STATE UNIVERSAL BASIC EDUCATION BOARD

Telephone: 073 - 464260.

All correspondence should be directed to the Executive Chairman

Ref: SUBEB/OFF. 6/VOL. I/17

Plateau State Universal Basic Education Board,
Private Mail Bag 2063,
Jos,
Plateau State,
Nigeria.

Date: 3th July, 2018 20

Lois Nanshunyang Kidmas
School of Education
University of Tasmania,
Australia

RE: REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY

Reference to your letter dated 6th June, 2018 on the above subject; I am directed to convey the Board's approval of your request to conduct the research study within Bassa LGEA during the first term of the 2018/2019 school year.

Wishing you good luck as you carry out the research study.

A.S. Tanko
***For:* Executive Chairman**

Appendix D
Letter to Principals Requesting Teacher Participants

UNIVERSITY of TASMANIA **College of Arts, Law and Education**

Let's learn together! Exploring the Pedagogical Approaches of Nigerian Primary Teachers in Developing Scientific Literacy

Dear Sir/Madam,

My name is Lois Nanshunyang Kidmas. I am a PhD candidate at the University of Tasmania, under the supervision of Drs Greg Ashman, Megan Short and John Kenny. I am writing to request your permission to invite teachers in your school to participate in my research project in partial fulfilment of the Doctor of Philosophy (Education) degree.

My study aims to explore primary teachers' approaches to teaching Science and how they perceive their role as science teachers, and their students' roles in learning science. The study hopes to explore the teaching practices of Nigerian primary teachers with a view to developing and enhancing scientific knowledge, skills and literacy. Initial surveys using questionnaires will be distributed to teachers to obtain general information about their ideas on Primary Science teaching and learning, and their willingness to further participate in a more in-depth study of their practice through observation, reflection, planning and implementation stages.

Data collection will occur in two (2) phases. Phase 1 will involve a survey of primary teachers in public and private primary schools within the Jos- Bassa Local Government Area. A questionnaire will be used to obtain a general overview of teachers' backgrounds, beliefs and perspectives about teaching and science teaching and learning, in Nigeria. The surveys will be conducted between May and July 2018. In Phase two, teachers from one selected school will be invited to participate in a Participatory Action Research. Activities in this phase will include an observation of the class teacher teaching by the researcher, a reflective session (15 minutes interview post teaching session), a Professional Learning session for all participants and the planning and implementation of revised plans by all participants. I have attached the letters of introduction and consent forms which explain in detail, the procedures involved in participating in this study.

Thank you for taking the time to consider allowing your teaching staff to assist with this study and please do not hesitate to contact me if you require any further clarification. Should you grant permission, I request that you pass on the information and consent letters to teachers in your school. Would you please advise me of your decision to participate by return email?

Kind regards,

Lois Nanshunyang Kidmas

University of Tasmania,

Australia

Appendix E

Teacher Information Letter

UNIVERSITY of TASMANIA

College of Arts, Law and Education

Let's learn together! Exploring the Pedagogical Approaches of Nigerian Primary Teachers in Developing Scientific Literacy.

Dear Teacher,

Invitation

You are invited to participate in a study to explore the teaching and learning approaches utilised by Nigerian primary teachers in supporting students to develop scientific literacy. This study is being conducted in partial fulfilment of a PhD for Lois Nanshunyang Kidmas under the supervision of Drs Greg Ashman, Megan Short and John Kenny.

What is the purpose of this study?

The purpose of this study is to investigate effective primary school science teaching and learning practices and how Nigerian primary teachers may employ these instructional practices within their context, recognising that there may be limitations. We are particularly interested in those actions carried out by teachers that serve as being beneficial to overall student outcomes in learning science. The personal qualities and attributes of individual teachers will not be the focus of this research.

Why have I been invited to participate?

You have been selected to participate in this study because you are currently teaching in a primary school and are responsible for teaching Primary Science in your classroom.

If you consent to participate in this study, you will be invited to contribute data in the following ways:

Initial surveys:

- completing an initial survey questionnaire about your beliefs about science teaching and learning

  Further study (should your school be involved in a more in-depth study)

- having your teaching observed and video-recorded and your written work (e.g., lesson plans, diagrams or explanations) photographed.
- participating in audio-recorded follow-up interviews for up to 15 minutes after each lesson.
- participating in a Professional Learning (PL) session to discuss strengths and possible areas to improve pedagogical practices.
- developing and delivering a lesson plan considering information from the PL session which will be observed and recorded.
- participating in an audio-recorded follow-up interview for up to 15 minutes to reflect on the lesson taught.

  Details of the above activities are given in the next sections.

Lesson observations

The researcher will observe science lessons that you teach your students. It is anticipated that at least two observations will occur on whatever science topic you are teaching. The lesson observations will be as unobtrusive as possible and will be conducted by the researcher while you continue with your teaching. Data collected during the lesson observations will be in the form of field notes that document the teaching and learning interactions that take place as well as aspects of your direct instruction to the whole class.

Video recording of lessons and written work photographed

With your consent the lessons observed by the researcher will be video-recorded. The primary purpose of video-recording each lesson is to obtain documentation of teaching and learning interactions for later description. The researcher may also take photographs of your written work such as your examples on the whiteboard, and students' responses to tasks in their exercise books to supplement the video footage.

The video camera will be placed in a fixed position at the back of the classroom, with the lens set to focus on you the teacher. Student faces will not be captured and if any of the students inadvertently appear in any of the recordings they will be pixelated in the recordings. Only the researchers and possibly, on rare occasions yourself, will see the video footage.

Audio recorded interviews

After each of the two lessons observed by the researcher, you will be invited to participate in an interview with the researcher at a mutually convenient time. Each interview will take no longer than 15 minutes and will be audio-recorded and transcribed. During the interviews the researcher will invite you to respond to questions that arise from the following sources:

- Observations of particular teaching and learning interactions that occurred during the day's lesson. On occasions, this may include viewing video footage, as a visual reminder of particular learning and teaching events.
- General questions about your own identification and perception of significant teaching and learning interactions.

You will be offered the option to read and amend the transcripts of your interviews.

Are there any possible benefits from participation in this study?

The study will give you an opportunity to reflect on, examine and discuss your practice. The science research community and the teaching community may benefit from the findings of this study in terms of identifying the kinds of teaching practices that are most influential in assisting students in their learning of Primary Science. The findings from this study will offer teachers, researchers and students further insight into Primary Science.

Are there any possible risks from participation in this study?

It is hoped that your participation in the study will not interfere with the usual activities of teaching and learning with your class. Data collection will occur at mutually agreed times and not around revision and examination periods. Although this is not anticipated, there is a chance that you may feel anxious during an interview or during lesson observations. You can decline to answer any or all questions or ask that the interview cease at any time without any explanation or consequence. Similarly, you may ask that any observation and video recording and photographing of your participation in the lesson cease at any time without explanation or consequence.

What if I change my mind during or after the study?

If you decide to decline your participation at any time, you may do so without providing an explanation. You will be able to view and amend your own interview transcripts and ask that any data that you have contributed be withdrawn from the study up until the end of November 2018.

What will happen to the information when this study is over?

Surveys, hard copies of interview transcripts, audio and video files, and photographs will be stored on the Launceston campus of the University of Tasmania in locked cabinet, accessible only by the researchers. Your name and other identifying information will be removed from these data and replaced with a code. Computer files will be password protected and stored on a secure server at the School of Education, Launceston campus. After a period of five years from the publication of the thesis, all transcripts and field notes will be shredded, computer files deleted, raw audio and video recordings, and photographs deleted. All information collected by the researchers will be treated confidentially.

How will the results of the study be published?

After the completion of data collection at the end of 2018, the researcher will provide a summary report of the data for participating teachers and students. You will be provided with the thesis in electronic form when the thesis is completed by the end of the 2020 school year. The thesis will also be available to students and their parents upon request.

Teachers, students, and schools will be anonymous in all publication of results. Pseudonyms will be used when referring to quotes from interview transcripts and descriptions from lesson observations in all publications of results of the study.

What if I have questions about this study?

If you have any questions relating to this study, please feel free to contact one of the researchers: Lois Kidmas email: lois.kidmas@utas.edu.au or Dr Greg Ashman Email: Greg.Ashman@utas.edu.au

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on +61 3 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants.

Thank you for taking the time to consider this research. If you would like to participate in this study, please indicate on the consent form if you agree to be involved and sign it. **Please return completed forms in paid return-envelop to local Nigerian postal box to C/O Prof Barnabas Kwaha, P.O. Box 1655, Jos- Plateau.**

Appendix F

Teacher Consent Form

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Let's learn together! Exploring the Pedagogical Approaches of Nigerian Primary Teachers in Developing Scientific Literacy

1. I have read and understood the Information Sheet for this study.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves:

    Having my teaching observed by the researcher.

    Participating in a reflection and planning process

    Participating in a Professional Learning (PL) session

    Implementation of lesson plans

    Having my teaching video-recorded by the researcher.

    Having photographs taken of my written work that I produce/use in class.

    Participating in a post-lesson audio recorded interview following each lesson observed by the researcher.

4. I understand that my participation in this study involves low risk.
5. I understand that all research data will be securely stored on the Launceston campus of the University of Tasmania for five years from the publication of the study results, and will then be destroyed
6. Any questions that I have asked have been answered to my satisfaction.
7. I understand that the researcher(s) will maintain confidentiality and that any information that I supply to the researcher(s) will be used only for the purposes of the research. I understand that in any public documents arising from this research, pseudonyms will be used for my own name and the names of my school and students.

8. I understand that the results of the study will be published so that I cannot be identified as a participant.
9. I understand that my participation is voluntary and that I may withdraw at any time without any effect.

If I so wish, I may request that any unprocessed data I have supplied be withdrawn from the research.

I give consent to participate in this study.

Yes ☐ No ☐

Participant's name: ____

Participant's signature: ____

Date:________________________

Statement by Investigator

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have had the opportunity to contact me prior to consenting to participate in this project.

Investigator's name:

____

Investigator's signature:

____

Date: _____________________

Appendix G

Parent Information and Consent Letter

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Appendix G: Parent Information Letter

Dear Parent/Guardian,

This letter is to inform you that your child's teacher has consented to participate in a research study that explores the teaching and learning approaches utilised by Nigerian primary teachers in supporting students to develop scientific literacy.

The research involves observing your child's teacher with specific reference to science teaching approaches as well as videoing your child's teacher teaching. Discussions with the class teacher about their teaching practice will follow. This observation will mean that the researcher and the teacher may need to look at students work samples and discuss after a teaching session. Such action has no implication on your child's assessment.

Thank you.

Kind regards,

Lois Nanshunyang Kidmas
University of Tasmania,
Australia.

Please indicate below whether or not you are happy for the researcher to look at samples of your child's work with the teacher.
I give consent for the researcher to view my child's work along with classroom teacher to reflect on teacher's practice in the above-mentioned study.

Yes ☑ No ☐

Parent's name: _

Parent's signatu

Date: 8/10/2018.

Appendix H Classroom Observation Checklist

Date:

Time: Start Finish:

Class: No. of Students:

Lesson Length:

Science Concept/Topic:

Criteria/Rating scale	**Exceeds Expectation**	**Always Demonstrated**	**Sometimes Demonstrated**	**Not Demonstrated**
Planning: Has a clear learning outcomes for the lesson based on the curriculum Evidence of lesson planning Teacher and student resources were organised Teacher made provisions to improvise as necessary				
Classroom Setup: Tables and chairs are arranged in ways to enable small group discussions Classroom has charts, pictures or student				

work samples on display Various working spaces are created				
Content Knowledge: Teacher appears knowledgeable about topic taught Teacher explains current scientific knowledge and thinking				
Classroom Expectation & Pedagogy: Students are involved in setting classroom expectations Teacher shares the intended learning outcomes with students All students are engaged Students are provided opportunities to share their ideas				

Students had opportunities to explore and test their ideas Students had opportunities to collect evidence and explain their thinking Students had opportunities to work in small groups Teacher used open-ended questions Students had opportunities to ask questions Connections to real-life situations are made				
Behaviour Management: Teacher recognises and commends students' positive behaviour Negative behaviour is immediately and appropriately addressed				

Cultural considerations: Teacher tries to build positive relationships with students Respect for students and their opinions Learning relates to students cultural dispositions Learning connects to students experiences and local context				
Assessment: Students' prior knowledge was elicited Opportunities to collect formative data was provided Teacher gave timely feedback Students had opportunities for self-assessment Opportunities for peer				

assessments were provided				
Comments:				

Appendix I

Interview Schedule-Post Classroom Observation

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The interviews will take no longer that 15 minutes and will include questions that arise from the following sources:

- Observations of particular teaching and learning interactions that occurred during the day's lesson.
- General questions about the teacher's identification and perception of significant teaching and learning interactions.
- Video footage and accompanying photographs of written work may be used as a visual stimulus for teacher to recall specific incidents/actions that took place during the lesson.

Following are examples of the generic questions that teachers will be invited to respond to:

i) What do you believe science teaching is?

ii) How do you feel the lesson went? What are some aspects of the lesson that worked well?

iii) What were some challenging aspects of the lesson?

iv) How would you improve these aspects of the lesson if you had a chance to teach it again?

v) What is your overall opinion of students' engagement during the lesson?

vi) What is your overall opinion of students' understanding of the topic taught?

vii) What evidence can you draw on from the lesson to demonstrate your response to question iv. above?

viii) How are you able to judge when learning is occurring in your classroom?

ix) What do you think is the most important way that science teaching could be improved in your school?

Appendix J

Sample of Initial Codes

Nodes

Name	Files	References
Classroom interactions	16	211
Before PL	11	280
Teacher QuestioningBefore	18	679
Closed questions	16	305
Asking what's happening	1	1
Open ended question	15	86
Opportunities to make questions more open-ended	9	19
Reviewing previous learning	3	3
Teacher answering before PL	2	7
After PL	5	191
Teacher Questioning After PL	6	296
closed questions	5	112
Open questions	5	71
Encouraging deeper thinking after PL	2	5
Teacher assisting students in class after PL	1	2
Instructional or procedual interactions	16	164
Note copying from the board	11	27
Punishment	4	10
Learning to avoid punishment	1	1
Correcting students' pronunciation	3	3
Finishing tasks before next subject begins	1	1
Direct instructions	0	0
Pedagogical interactions	1	1
Acknowledging student response	20	126
Repetition	15	49
Before PL	5	26
after PL	4	12
Teacher definitions	6	23
Encouraging more students to talk	8	19

Appendix K

Sample Exam Question

Section B: Essay

nswer all questions

1. (a) Define wind.
   (b) State 4 sources of wind.
   (i) ______________ (ii) ______________
   (iii) ______________ (iv) ______________
2. Mention 5 uses of soil.
   (i) ______________ (ii) ______________
   (iii) ______________ (iv) ______________
   (iv) ______________
3. St. te 5 source of water
   (i) ______________ (ii) ______________
   (ii) ______________ (iv) ______________
   (iv ______________
4. Wh. h of the 'ollowing below are living this? Which of them are ı on-living things?

(a) D ck (f) Lizard
(b) Or ge tree (g) Ball
(c) Okra ee (h) Fish
(d) Rock (i) Insect
(e) Electric po (j) pencil

Living things		Non-lIving things	
(i)	______________	(i)	______________
(ii)	______________	(ii)	______________
(iii)	______________	(iii)	______________
(iv)	______________	(iv)	______________
(v)	______________	(v)	______________

Appendix L
Sample Evaluation Form

Evaluation Form

Professional Learning Session Inquiry Learning and Teaching of Science in Primary Schools in Nigeria.

Presented by: Lois N. Kidmas (Mrs)

PhD Candidate, Faculty of Education

University of Tasmania, Australia.

Kindly take a few minutes to complete this feedback form to share your opinion about the Professional Learning Session. Your opinion is valuable, so feel free to express yourself. This will assist in improving subsequent sessions.

1. What subject (s) do you teach?

2. How relevant was the session to your practice? (Circle)
   a) Not relevant b) Somewhat Relevant c) Not sure d) Relevant e) Highly relevant

3. Were some of the ideas presented familiar to you? (Circle)
   a) Not familiar b) Somewhat familiar c) Not Sure d) Familiar e) Completely familiar

4. What parts of the session did you find most useful? Why?

5. Please indicate one specific aspect you intend to implement within your classroom teaching and learning next week.

6. Will you be interested in attending a subsequent session? Yes No
7. What specific teaching and learning area would you like more professional learning in?

8. What suggestions do you have on how to improve subsequent sessions?

Thank you for your input.