# Classroom practices of Grade 9 Natural Sciences teachers when teaching the planet, earth and beyond topic: A case study

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## DECLARATION

I, the undersigned, David Modise Sentsho, hereby declare that the work contained in this dissertation is my own original work and that I have not submitted it previously, in its entirety or in part, at this or any other university for a degree.

_____

David Modise Sentsho

February 2021 .

Date

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First and foremost, I express my deepest appreciation to my supervisor, Professor Washington T. Dudu, for being supportive, patient and for having confidence in me. I would like to thank my supervisor (at work), Joyce Godisamang Poti, who was also my research assistant, for all the support and advice she gave me during difficult times. I am thankful to Dr Lephogole C.M for her unwavering support throughout my study. Without the support of my family, my wife Emily Sentsho and my children, and all my friends who supported me throughout my study, I couldn't have made it. Thank you very much. My sincere gratitude goes to the North West Department of Education for granting me permission to conduct this research, especially the teachers who voluntarily participated in this study, and their families. I am also thankful to NRF for sponsoring my studies. Through God, anything is possible.

## DEDICATION

I dedicate this dissertation to my brother, Levy Molefe Sentsho, my mother, Bettie Modie Sentsho, and my father, John Modibeng Sentsho, for believing in me, and for ensuring that I received all the necessary support and funding from the early years of my schooling to where I am right now.

## ABSTRACT

This study focuses and aims to contribute to research-based classroom teacher practices by addressing the main research question: How does teachers' Pedagogical Content Knowledge (PCK) of *Planet Earth and beyond* strand concepts influence their teaching? The study followed qualitative methodology. Data were gathered through pre-intervention interviews, an intervention workshop, post-intervention interviews, and document analysis of lesson plans, participants' manual journals, and portfolios of evidence. The intervention workshop was conducted as a Professional Development Programme, with the purpose of improving teachers' PCK and classroom practices in relation to the teaching of *Planet Earth and beyond* topics. Six schools purposively and conveniently selected participated in this study, hence a multiple case study design was employed to generate data. A teacher from each school teaching Natural Sciences was also purposively selected. The IMTPG model was utilised as data analytic tool. The study revealed that the pedagogical Content knowledge of teachers, teachers' orientations towards science teaching, knowledge of science curricula related to *Planet Earth and beyond*, teachers' knowledge of learner understanding of science, their beliefs, skills, attitudes towards teaching *Planet Earth and beyond*, and confidence level to teach *Planet Earth and beyond* had improved. The study also revealed that at the current moment, training qualifications for the selected Natural Sciences teachers do not cover the *Planet Earth and beyond* strand. The study recommends that teachers be taken through interventions for professional development programmes at the end of term three to enhance their pedagogical content knowledge of *Planet Earth and beyond*, and professional development programmes to focus on both content and pedagogy. Content discussion should not to be coupled with moderations or any other activity, other than discussing pedagogy and content.



**Keywords:**

*Classroom practices, Pedagogical Content Knowledge (PCK), Planet Earth and beyond, Science orientation, Community of Practice (CoP)*

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ACE | Advanced Certificate in Education |
| AC | Alternative Conception |
| CAPS | Curriculum and Assessment Policy Statement |
| CK | Content Knowledge. |
| CoP | Community of Practice |
| CS | Change Sequence |
| DBE | Department of Basic Education |
| DC | Domain of Consequence |
| DoE | Department of Education |
| DP | Domain of Practice |
| ED | External Domain |
| EGD | Engineering Graphics and Design |
| FDE | Further Diploma in Education |
| GET | General Education and Training |
| GPK | General Pedagogical Knowledge |
| GN | Growth Network |
| IMTPG | Integrated Model of Teacher Professional Growth |
| LSAY | Longitudinal Study of American Youth |
| MPCK | Maker Pedagogical Content Knowledge |
| NCS | National Curriculum Statement |

| | |
|---|---|
| NWPA | North West Provincial Assessment |
| PCK | Pedagogical Content Knowledge |
| PD | Professional Development. |
| PK | Pedagogical Knowledge |
| PLC | Professional Learning Community |
| PPT | Prospective Primary Teachers |
| PSCT | Preservice Chemistry Teachers |
| RNCS | Revised National Curriculum Statement |
| SCK | Science Content Knowledge |
| SMK | Subject Matter Knowledge |
| STaRRS | Science, Teachers and Rangers Research Scientists |
| STSP | Student Teacher Scientist Partnerships |
| TPCK | Technological Pedagogical Content Knowledge |
| TSPCK | Topic-Specific Pedagogical Content Knowledge |
| UDES | University Diploma in Education |

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# CHAPTER 1

# INTRODUCTION AND BACKGROUND OF THE STUDY

## 1.1 INTRODUCTION TO THE STUDY

This study investigated South African Grade 9 Natural Sciences teachers' classroom practices in the teaching of the *Planet Earth and beyond* strand, in the Bojanala District of the North West province. This is a Senior Phase topic in the Curriculum Assessment Policy Statement (CAPS) (DBE, 2011). In this study, classroom practices refer to the teachers' abilities to acquire knowledge, develop learning and teaching material, and the usage of the correct methodology to impart knowledge, to assess and foster understanding, as well as to grow professionally.

In this study classroom practices focused on four pillars of pedagogical competence, namely content knowledge (CK), pedagogical knowledge (PK) (the teaching approaches used), pedagogical content knowledge (PCK), and teachers continued professional development (TCPD).

Pedagogical competencies refer to teachers being able to transform their content knowledge (CK) through drawing interactively on other teacher knowledge bases (general pedagogical knowledge, content knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners, knowledge of educational contexts, and knowledge of educational ends, purposes and values) to formulate effective teaching strategies (Aydin & Boz, 2013; Mavhunga, 2016). CK is knowledge about the actual subject matter to be learned (Aydin & Boz, 2013). Pedagogical content knowledge (PCK) is the transformation of content knowledge into a version understandable by learners (Mavhunga, 2016). Teachers continued professional development (TCPD) refers to a structured learning activity that is aimed at supporting teachers' practices in the classroom (Darling-Hammond, Hyler & Gardner, 2017). All of these are anchored by the pedagogical reasoning and action framework, developed and proposed by Shulman (1987), which provides a process of reasoning about teaching. In sum, it consists of aspects of reasoning, starting with comprehension of CK, followed by its transformation, then the actual instruction, evaluation, reflection and finally new comprehension.

Within the South African context, Burton (2018), in her study in the Eastern Cape, found that many teachers were declared underqualified and incompetent to teach Natural Sciences after the inception of the National Curriculum Statement (NCS). Most of them did not do Science at school, and of those who did, very few did practical activities. Having shifted to a new curriculum, CAPS, a question is posed: Are the same problems experienced during the inception of NCS not reliving themselves?

The focus in this study is Grade 9 Natural Sciences (NS), which is a school subject taught and assessed in the General Education and Training (GET) band in the senior phase (grades 7 to 9). The study focuses only on one strand, *Planet Earth and beyond*, which is content taught in term 4, according to CAPS Natural Sciences at the Senior Phase level. This level lays the basis of further studies in more specific Science disciplines, such as Life Sciences, Physical Sciences, Earth Sciences (Geography) or Agricultural Sciences (DBE, 2011).

## 1.2 BACKGROUND TO THE STUDY

The South African education system has gone through a series of changes for many years. During the period prior to 1994, there were many different curricula in the country, which further divided the South African population. Education in South Africa during the apartheid era (before 1995) was differentiated, with the existence of racially separate education departments (Adu & Gosa, 2014). The Bantu Education Act (47 of 1953) intended to separate black South Africans from the main, comparatively very well-resourced education system for whites. Education offered to black learners was of an inferior quality and lacked effectiveness, and black schools had inferior facilities, teachers and textbooks (Mason *et al.*, 2011). In order to reverse the imbalances of the past, outcomes-based education (OBE) was introduced in 1997, but the shortcomings of implementation prompted a review in 2000. This led to the first curriculum revision, the Revised National Curriculum Statement Grades R-9 and the National Curriculum Statement Grades 10-12 (2002). Ongoing implementation challenges resulted in another review in 2009, which led to the Revised National Curriculum Statement (2002) and the National Curriculum Statement Grades 10-12. From 2012 the two National Curriculum Statements for Grades R-9 and Grades 10-12 were combined in a single

document known as the National Curriculum Statement Grades R-12. This led to the formation of curriculum and assessment policy statement (CAPS).

Numerous challenges experienced by teachers during the implementation of the NCS included, among others, too much paperwork for teachers instead of teaching and assessing the learners, as reflected in duties and responsibilities of educators in the Employment of Educators Act (DBE, 2011). In response to this outcry, the National Curriculum Statement was amended. Amendments included developing a single comprehensive Curriculum and Assessment Policy Statement (CAPS). It was recommended that that implementation of NCS, i.e. shifting from the Revised National Curriculum Statement (RNCS) to CAPS, needed to be strengthened by improving teacher orientation and training, learning support materials and provincial support (DBE, 2011). CAPS was developed for each subject to replace subject statements. All these amendments were effected from the year 2012, hence introduction and implementation happened as follows: January 2012: Grade R-3 and Grade 10; January 2013: Grade 4-6 and Grade 11. For Grade 7-9 and Grade 12, CAPS was implemented for the first time in 2014 (DBE, 2011).

The NCS envisions teachers who are qualified, competent, dedicated and caring, and who will be able to fulfil the various roles outlined in the Norms and Standards for educators of the year 2000. The NCS further declares teachers to be mediators of learning, interpreters and designers of learning programmes and materials. Teachers are declared leaders, administrators and managers, scholars, researchers and life-long learners, community members, citizens and pastors, assessors and learning area/phase specialists (DoE, 2000). Curriculum reform initiatives in South Africa reflect a paradigm shift from a teacher-dominated to a learner-centred approach (Ramnarain, 2014). Dudu (2014) asserts that shifts in curriculum have put teachers through a number of challenges in South Africa, which meant a significant change in teacher roles. For curriculum changes to be effective, a great deal of learning on the part of educators is required if changes of this magnitude (RNCS to CAPS) are to be a success.

Section 3 of the CAPS document deals with senior phase Natural Sciences Content and Concepts, known as the Annual Teaching Plan (ATP/topics to be taught). The curriculum layout in ATP is as follows: Term 1: Life and Living (formerly Biology); Term 2: Matter and Materials (Chemistry): Term 3: Energy and Change (Physics) and Term 4: Planet Earth and

beyond (Geography). This study focuses on Term 4 content (Planet Earth and beyond) of section 3 of CAPS.

## 1.3 PROBLEM STATEMENT

According to Section 4 of the CAPS (Natural Sciences) document, when learners obtain between 0 and 29% it indicates that they have not performed according to the level descriptors (DoE, 2011: 93). The provincial average in the North West Province for the past three years, as outlined in the North West Provincial Assessment Diagnostic Report (2014-2016) in Provincial NWPA examinations is 29.9%, which is a sign of underperformance. Natural Sciences is a very complex subject, because based on its organisation, it consists of four different subjects, all brought together to form one subject, namely Natural Sciences. The context of setting the NWPA paper has been narrowed by the exclusion of questions from term 1 and 2 content (DoE, 2000), yet learners are underperforming (NWPA Diagnostic Report, 2014-2016). The changes made in this subject, Natural Sciences, focus only on the structure of the subject, the sequencing and general organisation of the subject; nothing was done to equip Natural Sciences teachers with all the necessary skills and knowledge that would make them more competent and effective teachers, and who would teach all the four strands, Life and Living, Matter and Materials, Energy and Change, as well as *Planet Earth and beyond*, without having to face any hurdles.

According to Rollnick and Mavhunga (2014), reasons for the poor performance have been attributed inter-alia to poor school management, but more prevalently to poor teacher preparation and thus teachers' poor understanding of content concepts. A construct that explicitly considers knowledge for teaching specific topics, exploring common misconceptions as part of learner prior knowledge is topic-specific pedagogical content knowledge (TSPCK). For example, the NWPA diagnostic report (2014-2016) indicates that learners did not perform well in questions based on *Planet Earth and beyond* (which is a subject under investigation). Figure 1.1 shows the performance of Grade 9 learners when responding to questions about the life cycle of a star.

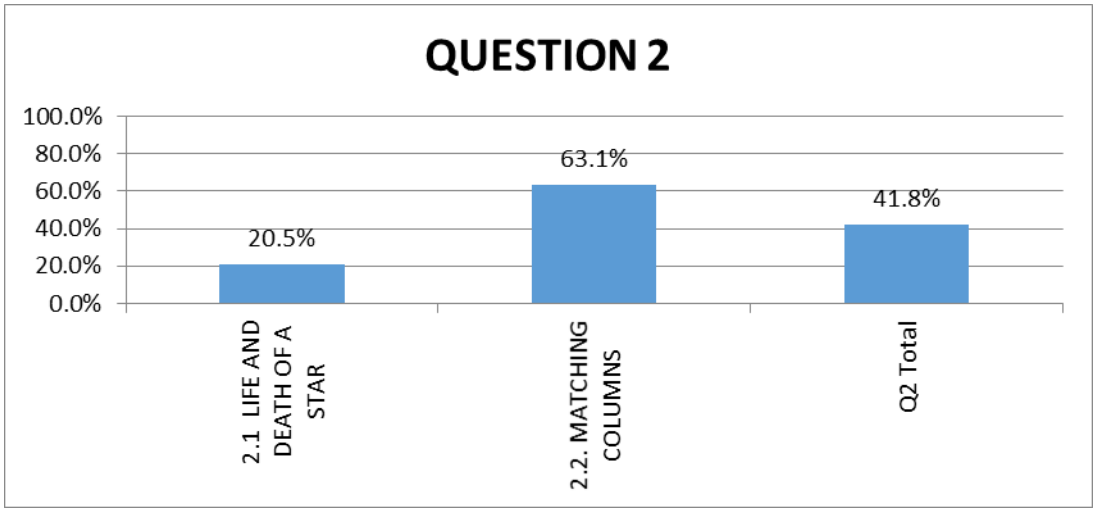



**Figure 1.1:** Birth, life and death of a star

The performance of learners in sampled moderated scripts for question 2, as shown in Figure 1.1, indicates that only 21.5% did well in the question, which might be inferred as underperformance according to level descriptors (DoE, 2000).

Another example is question 7, dealing with Layers of the atmosphere and the Greenhouse effect, shown in Figure 1.2.

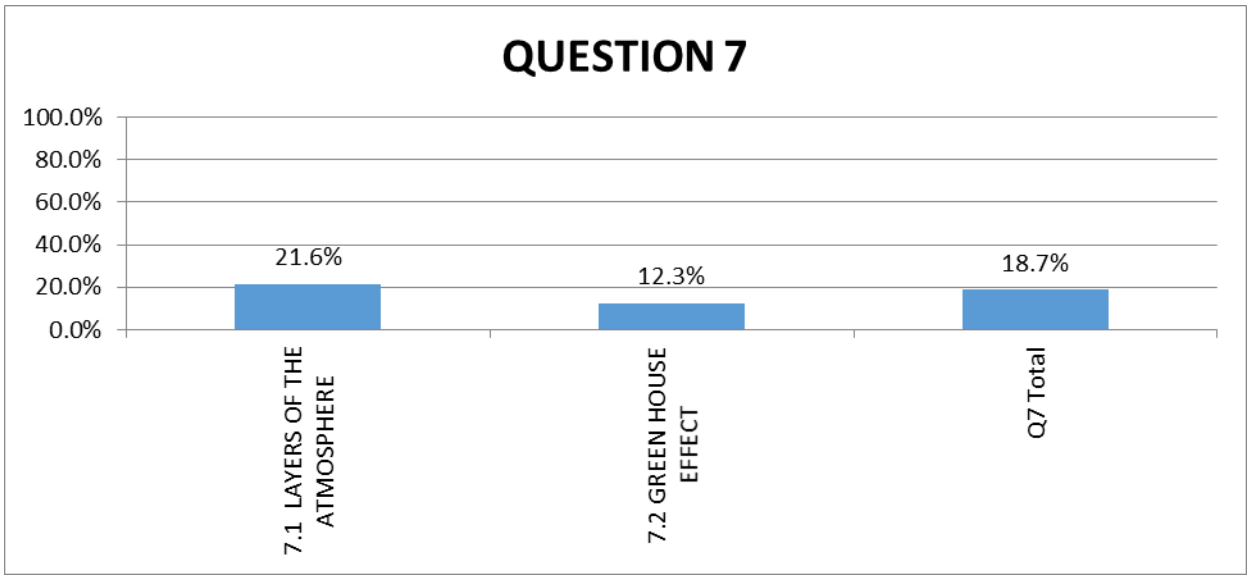



**Figure 1.2:** Layers of the atmosphere and the Greenhouse effect

Figure 1.2 (NWPA 2015 diagnostic report) indicates that the general performance of learners in question 7.1 about Layers of the Earth was 21.6%, and 12.3% in question 7.2 (referring to the Greenhouse effect), might also signal underperformance according to level descriptors (DoE, 2000). Trumper (2004) suggests that very few studies investigating teachers' astronomy conceptions, which is part of the topics of the strand *Planet Earth and beyond*, have been carried out, hence there was a need for this study to be conducted. Trumper (2004) further indicates that training of teachers is necessary and has to be followed by reinforcement. Similar trends still reveal themselves, thus this study was warranted. The reasons might be that very few teachers venture to teach astronomy because they lack the necessary knowledge and training; the majority of elementary and junior high school teachers have not studied astronomy in school or in college (Bisard, Aron, Francek & Nelson, 1994). New studies of students' misconceptions and ideas regarding astronomy are therefore needed to provide a useful basis for the further development of teaching methods. This study tries to address this grey area.

## 1.4 RESEARCH QUESTIONS, AIMS AND OBJECTIVES OF THE STUDY

The study aims to contribute to research-based classroom teacher practices by addressing the following main research question:

- How does teachers' Pedagogical Content Knowledge (PCK) of the *Planet Earth and beyond* strand concepts influence their teaching?

## 1.5 SUB-QUESTIONS

The following sub-questions guided this study:

(i) How do teachers' orientations to science teaching influence their pedagogical content knowledge?
(ii) How does Grade 9 teachers' pedagogical content knowledge manifest during the intervention?
(iii) In what ways do specific characteristics of the professional development programme contribute to the development of teachers' pedagogical content knowledge of the concepts of the strand *Planet Earth and beyond*?

## 1.6 RESEARCH AIM

The main aim of the study was to explore how teachers' PCK of the *Planet Earth and beyond* strand concepts influence their teaching.

## 1.7 RESEARCH OBJECTIVES

The following objectives guided this study. To:

(i) establish how teachers' orientation to science-teaching influences their pedagogical content knowledge of the strand *Planet Earth and beyond.*
(ii) investigate how Grade 9 teachers' pedagogical content knowledge manifests during their teaching of concepts of the strand *Planet Earth and beyond*.
(iii) suggest ways in which specific characteristics of the professional development programme contribute to the development of teachers' pedagogical knowledge and pedagogical content knowledge of the concepts of the strand *Planet Earth and beyond*.

## 1.8 THEORETICAL FRAMEWORK

This section gives a synopsis of the theoretical framework. The theoretical framework employed in this study is Pedagogical Content Knowledge (PCK), and Community of Practice (CoP) and Clarke and Hollingsworth's (2002) Interconnected Model of Teacher Professional Growth as conceptual constructs. Elaboration on the theoretical and conceptual framework is done in detail in Chapter 2.

PCK recognizes and highlights the curriculum as one of the teacher knowledge domains, as it provides a framework within which to plan. According to Mulhall and Loughran (2003), teacher knowledge about properties of substances (content knowledge) and knowledge about how students learn (pedagogical knowledge) together inform the decision that is made, which is PCK. Teacher knowledge is derived from experience of practice; noticing a pattern in the way students respond. According to Etkina (2010) and Wongsopawiro *et al*. (2017), Shulman introduced the concept PCK as 'that special amalgam of content and pedagogy that is uniquely the providence of teachers, their own special form of professional understanding'. Shulman further describes PCK as the knowledge of subject matter for teaching. It includes knowledge of students' difficulties and prior conceptions in the domain, knowledge of

domain representations and instructional strategies, and knowledge of domain specific assessment methods.

PCK as a theory can be linked to learning as a social practice and as increased participation in communities of practice (Lave, 1993; Wenger, 1998). Wenger (1998) explain communities of practice (CoP) as groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly. However, Wenger (1998) also notes that this allows for, but does not require, intentionality. A CoP has an identity defined by a shared domain of interest. A necessary component is that members of a specific domain interact and engage in shared activities, help each other, and share information with each other. They build relationships that enable them to learn from each other. In this way, merely sharing the same job does not necessitate a CoP. Thus, a CoP is not just about people who have an interest in something (e.g. sports or agriculture practices). The third requirement for a CoP is that the members are practitioners. They develop a shared repertoire of resources which can include stories, helpful tools, experiences, ways of handling typical problems etc. This kind of interaction needs to be developed over time. Shulman (1987:8) further states that at the heart of PCK lies what teachers know about (a) how their students learn specific subject matter, (b) the difficulties or misconceptions students may have regarding this subject matter, and (c) their knowledge of instructional strategies, such as representations (e.g. models, metaphors) and activities (e.g. explications, experiments) to teach this specific subject matter. These two theories were seen as fit to guide this study as they provide the theoretical groundings followed by this study and in turn informing it.

This study utilised the interconnected model of teacher Professional growth (IMTPG) proposed by Clarke and Hollingsworth (2002) as its theoretical framework (see Figure 1.3). Clarke and Hollingsworth argue that teachers' professional growth can best be understood in terms of reciprocal relationships between four different domains which encompass their professional world: (1) the Personal Domain, which contains teachers' knowledge, beliefs, and attitudes; (2) the External Domain, which contains external sources of information or stimuli; (3) the Domain of Practice, which involves professional experimentation; and (4) the Domain of Consequence, which contains salient outcomes related to classroom practice. Reflection and enactment form part of the model and can indicate translation to changes from one domain into another, e.g. undertaking a new practice in the classroom might cause us to reflect in such a way as to change our attitude to a particular approach. Using an integrated

model, we can gain insights to help inform our approach to professional development or professional learning. In developing a new activity, or simply modifying an old one, we might use current knowledge to plan, and then try out the activity with a class. Reflecting on how the activity was, we might then readjust our knowledge base to accommodate that new learning for future use.

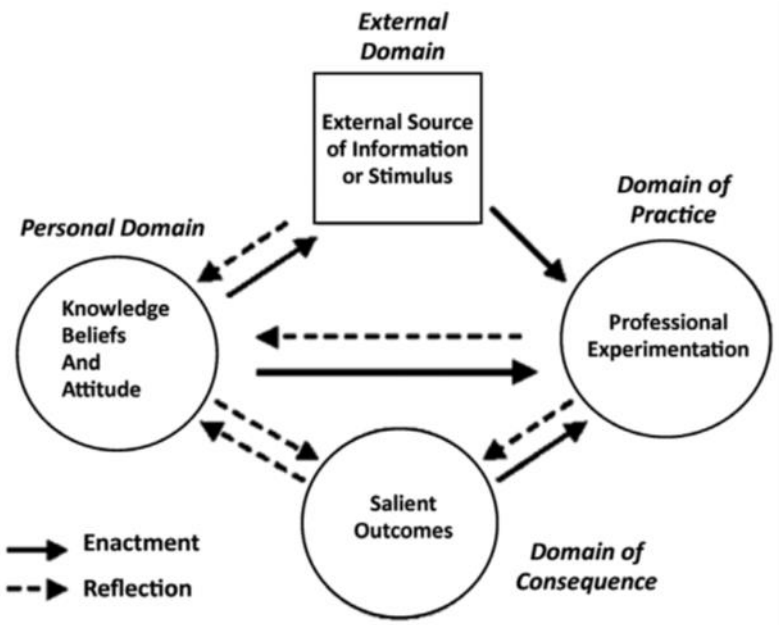



**Figure 1.3:** Clarke and Hollingsworth's (2002) IMTPG model

## 1.9 RESEARCHER'S ROLE

Maree (2010:299) outlines the researcher's role as "has to be an active participant as an interviewer, including being a vital part of the data collecting process" According to Yilmaz (2013), the researcher needs inextricable connection with the participants from the research community in order to avoid ethical issues arising. In this study, the researcher was an active participant as an instrument designer (interview questions and template for document review), data collector (face to face interviews and document review), lesson observer, transcriber, data analyst and reporter. The researcher recorded participants' responses and observed and listened carefully, ensuring at all times that he abided by all ethical guidelines.

After data collection was completed, an intervention strategy to deal with the challenges identified through data collection by the researcher in consultation with the Department of Education, was employed. Intervention included workshops to strengthen the Grade 9 NS teachers' classroom pedagogical practices and their CK in the strand *Planet Earth and*

*beyond* of CAPS. This intervention included resources such as the facilitator guide and participants' manuals. The researcher ensured that during the study he created a good relationship with participants and all stakeholders. Bias was avoided at all costs, by ensuring that no preconceived ideas were proved during interviews due to the nature of the questions. Interviewees were allowed to speak freely. This helped to collect their real experiences with regard to the teaching of the strand *Planet Earth and beyond*. The researcher remained honest in data collection, data capturing, data analysis and report writing, in order to ensure that true findings of the study about the competencies of Natural Sciences teachers in senior phase, in *Planet Earth and beyond*, were correctly documented and correctly reported.

## 1.10 PRELIMINARY STRUCTURE AND LAYOUT OF THE STUDY

**Chapter 1: Introduction**

This chapter provides a general overview to the study, including the introduction and rationale for the study. It presents the research problem, research questions, and purpose of the research and definition of concepts.

**Chapter 2: Literature review**

This chapter outlines the conceptual framework for the study by providing a literature exploration with regard to information on pedagogical competencies of teaching of the strand *Planet Earth and beyond* and other related topics.

**Chapter 3: Methodology**

This chapter describes the research process in depth, including the research designs and methodology followed in the study.

**Chapter 4: Empirical results**

Chapter 4 presents the research findings of the study and discussion. Results are presented in accordance with the research questions.

**Chapter 5: Conclusions and recommendations**

In chapter 5 the researcher presents conclusions drawn from the study and recommendations for further research are provided, and limitations of the study are outlined.

## 1.11 SUMMARY

The chapter provides background detail on the entire study and explains the main aim of the study, which was to explore how Grade 9 teachers' PCK of *Planet Earth and beyond* strand concepts influence their teaching. It begins by focusing on an introductory background to the challenges investigated, followed by the statement of the problem and outlining the purpose of the study. The research questions of the study are also highlighted. The literature review is discussed in Chapter two, the research design and methodology in Chapter three, and data analysis and interpretations in Chapter four. The summary, recommendations and conclusions are highlighted in Chapter five.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

The previous chapter focused on the background and rationale of the study. This chapter focuses on the theoretical framework and critical literature review, under the following subtitles; pedagogical content knowledge (PCK), content knowledge (CK), teacher orientations, professional teacher development and the strand under investigation, *Planet Earth and beyond*.

## 2.2 THEORETICAL FRAMEWORK

According to Mika (2018), a theoretical framework is an explanatory mechanism which serves as the lens that guides the research process. Okeke (2014) contend that a theoretical framework determines things to be measured, to establish relationships and to provide the study with an identity, also to position the discussion within the study based on its theoretical orientation. "The importance of utilizing a theoretical framework in a dissertation study cannot be stressed enough. The theoretical framework is the foundation from which all knowledge is constructed (metaphorically and literally) for a research study. It serves as the structure and support for the rationale for the study, the problem statement, the purpose, the significance, and the research questions. The theoretical framework provides a grounding base, or an anchor, for the literature review, and most importantly, the methods and analysis" (Grant & Onsaloo, 2016:12). It is with this view that the three interlocked concepts outlined below form the framework for this study. These are: Pedagogical Content Knowledge (PCK), Community of Practice (CoP) and Clarke and Hollingsworth's (2002) Interconnected Model of Teacher Professional Growth, the latter also adopted in this study as the data analytic tool.

### 2.2.1 Pedagogical Content Knowledge

Shulman (1987) defines PCK as a special amalgam of subject matter knowledge and PK. Shulman (1986) conceptualizes PCK as professional knowledge specific to teaching and

learning about a topic. A number of researchers proposes various explanations which may differ in words but have a common meaning. For example, Pompea, Constance and Walker (2017) contend that PCK relates to how the educator would teach a subject. It might include an awareness of student misconceptions or the naïve theories that they bring to the subject when they first learn about it. Shulman (1986) suggests that a person who knows something does not necessarily mean he/she can teach about that particular issue. This calls for a specific strategy or skill to be used, which various researchers refer to as PCK. Gess-Newsome (2015) explains personal PCK as the knowledge of, reasoning behind, and planning for teaching a particular topic in a particular way for a particular purpose to particular students for enhanced student outcomes.

Carter (1990) elucidates that PCK is what teachers know about their subject matter and how they transform that knowledge into classroom curricular events. According to Mika (2018), PCK is a broad knowledge of subject matter, how to teach it effectively based on understanding of the learners' needs and the nature of certain topics, hence Mavhunga (2016) defines PCK as the transformation of CK into a version that the learners can understand. Different scholars used different approaches to explain PCK, but what is key and surfaces from all explanations, is that a teacher must understand concepts and content, and should have a specific skill of translating those concepts and content into information that learners may be able to understand and grasp in a learning situation. Grieser and Hendricks (2018) explain PCK as the integration of CK and PK.

A summary of the definitions above of PCK can best be summarised by Shulman (1987:8), who defines it as "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction," as also reflected in Cochran's (2016) description of "it's all in your mind – Pedagogical Content Knowledge". Grossman (1990) and Shulman (1987) perceive PCK as the knowledge of transforming subject matter into teachable form that can be understood by learners.

### 2.2.2 What is the value of Pedagogical Content Knowledge?

According to Grieser and Hendricks (2018), teachers use both CK and PK to transform the subject matter in a way that students are able to understand. PCK is used to teach a concept or

skill that can help students deepen their understanding of complex skills and concepts. Shulman (1986, 1987) contends that PCK is the knowledge formed at the intersection of content and pedagogy demonstrated by teachers through their understanding of how particular subject matter topics, problems or issues are organized, represented, adapted to the diverse interests and abilities of learners, and then used to engage learners during the learning process.

The concept of PCK was introduced by Shulman to fill in the gap between CK and PK (Veal van Driel & Hulshof, 2001). This suggests that for effective teaching to take place, teachers must have both CK and PK, which will equip them to know what to teach and how to teach. Grieser and Hendricks (2018) attest that according to Grossman (1990), the degree to which teachers possess specific CK may influence how they represent their discipline to students. This implies that for relevant PCK to be crafted, mastery of relevant content concepts by the teacher is vital.

Grieser and Hendricks (2018) state that teachers' understanding of CK may influence concepts chosen, how these concepts are taught, knowledge about when students do or do not understand these concepts, and how to present the content at an appropriate level. As Shulman (1987:15) states, "the key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, is the capacity to transform the content knowledge into forms that are pedagogically powerful and yet adaptive." Subject matter knowledge can inform knowing how to teach, as reiterated by Rovegno (1992). Roehrig and Nam (2011) also corroborate that teachers' specific pedagogical practice cannot be separated from their CK as well as their PK.

### 2.2.3 Models of Pedagogical Content Knowledge

Grieser and Hendricks (2018) pronounce PCK to be the integration of CK and PK in regard to shifting and vibrato in the heterogeneous string classroom, to demonstrate how knowledge of technique works hand-in-hand with knowledge of teaching. The model below is adopted from Shulman (1987:8) and used in the study by Grieser and Hendricks (2018) to show that CK and PK have to be integrated by teachers to teach specific content, as shown in Figure 2.1 below.

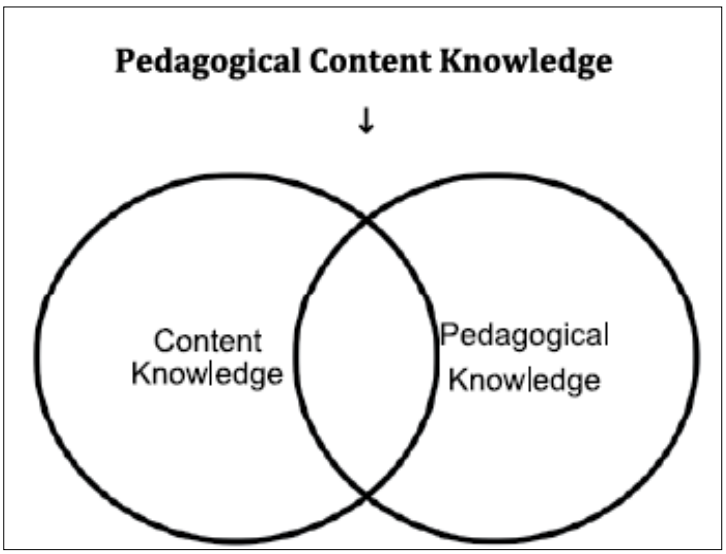



**Figure 2.1:** The Grieser and Hendricks (2018) model of PCK as adapted from Shulman (1987:8)

Grieser and Hendricks (2018) used the Schulman (1987:8) model to clearly describe the integration of CK and PCK to teach a specific content. The model demonstrates that string educators need both subject-matter CK and PK knowledge to teach string-specific content. According to Grieser and Hendricks (2018), CK is related to the teacher's factual knowledge of a particular subject and an understanding of how to organize the subject matter to teach it, and PK refers to a particular instructional approach to teach CK. Grieser and Hendricks (2018) reveal that for teachers to simply know string-specific content may not be sufficient for teaching string-specific content, and simply knowing a few "tricks" may not be sufficient to teach them correctly. String educators need to be able to choose instructional strategies that will transform PCK in such a way that students can understand and apply knowledge. In the context of the current study, the CK domain responds to the research objectives, which is, firstly, to establish how teachers' orientations to Science teaching influence their PCK.

Secondly, the PK domain responds to objective number two, which is to investigate how Grade 9 PCK of *Planet Earth and beyond* manifests during intervention, but there is no knowledge domain that responds to research objective three, which is in what ways do specific characteristics of the professional development programmes contribute to the development in teachers' PK and PCK. Harlow *et al.* (2018) conceptualise PCK as shown in Figure 2.2.

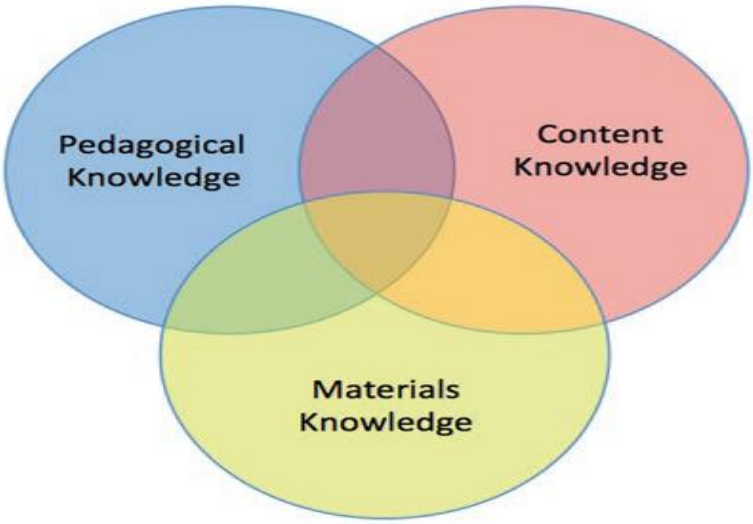



**Figure 2.2:** The Harlow *et al.* (2018) model of 'MPCK'

Components of the MPCK model above, as proposed by Harlow *et al.* (2018), are: Pedagogical Knowledge, Content Knowledge and Materials Knowledge. This model utilised two domains of teacher knowledge as proposed by Schulman (1986), which are Pedagogical Knowledge and Content Knowledge, and introduced a new domain called Material Knowledge, which is not included in Shulman's domains of teacher knowledge. Materials knowledge includes use of tools and of educative making activities by learners in class to create understanding of concepts. The CK required includes both science content knowledge and engineering content knowledge. In the current study, educative making activities were used by participants during the intervention workshop. Participants developed models which assisted them to enhance learners' understanding of *Planet Earth and beyond* content and concepts.

Harlow *et al*. (2018) contend that Koehler and Mishra (2008) adapted Shulman's model to include a focus on technology in the digital age, proposing that there were three primary areas of knowledge that teachers needed to develop to effectively and flexibly use technology in their classroom: content knowledge, pedagogical knowledge and technology knowledge. They named their model 'Technological Pedagogical Content Knowledge' (TPCK). Just like Koehler and Mishra (2008), Harlow et al. (2018) adapted Schulman's model to include educative making activities, proposing that there were three primary areas of knowledge that teachers needed to develop to effectively and flexibly use educative-making activities in their classroom: content knowledge, pedagogical knowledge and materials knowledge. They called their model 'Maker Pedagogical Content Knowledge.'

The difference between TPCK and MPCK is that in TPCK, technology is in the hands of the teachers, whilst with MPCK technology is in the hands of the learners. In terms of the current study related to MPCK, the CK domain responds to research objective one, whilst the PK domain responds to objective number two, and the domain of educative making activities responds to research objective three. However hands-on activities, or 'technology', are in the hands of both teachers and learners in the current study.

The other model of PCK discussed in this study, is the Rollnick *et al*. (2008) model adopted by Khoza (2016) in the study of identifying the gaps of fourth-year degree pre-service teachers' PCK in teaching engineering graphics and design. According to Khoza (2016), fourth-year pre-service teachers find Engineering Graphics and Design difficult to teach, for various reasons. Findings of the study revealed that pre-service teachers found teaching practice too short to perform all the teaching tasks required of them. Some pre-service teachers did not have drawing models to make learning concrete to their learners. Khoza (2016), like other researchers, acknowledges that there are still gaps in our knowledge about teacher development of PCK. The study by Magnusson *et al.* (1999) is helpful in clarifying this special form of a teacher's professional knowledge by proposing that PCK is made up of five components, namely: knowledge of and about their subject, beliefs about it, and how to teach it, content and when is it suitable to teach it, principles and purposes of assessment, knowledge of students' understanding of the subject, and knowledge of instructional strategies. The current study also focuses on knowledge of and about *Planet Earth and beyond,* how to teach *Planet Earth and beyond*, participants' beliefs about *Planet Earth and beyond,* knowledge of students' understanding of the subject and knowledge of instructional

strategies. Figure 2.3 represents Rollnick and Krockover's (2008) Model of PCK that is proposed to close gaps identified in the PCK model, as originally suggested by Shulman:

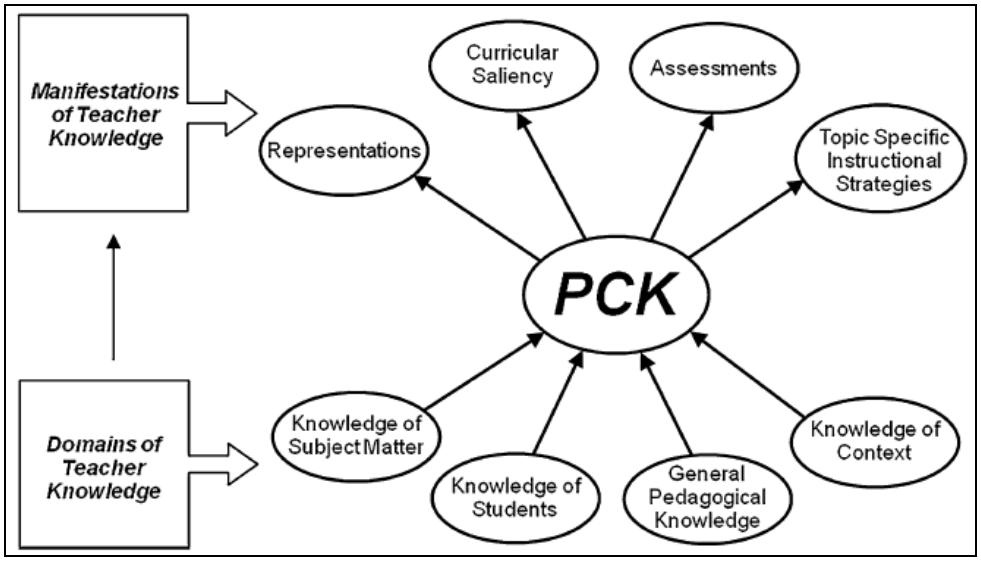



**Figure 2.3:** Model of PCK by Rollnick *et al*. (2008)

Rollnick *et al.* (2008) developed a model that extends Shulman's notion of PCK by classifying the categories of the knowledge base into knowledge domains for teaching and manifestations. These knowledge domains are: ''knowledge of subject matter, knowledge of students, general pedagogical knowledge and knowledge of context", as suggested by Shulman. In order to close gaps identified, Rollnick (2008) introduced representations, curricular saliency, assessments and topic specific instructional strategies. The current study incorporates both the domains of teacher knowledge and manifestations of teacher knowledge. The latter surfaced during the intervention workshop when video-clips, posters and PowerPoint presentations were used to enhance understanding of *Planet Earth and beyond* content and concepts. The portfolio of evidence submitted by participants included informal tasks done to assess understanding of content and concepts learnt under *Planet Earth and beyond.* Domains of teacher knowledge surfaced when *Planet Earth and beyond* content was discussed during the intervention workshop (subject matter knowledge), and lesson planning (general pedagogical knowledge), knowledge of context as well as relevant approaches for teaching *Planet Earth and beyond* topics.

The other model discussed in this study is the one by Adams and Krockover's (1997). It is the model of teacher knowledge to explain the relationship between CK and PCK, as illustrated in Figure 2.4.

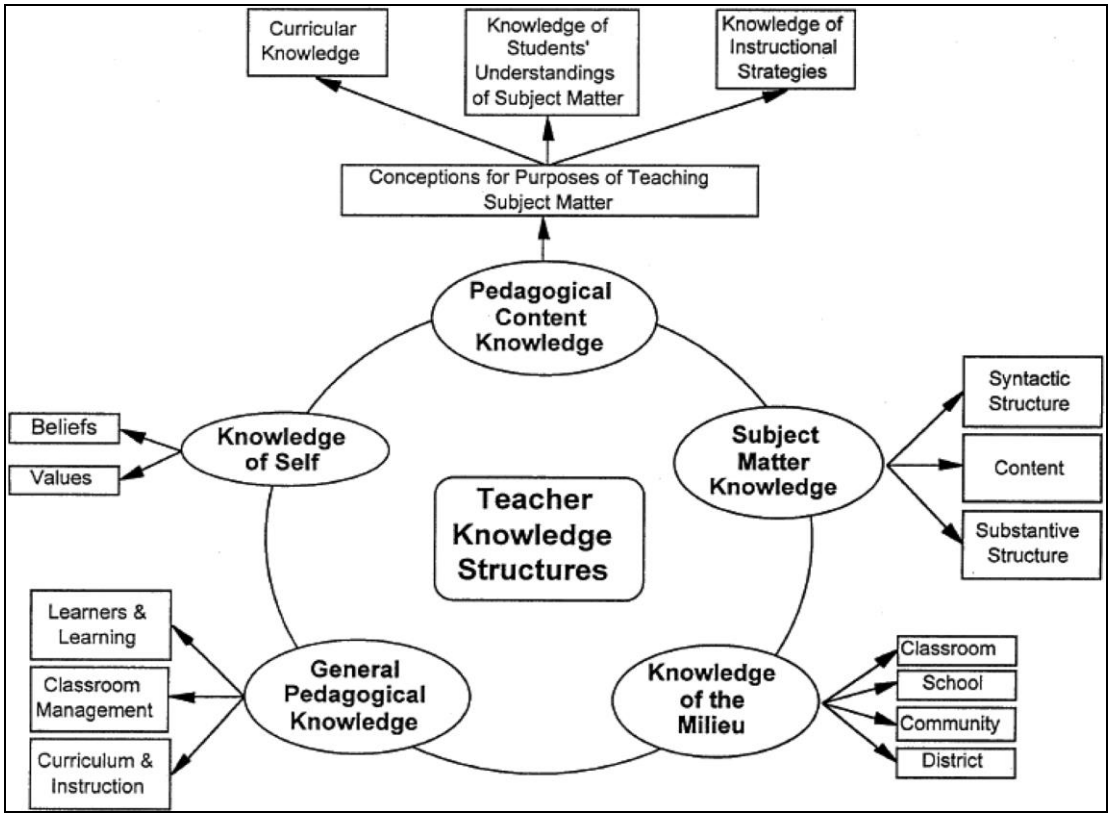



**Figure 2.4:** Adams and Krockover's (1997:636) model of teacher knowledge to explain the relationship between CK and PCK

The model refers to teacher knowledge literature consisting of: (a) PCK, (b) Subject Matter Knowledge, (c), General Pedagogical Knowledge, (d) knowledge of the milieu, and (e) Knowledge of Self. This model was used to suggest that good classroom practices include all aspects of teacher knowledge structures. PCK is addressed as research objective 1: how does the teachers' orientation to science teaching influence their PCK, and to investigate how teachers' PCK manifests during the intervention. Subject Matter Content Knowledge from this model is addressed as research objective (1), which is aimed at establishing how teachers' orientations to Science teaching influence their PCK and appears again in the model shown on the previous page as knowledge of the milieu. Magnusson *et al.* (1999) indicate that even though teachers' CK is not sufficient to ensure effective teaching of a subject, some critical amount of content has to be mastered to ensure effective teaching. This suggests that

specific professional development programmes are necessary to develop PCK. This, together with CoP, addresses research objective 3 of this study.

PCK recognises and highlights the curriculum as one of the teacher knowledge domains, as the curriculum provides a framework within which to plan. According to Mulhall and Loughran (2003), teachers' knowledge about properties of substances (content knowledge) and knowledge about how students learn (pedagogical knowledge) together inform the decision that is made, which is PCK. According to Etkina (2010) and Wongsopawiro *et al.* (2017), Shulman (1987:8) introduced the concept PCK as that special amalgam of content and pedagogy that is uniquely the providence of teachers, their own special form of professional understanding. Shulman (1987:8) further describes PCK as the knowledge of subject matter for teaching. It includes knowledge of students' difficulties and prior conceptions in the domain, knowledge of domain representations and instructional strategies, and knowledge of domain specific assessment methods. A teacher's PCK level is positively related to the extent to which the teacher's instruction is reform-oriented. Stated differently, a teacher who has more sophisticated PCK is likely to implement higher levels of reformed Science teaching approaches or vice versa.

According to Iserbyt *et al.* (2017), pedagogical content can best be explained as knowledge at an interaction of several knowledge bases upon which the teacher makes decisions about what and how to teach. All explanations of PCK as provided by different researchers, highlight two issues, namely: knowledge of subject matter and the ability to teach that subject matter to the learners, and not the mastery of the subject content alone, but lacking the relevant approach to teach the said subject matter to the learners. This implies that Grade 9 Natural Sciences teachers must have a broad knowledge matter of *Planet Earth and beyond* topics, and they must also know how to teach *Planet Earth and beyond* topics effectively. Educational researchers have argued that knowledge of subject matter and pedagogical methods, as well as the level of mastery to teach different subjects, are important predictors of teaching quality and student learning (Darling-Hammond & Hudson, 1990). According to Kind (2009), PCK is claimed as only one type of teacher knowledge and involves transforming knowledge for students' benefit. In terms of the current study, teachers must understand *Planet Earth and beyond* content they have to teach, and they must be able to transfer their knowledge and understanding of *Planet Earth and beyond* topics to Grade 9 learners whom they teach.

Mika (2018) explains PCK as the broad knowledge of subject matter, how to teach it effectively based on understanding of the students' needs and the nature of certain topics. In support of Mavhunga (2016), Taşdan and Çelik (2016) contend that the agreed components for PCK that have been modelled through different components by several researchers can be listed as knowledge of students' thinking, knowledge of instructional strategies, knowledge of curriculum, content knowledge and knowledge of assessment. Shulman (1986:87) indicates that the relationship between knowledge of content and knowing how to teach such content, make learning of specific topics either simple or difficult, depending on teachers' PCK. This prompted the study about classroom practices of Grade 9 Natural Sciences teachers when teaching *Planet Earth and beyond* topics.

### 2.2.4 Review of some related studies on PCK

The aim of the study by Ozden *et al.* (2013) was to explore prospective primary teachers' (PPTs) PCK regarding the subject of humans and environment. This study was carried out with 30 PPTs enrolled in primary education in the 2008-2009 academic year. Researchers collected the data by reviewing lesson plans and interviews. The PCK related to the teaching lesson on the unit of humans and environment was analysed through the use of prepared lesson plans and commentaries of interview results based on literature. The results showed that PPTs did not have appropriate PCK consisting of learning difficulties of the students, instructional strategies or activities and using materials (using technology or other materials) related to the subject of the unit of humans and the environment. Most of the PPTs had insufficient knowledge of current curricula involving humans and the environment.

The study indicated that as a result of not having appropriate PCK, PPTs could not acquire sufficient knowledge of curricula involving humans and the environment. Relevant concepts could not be transferred to the learners, due to the absence of the necessary strategy, for PCK to be employed to transfer knowledge from PPTs to learners. It is evident that the findings presented by Ozden *et al*. (2013), indicate that as a result of not having appropriate PCK, PPTs could not acquire sufficient knowledge of curricula involving humans and the environment. The value and effect of possessing PCK are perfectly aligned with aims of the current study.

Thakur *et al.* (2018) implemented PBL in a Grade 9 Biology class in New Delhi, India. With reference to the current study, the purpose was to enhance beginner teachers to implement PBL in their chemistry classrooms while teaching PNM. The purpose of the study by Thakur *et al.* was to investigate the learners' perceptions of PBL in learning Biology. Their sample was 93 students who had recently passed from Grade 8 to Grade 9 in a government school, whereas the current study purposively sampled five beginner teachers to explore PBL with their Grade 9 learners.

Thakur *et al.* (2018) divided students into control and experimental unequal groups, in which PBL was implemented with the experimental group and the control group was taught through the traditional lecture method. During teaching, the students were further divided into four groups. After the PBL implementation, questionnaires were administered to the experimental group students to analyse their perceptions about the PBL strategy in learning Biology. The current study required participants to submit a portfolio reflecting the material used and activities that occurred during the PBL implementation. The questionnaire evaluated PBL on the basis of content and level of the modules; positive attitude towards learning; integrating new and old knowledge; understanding of the concepts; and principles of self-learning. A four-point Likert scale was used, ranging from strongly agree to strongly disagree.

In contrast, the portfolio submitted by beginner teachers in the current study included their reflections and rubrics aimed at observing 21$^{st}$ century skills that learners acquired during PBL implementation. With regard to their results and interpretations, Thakur *et al*. (2018) support PBL as being one of the best strategies to motivate, interest and encourage learners. The Likert scale respondents' views mostly confirmed the following about PBL, among others: it makes learning an enjoyable experience; it helps in discovering new things; it creates a tension-free environment as learners can work beyond the boundaries of the classroom environment; it creates a challenging atmosphere; it develops self-confidence within the learners; it promotes scope for social interaction as well as communication skills; it promotes discussion and sharing of ideas; it motivates; it makes learning more meaningful; it creates curiosity among learners; it promotes active learner participation; it encourages critical thinking; it upholds collaboration and excites decision-making. It is evident that the findings presented by Thakur *et al*. (2018), promoting and affording the learners with 21$^{st}$ century skills and reflecting the elements of SDL, are perfectly aligned with the aims of the current study and it is yet to be seen what the current study findings reveal.

Pompea *et al.* (2017) indicate that teachers acquire pedagogical content knowledge during their pre-service training as teachers, and through appropriate training and experience as practitioners. In the current study, to ensure that participants developed and gained PCK, they were engaged in an intervention workshop. Pompea *et al.* (2017) further indicate that a teacher with better CK knows how to teach the subject to a specific audience and should create student gains over a less prepared or less experienced teacher. Contrary to that, Tobin and Garnett (1988) found that experienced, 'time-served' teachers are not necessarily experts in their field. Pompea *et al.* (2017) suggest that additional professional development and training can be useful in keeping teachers abreast with current developments. Professional Development Programmes are implemented to assist teachers to improve their knowledge and skills, and enhance their classroom practices (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007; Blank & Alas, 2009; DeSimone, 2009). Science teachers should possess appropriate PCK for effective Science teaching and to facilitate student learning (Soonhye *et al.*, 2010). According to Bustamante, White, and Greenfield (2018) there is a need for effective science teachers who inspire students to engage in authentic questioning activities which are generated from their experiences in order to help them develop a theory that provides a coherent explanation for a scientific phenomenon. This requires a teacher not only to know content, but to have an understanding of how to teach content to a specific group of students in a particular teaching context (Park & Oliver, 2008).

Lombard (2015) conducted a study in South Africa which investigated a sample of Grade 4-7 Natural Sciences teachers' attitudes towards teaching Botany and teachers' pedagogical content knowledge. The purpose of the study was to explore if a relationship existed between teachers' attitudes towards teaching Botany and their PCK. The study revealed that teachers' attitudes towards Botany teaching influence their PCK and teachers' PCK can in turn influence their attitudes towards Botany, which can affect their ways of teaching.

The current study also investigated how PCK can influence classroom practices of Grade 9 teachers, when teaching *Planet Earth and beyond*. Just like in the Lombard (2015) study, qualitative data were generated using document analysis and semi-structured interviews. The difference between the two studies is that the current study did not utilise classroom observations but replaced them with a portfolio compilation by the teacher. Lombard's study did not utilize an intervention workshop to collect data. Both studies investigated how PCK

influences classroom practices. Significant shifts were revealed in investigating the influence of teacher attitudes in their PCK, and vice versa in Science lessons in the study by Lombard. It is yet to be seen if PCK and professional development programmes could contribute to acceptable classroom practices when teaching *Planet Earth and beyond* topics. During the intervention in this study, teachers were working in a professional learning community (PLC), hence the inclusion of the construct community of practice.

### 2.2.5 Community of Practice (CoP)

Lave and Wenger (1991:98) define a CoP as a "set of relations among persons, activities, and world over time". The explanation by Wenger (1998) goes further to indicate that regular interaction of teachers allows for, but does not require, intentionality. According to Shapiro (1988), CoPs are Communities of Learning for professional growth and development of teachers, which may allow teachers to gain from each other, and proposes that they should be introduced as part of dealing with content and pedagogical content knowledge. Wenger, McDermott and Snyder (2002) suggest that a CoP allows a group of people sharing a concern or a set problem, or are passionate about a topic, to deepen their knowledge and expertise in the said area by interacting on an ongoing basis. More recently, Wenger, Trayner and de Laat (2011:9) defined CoP as a "learning partnership among people who find it useful to learn from and with each other about a particular domain. They use each other's experience of practice as a learning resource". According to Schiera (2016), the term CoP was first used to describe learning through practice and participation, which was called "situated learning".

Wenger (1998) contends that a CoP has an identity defined by a shared domain of interest, and that members of a specific domain interact and engage in shared activities, help each other, and share information with each other. They build relationships that enable them to learn from each other. CoP addresses learning that occurs through execution and participation in the daily routine of activities shared with colleagues (Orsato *et al.*, 2019). Continuous interaction with colleagues who perform related, similar or the same activities, improve the ways of doing what should be done (Wenger, 1998). In this way, merely sharing the same job does not necessitate a CoP. Thus, a CoP is not just people who have an interest in something (e.g. sports or agriculture practices), but a group of people with a shared interest, working together to achieve a desired goal.

Orsato *et al*. (2019) note that the approach to CoP has changed over time. Currently, it tends to focus on the value of the community as a management tool, as well as on its innovation and problem-solving potential. According to Orsato *et al*. (2019), Wenger (1998) declares that a CoP allows colleagues to work together and improve ways of doing what should be done, but (Cox, 2005) extends that further, and proposes that the present purpose of a CoP is more about learning and sharing of knowledge than about getting the job done. Even though there is a lot that participants may gain from a CoP, Orsato *et al*. (2019) contend that Wenger *et al*. (2002) propose that participation in a CoP is informal and voluntary and might be constituted by people who act within or across functional areas, or from different organizations.

The current study utilized a CoP as Professional Development for participants. Participating teachers attended a three-day intervention workshop. Their participation was voluntary, and they came from six different schools sampled for the current study. *Planet Earth and beyond* content and concepts were discussed in this CoP, as well as teaching approaches relevant for the teaching of *Planet Earth and beyond*. Participating teachers shared best practices in an informal setting.

The other requirement that defines a CoP is that the members should be practitioners. They develop a shared repertoire of resources which can include stories, helpful tools, experiences, ways of handling typical problems etc. This kind of interaction needs to be developed over time. Teachers who participated in the current study were also seen as practitioners who shared knowledge and understanding of *Planet Earth and beyond* content and concepts, teaching approaches, skills to conduct practical investigations, and skills to develop models to enhance understanding of *Planet Earth and beyond* content and concepts.

Shulman, (1987:8) further states that at the heart of PCK lies what teachers know about (a) how their learners learn specific subject matter, (b) the difficulties or misconceptions learners may have regarding this subject matter, and (c) their knowledge of instructional strategies, such as representations (e.g. models, metaphors) and activities (e.g. explications, experiments) to teach this specific subject matter. The current study also focused on subject matter knowledge, referred to as content knowledge (CK), and representations (e.g. models, metaphors) were used, practical investigations were conducted during the intervention workshop, and teaching approaches relevant for *Planet Earth and beyond* were applied. Mika

(2018) attests that teacher learning in a community can be a source of efficacy and confidence in the process of adopting new practices, which is something that was achieved through the intervention workshop in the current study.

Wenger *et al*. describe the life cycle of a community of practice as organic, variable and finite, with its longevity dictated by its value to the participants (rather than its value to an employer or trainer). According to Wenger *et al*. (2002), a CoP undergoes a life-cycle taking place in five stages of development in a community of practice: *a potential stage*, in which individuals with similar practice issues make contact and discuss their common needs; *a coalescing stage***,** where members come together and negotiate the functioning and structure of the community; *an active stage,* where joint activity enriches a shared practice repertoire; *a dispersing stage*, in which the frequency of meetings and communication is reduced but remains a useful resource for members; and a *memorable stage*, when the community no longer functions but remains in the repertoires of the former members in the form of stories, reunions, or the retention of memorabilia. This confirms that a CoP is unstructured, voluntary and meant to deal with a specific issue, after which it is dissolved. In the current study an intervention workshop was conducted in a CoP setting. *Planet Earth and beyond* content and concepts as well as pedagogy were discussed in an informal setting for a specified period of time. At the end of the intervention workshop the CoP was dissolved.

Orsato *et al*. (2019) conducted a study to investigate how a community of practice enables social learning for Anticipatory Adaptation to Climate Change (AACC*),* moving away from traditional learning methods to non-traditional learning that can be promoted through dynamic interactions among individuals, such as a CoP. Findings of the Orsato *et al.* (2019) study indicate that their participants benefited from participating in a CoP, by being inspired and empowered through the exchange of experiences, taking notes of insights about what to do, or small actions to put into practice. It also revealed that sometimes they felt more comfortable knowing that other CoP members were facing the same difficulties when developing the adaptation plans in their respective companies.

In the current study a more constructivist approach was followed, that enabled participants to move away from the traditional teacher-centered approach to a more learner-centered approach. This enhanced understanding of *Planet Earth and beyond* content and concepts, as well as lesson planning skills, thus leading to an improvement in participants' classroom

practices. Mika (2018) explains the learner-centered approach as an educational approach that moves students from passive receivers of information to active participants in their own discovery process. Teachers implement academic-support strategies based on what students learn, how they learn it and how their learning is assessed, which are all driven by each individual student's needs and abilities. In the current study, the intervention workshop allowed teachers to become active participants and not passive receivers of information.

Oliver *et al.* (2018) agree with Cordingley (2008) in cementing the value of a CoP, reverberating that a CoP is a kind of learning that enables teachers to make the leap from theory to accomplished practice. Similar to the current study, participants discussed *Planet Earth and beyond* content and concepts, followed by hands-on practical activities to ensure understanding. Lesson planning and lesson presentations were also discussed, followed by lesson demonstrations which were intended for the acquisition of both content knowledge and pedagogical knowledge, ultimately leading to the acquisition of PCK and an improvement in classroom practices.

Based on identified benefits of participating in a CoP, in the current study teachers came together as a CoP, which unfolded in the form of an intervention workshop, as indicated already. Participants shared best practices, which assisted them to improve the ways of doing what should be done, as attested to by Wenger (1998). Sharing of best practices in the current study assisted to clear all misconceptions that prevailed before the intervention workshop. Participants worked in a group, shared ideas and teaching practices, which ultimately impacted on their classroom practices. This CoP proposed to help to respond to the research questions about (i) teacher orientations, (ii) pedagogical content knowledge, and (iii) Teacher Professional Development. Kekana (2016) states that in a CoP, teachers cooperate and assist each other to reach a desired goal. Similar to the Kekana (2016) study, participants in the current study assisted each other, and cooperated to improve their classroom practices in the teaching of the *Planet Earth and beyond* topic.

### 2.2.6 Classroom practices

Rietdijk *et al.* (2018) refer to classroom practices as teaching and learning strategies, differentiating, and promoting active learning, and the ability to create a learning environment that sufficiently includes aspects of high-quality instruction. According to Ajani (2019), classroom practices are associated with in-depth knowledge of the subject, good

mastery of communication skills, effective classroom management strategies and instructional task delivery in a logical sequence and having in mind learners' individual differences. Flowers *et al*. (2000) attest that the classroom is where curriculum and instructional practices intersect with individual teachers and students. This proposed intersection of curriculum and instructional practices refers to CK and PCK, both which form part of pedagogical competence, underpinning classroom practices. The classroom is the place where goals are implemented, and their impact is immediately observed in the teaching-learning process. According to Liakopoulou. (2011) classroom practices leads to pedagogical competence needed for effective classroom management and effective teaching. Teachers provide opportunities to students for active participation and improved learning through effective classroom practices.

According to Murtaza and Akbar (2019), an effective classroom is the one that maintains high levels of academic rigor; has a curriculum that is meaningful, relevant, and connects subject matter; provides opportunities for active learning; goes beyond the boundaries of the classroom into the community; and fosters a positive climate that stems from mutual respect and beneficial interactions. Murtaza and Akbar (2019) further contend that classroom practices relate to the frequency of integration of subjects, authentic instruction, student recognition, critical thinking skills, and subject-specific enhancement practices. This study further proposes that teaming improves classroom practices. In this study, teaming is accordingly discussed as a community of practice.

Mika (2018) indicates that CK is one of the pillars of pedagogical competence. It is the knowledge about the actual subject matter that is to be learned or taught. Mika further contends that PK is deep knowledge about the processes and practices or methods of teaching and learning. According to Mishra and Koehler (2006), PK includes knowledge about techniques or methods to be used in the classroom, the nature of the target audience, and strategies for evaluating student understanding. In the context of the current study, PK includes CK, techniques or methods used to teach *Planet Earth and beyond* topics, and representations such as pictures and posters, integrating technology with the class by showing DVDs, using PowerPoint presentations and hands-on activities to let teachers be actively involved, as echoed by Rollnick *et al*. (2008).

The study on the evaluation of teacher practices and student achievement in high-poverty school by Reddy *et al.* (2020) suggests that classroom practices need to be evaluated in order to effect improvement. School leaders could employ classroom observations to evaluate teachers' practices, gauge professional development needs, and provide feedback to teachers for improving classroom practices. Reddy *et al.* (2020) propose the use of the Danielson Framework to evaluate classroom practices in schools. The Danielson Framework is a standard-based assessment that focuses on constructivist models of teaching, examines teacher performance across four domains of practice, namely preparation and planning for student learning, classroom management, instruction, and professional responsibilities. Four domains of practice mentioned by Reddy *et al*. (2020) are closely related to pillars of pedagogical competence, underpinning classroom practices (Hornes, 2018). If classroom practices are evaluated, effective teaching will take place. Effective teaching impacts student learning and behaviour (Reddy *et al.*, 2020). The current study utilised a three-day intervention workshop with the aim to improve participant's content knowledge of *Planet Earth and beyond*, as well as preparation and planning for student learning. The impact of this intervention is yet to be seen.

According to Harlen (1999), teachers need to have understanding and mastery of concepts and content that they teach. Correct pedagogy and continued reskilling of teachers are needed to develop healthy classroom practices. Murtaza and Akbar (2019) propose that classrooms are communities for learners to spend their time through participating in learning experiences, and that learners' individual choices, needs, abilities and educational objectives are focused during their stay in classrooms, as echoed by Seashore-Louis (2003); Weimer (2002); and Yilmaz (2009). Participating in classroom activities plays an important role to activate students in teaching the learning process (Petress, 2006; Weaver & Qi, 2005). Murtaza and Akbar (2019) furthermore indicate that more participation of students in classroom practices decreases their memorization of content. They develop logical thinking, including interpretation of facts, analysis of issues and synthesis of ideas.

Feiman-Nemser (1987) indicates that classroom practices include academic orientation, personal orientation, and developmental teacher orientation. Academic orientation covers both CK and PCK, as envisaged in this study. Academic Orientation as suggested by Feiman-Nemser (1987) is fulfilled by the intervention workshop in which CK and pedagogy are discussed. Findings of the intervention workshop are discussed in full in Chapter 4. Personal

orientation explains how teachers' orientations influence their pedagogical content knowledge. Developmental teacher orientation in this study refers to professional development programmes that teachers need to attend for further development and professional growth. In the current study, the intervention workshop was conducted to improve CK and PCK. Shayne *et al.* (2020) contend that higher levels of CK are associated with better classroom emergent literacy practices. CK, as one of the pillars of pedagogical competence, is unpacked as the next topic of discussion.

### 2.2.7 Content Knowledge (CK)

Aydin and Boz (2013) define CK as knowledge about the actual subject matter to be learned. According to Diamond, Maerten-Rivera, Rohrer, & Lee (2014), very little research has been conducted on how to measure teacher knowledge of Science content, or its impact on classroom practices and student achievement. Ball (2000) attest that Science CK is usually studied in pre-service teaching, and teachers already in the system have been ignored. According to Rollnick and Mavhunga (2014), reasons for the poor performance have been attributed inter alia to poor school management, but more prevalently to poor teacher preparation and thus poor understanding of content concepts by teachers. Fleer (2009) indicates that lack of Science CK is often cited as a primary cause of the inability of teachers to teach Science effectively. Feiman-Nemser (1987) further suggests that teachers need to know where and how they can be helped to acquire and develop knowledge about the subject they teach. Grade 9 Natural Sciences teachers have to be helped to acquire CK of *Planet Earth and beyond* topics, for them to teach effectively.

Kaya (2009) further indicate that strong CK is necessary for the acquisition and development of strong Pedagogical Content Knowledge. Ball (2000) suggest that adequate CK is necessary for interpreting reform ideas, managing the challenges of change, using new curriculum materials, enacting new practices, and teaching new content. According to Nowick, Sullivan-Watts, Shim, Young, and Pockalny (2013), elementary school teachers tend to have major gaps in their Science CK, and that these gaps are a major obstacle to effective teaching. This implies that if Grade 9 teachers might have gaps in knowledge of *Planet Earth and beyond* topics, it may be a major obstacle to effective teaching of topics on this strand, which may impact on their classroom practices when teaching this topic. Nowick *et al.* (2013) further stress the importance of teachers' academic preparation, which some associate with subject

matter knowledge and others with the ideals of liberal learning and that subject matter or CK consists of knowledge of the facts, concepts and procedures that define a given field and an understanding of how these pieces fit together. Grade 9 Natural Sciences teachers need to be continuously blended with content and pedagogy, as attested by Shulman (1986), in order to improve their classroom practices when teaching *Planet Earth and beyond* topics. This suggests that teachers have to ensure that they conceptualise and represent topics they teach in *Planet Earth and beyond*, and gain an understanding of why learning those topics is difficult or easy for learners of different ages and backgrounds, (Wilson, Shulman & Richert, 1987).

Gillian *et al.* (2011) indicate that as teachers gain more content background, they develop more confidence and consequently rely less on officially approved materials like lesson plans, as stated by Hashweh (1987). Such teachers usually possess more complex subject matter structures, for example *Planet Earth and beyond*, and can translate a more coherent view of such a discipline to learners. They can select the most appropriate topics to be included in the curriculum. (Gillian *et al*., 2011). Grade 9 teachers possess complex subject matter in *Planet Earth and beyond* topics that enables them to translate a more coherent view to learners, thus allowing proper and intensive articulation of such content.

Gillian *et al*. (2011) recommend that the following to be done when dealing with subject matter knowledge of the topic, 'Earth system concepts': (1) Teacher educators need to identify earth system concepts and related concepts as well as to define the depth of a teacher's understanding of the Earth system concept; (2) Teacher educators must provide opportunities for teachers to examine, elaborate, and integrate new knowledge and beliefs about Earth system concepts into their existing knowledge structure of Earth systems and their beliefs about the discipline of Earth systems; and (3)Teacher educators must provide opportunities for teachers to learn about instructional strategies and ideas in a meaningful and supportive context, as well as actual classroom situations involving the teaching of Earth system concepts. All three these recommendations address the research aim of the current investigation, 'to explore how Grade 9 teachers PCK of the *Planet Earth and beyond* strand concepts influences Grade 9 teaching'.

Gess-Newsome (2001) describes teachers' CK in two different ways, namely in-depth knowledge on a certain topic or concept (conceptual knowledge) and broader knowledge

around certain concept as they relate with other concepts in a discipline. Gess-Newsome and Lederman (1993) emphasise the importance of the actual experience of classroom teaching. According to them, until a teacher has gained experience and mastered basic classroom skills, it may be unrealistic to expect a readily accessible and useful subject matter structure to exist or to be translated into classroom practice. Abd-El-Khalick's (2006) study also supports the idea that teaching experience can influence teachers' development of their CK as more systemic and more complex relationships between content and pedagogical knowledge. According to Gillian *et al*. (2011), subject matter knowledge and topic-specific aspects of PCK are important.

Diamond *et al*. (2014) in their study on the effectiveness of a curricular and professional development intervention at improving elementary teachers' Science content knowledge and student achievement outcomes for year 1, specifically, examined two research questions, each with sub-questions tested by multiple measures. Firstly, what effect did the intervention have on teacher SCK in the treatment group compared to the control group over the course of the school year, as SCK was measured by a teacher Science knowledge test, a self-reported Science knowledge questionnaire and classroom observations. Secondly, what effect did teacher SCK have on student achievement outcomes in a high-stakes Science test when SCK was measured by a teacher Science knowledge post-test, a self-reported post-intervention Science knowledge questionnaire, classroom observations, and college Science courses taken The results of the study indicate that professional development had positive effects on enhancing teacher CK and pedagogy. This outcome is supported by other researchers like Hwang, Hong and Hao (2018), and Cox and Carpenter (1989) who bear out that professional development courses integrating Science CK and pedagogy have been found to increase teachers' confidence in teaching Science and created a continuing education course for practising elementary school teachers to develop Science teaching skills through hands-on inquiry lessons.

The current study utilised an intervention workshop as a professional development activity, in which both CK and pedagogy regarding the teaching of *Planet Earth and beyond* topics received attention. Similar to the Diamond *et al*. (2014) study, the impact of intervention on CK and learner outcomes were measured. Unlike Diamond *et al*. (2014), the impact of intervention was measured using pre- and post-semi-structured interviews, whereas Brandon *et al*. (2014) measured the impact of intervention using pre- and post-tests.

The impact of intervention on learner performance is yet to be observed. CK is one of the pillars of classroom practices. Strengthening teachers' content knowledge of *Planet Earth and beyond* might improve their PCK, and ultimately impact on their classroom practices when teaching *Planet Earth and beyond* topics. CK can be acquired through Teachers' Continued Professional Development, which is discussed in 2.2.8 below.

### 2.2.8 Teachers' Continued Professional Development

TCPD refers to learning about new techniques and ways to empower teachers (Murray, 2010). It includes any form of training and support received by teachers. TCPD is a way of providing a process of learning about professional development. It consists of aspects of reasoning, starting with comprehension of CK, followed by its transformation, then the actual instruction, evaluation, reflection and finally new comprehension (Shulman, 1987). Watters & Ginns. (2000), describe professional development as "an enterprise of tasks to strengthen professional teaching development and life-long learning in all learning areas". According to Garet, Porter, Desimone, Birman and Yoon (2001), CK increases as a result of professional development. Training of teachers is necessary but should be followed by reinforcement (Trumper, 2004).

Professional development is more meaningful when all components of teaching and learning work together towards a common goal. It may be more meaningful if there is collaboration between education stakeholders. Mika (2018) explains professional development as the professional work of established collaborative teams of teachers, school leaders, and other administrative, instructional and educational services staff members who commit to working together to accomplish common goals and who are engaged in a continuous cycle of professional improvement. Teacher education or professional development of teachers or CPD efforts are all same concepts of improving teachers for better instructional delivery tasks in schools (Ajani, 2018).

Professional development is used to bridge the gap created by poor Science preparation in pre-service teacher programmes, according to Brandon *et al*. (2014). Desimone (2009) indicates that professional development assisted in improving the quality of United States schools by improving the effectiveness of policy changes for teachers, teaching practices and

gains in student achievement. Mavuru and Ramnarian (2017) verify that teachers acknowledge the role of professional development in equipping them with knowledge and skills to make concepts more comprehensible to their learners. Continued teacher development is instrumental in the acquisition of relevant CK and PCK, and therefore teacher educators' role in designing their curricula with a focus on helping prospective teachers modify their pedagogical orientations that suit the kind of teaching and learning environment in which they are likely to work, is justifiable (Magnusson *et al*., 1999). Teacher educators should create a context where prospective teachers are engaged, challenged and stimulated to reflect upon their personal conceptions and ideas (Thomas & Pedersen, 2003).

Practising teachers may not be released completely from their daily activities as teachers to attend professional development programmes for a longer period as this may compromise teaching and learning in class. According to Mavuru and Ramnarian (2017), in-service teacher professional development programmes is a necessity to consider exploring orientations of practising Science teachers through continued teacher development programmes, with the hope of assisting them to redefine their CK and PCK about the goals and purposes of Science teaching. Professional development programmes are designed to provide teachers with learning experience intended to enhance their classroom practice (Kekana 2016; Cross *et al.*, 2002).

Teachers who will facilitate learning should be efficient in instructional tasks delivery of knowledge, skills, values and attitudes. Professional development activities are designed or aimed at effectiveness and efficiency of teachers in schools (Ajani, 2018).

Cross *et al*. (2002) and Cox and Carpenter (1989) developed a model to show the impact of professional development on teacher Science Content Knowledge (SCK) and learner achievement. Figure 2.5 below shows the Cross *et al. (2002),* and Cox and Carpenter (1989) Model of Professional Development.

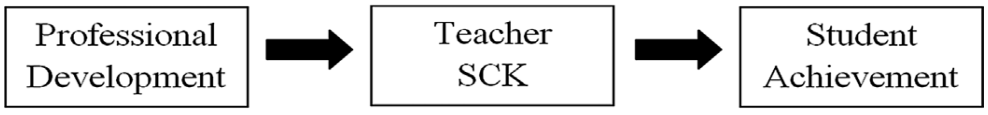



**Figure 2.5:** Model of the impact of professional development on teachers' SK and learner achievement (Cross *et al*., 2002)

Professional development in this study was conducted through an intervention workshop in which educators discussed content as well as pedagogy. Intervention provided will help to develop subject CK and how to teach content learnt, which will ultimately bring an improvement in learner achievement after intervention. Guskey (2002) also argues that professional development programmes are systemic efforts that bring about change in the learners' outcomes, as indicated by Cross *et al*. (2002). The intervention workshop in this study was utilised as professional development and adopted a constructivist approach. Richardson (2003) attests thereto that in a constructivist pedagogy, teaching should be student-centred, and learning as a group should be promoted. Kekana (2016), in support of Cross *et al*. (2002) and Cox and Carpenter (1989), determines that professional development programmes are used to improve teacher education and learner outcomes. Blank and Alas (2009) and DeSimone (2009) share the same view with Cross and Cox and Carpenter (1989) in believing that professional development programmes are implemented to assist teachers to improve their knowledge and skills.

Professional development allows learning to happen. Adjani (2018) states learning should be facilitated through experience. During professional development activities, teachers gain first-hand experience or involvements in the acquisition of knowledge, prompts or promotes teachers to gain lasting and quicker learning though interacting with others. Adjani (2018) further indicates that teachers view learning as problem-solving, and that the range of activities given to teachers to engage in during professional development activities are andragogic based. The experience aids teachers to also engage their classroom learners in tasks that are problem-solving. Professional development promotes and builds a teaching force that is vibrant, effective and modern to facilitate learning in the modern and challenging contexts of Africa. It promotes researcher-teachers as problem-solvers.

Heller *et al.* (2012) conducted a study in which teachers were offered a professional development intervention. Teachers learned about electric circuits using hands-on inquiry-based investigations. The results of this intervention showed that in their test scores teachers and their students gained 22% for treatment teachers, compared to 2.4% for control teachers after all completed tests on Science CK. This professional development strategy showed an improvement by the treatment teachers of about 7% over the control teachers.

Similar to the current study, the intervention workshop was used as a professional development activity. *Planet Earth and beyond* content and concepts were discussed, as well as relevant teaching approaches. An improvement in performance of the learners in schools that participated in the current study was marked at the end of the 2019 academic year. This suggests that professional development improves teacher CK as well as learner CK (Brandon *et al*., 2014). Based on this, a Community of Practice was proposed as a professional development opportunity, in which teachers would deal with *Planet Earth and beyond* content and concepts.

The purpose of a study conducted in the USA by Houseal *et al*. (2013) was to investigate the impact of a Student–Teacher–Scientist Partnership on their CK, their attitudes towards Science, and pedagogical practices. A Science-based inquiry was taught through experiential, authentic experiences through the Centre of Science, called Student Teacher Scientist Partnerships (STSP). Students, teachers, rangers and research scientists (STaRRS), and Expedition Yellowstone are programmes that were infused into STSP to provide professional development, conducted in a series of workshops for both teachers and learners. During these workshops, content and pedagogy were discussed in the case of educators, but learner workshops did not include pedagogical CK. This approach provided an opportunity for teachers to work on integrating the target content and processes into their own school contexts. Findings of the study showed massive gains in content and pedagogy by the teachers, and improved understanding of content by learners.

The current study also utilised an intervention and its purpose was to explore how teachers' PCK influences their teaching when handling concepts of the *Planet Earth and beyond* strand. Just like in the Houseal *et al*. (2013) study, data were generated in this study using workshop discussions as intervention. The difference between the two studies is that the current study did not utilise classroom observations and instead replaced them with a portfolio compilation by the teacher. In the study by Houseal *et al*. (2013) learners showed significant CK gains and increased positive attitudes regarding their perceptions of Science. In the current study it was yet to be seen if specific characteristics of a continued professional development programme contribute to the development of teachers' PCK in the current study.

Kekana (2016) conducted a qualitative study in South Africa using a case study as research design. The purpose of the study was to explore teachers' views on how the ACE Natural Sciences programme influenced their classroom practice. Four (4) Grade 7 Science teachers were purposively sampled to participate in the study. Clarke and Hollingsworth's (2002) model of teacher professional development was used as both the theoretical framework and data analytic tool. Findings of the study indicated that the envisaged outcomes of the programme were achieved to satisfaction in the case of three out of four teachers who participated, as they experienced a growth in their professional identity and classroom practices, while the fourth teacher was reluctant to embrace new ideas.

The current study also utilised an intervention workshop as a professional development opportunity, and its purpose was to explore how teachers' PCK influences their teaching when handling concepts of the *Planet Earth and beyond* strand. Similar to Kekana (2016), qualitative data were generated, also using workshop discussions, document analysis, semi-structured interviews, reflections and portfolio compilation. The difference between the two studies is that the current study did not utilise classroom observations and instead replaced them with a portfolio compilation by the teacher. As with Kekana (2016), data were subsequently analysed inductively to come up with themes in the current study. Significant improvement was recorded in terms of teachers' improved professional identity and classroom practices. It is yet to be seen if specific characteristics of a continued professional development programme contribute to the development of teachers' PCK.

Wheeldon (2017) explored the effect of intervention activities on the chemistry content knowledge of 92 pre-service chemistry teachers (PSCT), examined via a pre- and post-true/false questionnaire, with the confidence level test focusing on ionisation energy values and the use of a common alternative conception (AC). Two-hour intervention sessions were offered to develop subject matter knowledge of PSCTs. Applications of electrostatic concepts to electrons has wider application to bonding and were used, as interventions, offering PSCT more accurate chemical subject knowledge resources to draw on in their teaching.

The current study also utilised an intervention workshop as professional development. As in the Wheeldon (2017) study, data were generated using workshop discussions and semi-structured interviews. The difference between the two studies is that the current study did not utilise pre-/post-true false tests and instead replaced them with pre-intervention interviews

and post-intervention interviews. Similar to the Wheeldon (2017) study, data were subsequently analysed inductively and triangulated to come up with themes in the current study. Significant gains were revealed as interventions employed in the Wheeldon (2017) study offered PSCT more accurate chemical subject knowledge, which they did not possess before intervention.

Diamond *et al*. (2014) conducted a study, called the Longitudinal Study of American Youth (LSAY) (Monk, 1994) in which they compared how teachers prepared lessons in the junior phase as opposed to secondary schools, under the following headings: reparation and performance of Biology, Chemistry, Physics, Earth Science, Elementary Science Education, and Secondary Science Education. Findings indicated that for higher grades, teacher preparation in Life Sciences had no effect on student performance. For juniors, Life Sciences preparation showed a significant effect. For both higher grades and juniors, teacher preparation in Physical Sciences showed a significant positive relationship with student performance. The current study also incorporated lesson planning for senior phase teachers, as a way to improve pedagogy and general PCK of Grade 9 Natural Sciences teachers when teaching *Planet Earth and beyond* topics.

The study emphasised lesson preparation similar to Diamond *et al*. (2014), who compared lesson planning in junior and senior phases. The difference between the current study and the study by Brandon *et al.* is that the current study incorporated a professional development programme that unfolded in a three-day intervention workshop, during which teachers were trained in both PK and PCK. Unlike the current study, the study by Diamond *et al*. only compared the effects of lesson preparation without involving teachers in professional development. Significant improvements were recorded in the junior phase only, but in senior phase lesson preparation showed no effect. This leaves room for specific characteristics of a continued professional development programme to contribute to the development of teachers' PCK, which ultimately may lead to improved classroom practices.

Mika (2018) conducted a study in the Otjiwarongo circuit in Namibia, exploring the effect of intervention on the integration of local knowledge in Grade 9 Physical Science lessons. The study was carried out in four schools with four Physical Science teachers. Qualitative data were generated using workshop discussions, document analysis, semi-structured interviews, classroom observations and reflections. A variety of data generation techniques was used for

triangulation and validity purposes. Data were subsequently analysed inductively to come up with themes. The findings of the study revealed that before the intervention the teachers involved in the study had little knowledge of the integration of local or indigenous knowledge in Science lessons. However, after their voluntary participation in the intervention, they were enabled to develop and mediate model lessons that integrated local or indigenous knowledge in their classrooms which their learners subsequently found to be stimulating. The findings of the study further revealed that integrating local or indigenous knowledge in Science lessons has the potential to promote active participation by learners and foster learning using easily accessible resources.

The current study also utilised an intervention and its purpose was to explore how teachers' PCK influences their teaching when handling concepts of the *Planet Earth and beyond* strand. Just as in the Mika (2018) study, qualitative data were generated using workshop discussions, document analysis, semi-structured interviews, reflections and portfolio compilation. The difference between the two studies is that the current study did not utilise classroom observations and instead replaced them with a portfolio compilation by the teacher. Similar to the Mika study, data were subsequently analysed inductively to come up with themes. Significant shifts were revealed in integrating local or indigenous knowledge in Science lessons in the study by Mika and it was yet to be seen if specific characteristics of a continued professional development programme contribute to the development of teachers' PCK.

The study, Effective Teacher Professional Development, conducted by Darling-Hammond *et al.* (2017), reveals the following about continued professional development, as conducted by other researchers:

A study employing professional development was conducted in Missouri by Akiba and Liang (2016). The purpose of the study was to explore effects of teacher professional learning activities on student achievement growth. The focus of the study was to look at what types of professional development are associated with student achievement growth. Findings of the study indicated that student achievement growth rates were positively associated with school average amounts of participation in teacher collaboration, professional conferences and informal communication with colleagues.

The current study also utilised professional learning activities to determine their effects on student achievement, and its purpose was to explore how teachers' PCK influences their teaching when handling concepts of the *Planet Earth and beyond* strand. Just as in the Akiba *et al*. (2016) study, an intervention workshop as well as teachers' participation in collaboration (referred to as CoP in this study) were utilized as professional development activities for teachers that would ultimately impact on learner achievement, and improve teachers' classroom practices when teaching the *Planet Earth and beyond* topics. The differences between the two studies are that the current study did not use a survey as a research design, but used a case study instead. The focus of the current study was more on teacher development than on teacher qualifications, unlike in the Akiba *et al*. (2016) study. The purpose of the current study was to explore classroom practices of Grade 9 teachers when teaching *Planet Earth and beyond* topics, whereas the purpose of the Akiba *et al.* (2016) study was to explore the effects of teacher professional learning activities on learner achievement growth. Most importantly, it was realised that intervention strategies employed by Akiba *et al.* (2016) and as listed in the survey, yielded positive results, which means that continued professional development may contribute to teachers' PCK.

All these researchers, as reflected in the Darling-Hammond *et al*. (2017) study, support their explanation of effective professional development as structured professional learning that results in changes in teacher practices and improvements in learner learning outcomes. Darling-Hammond *et al*. (2017) outline the following as characteristics of effective Professional Development**:** Professional Development is content focused; incorporates active learning utilizing adult learning theory, supports collaboration, typically in job-embedded contexts; uses models and modelling of effective practice; provides coaching and expert support; offers opportunities for feedback and reflection; and it is of sustained duration.

The current study also utilized a three-day intervention workshop as Professional Development, which was content focused; incorporated active learning using activities in the participant guide that included hands-on practical activities; supported collaboration by allowing teachers to discuss their ideas independently; used development of models to enhance understanding of *Planet Earth and beyond* content and concepts; and provided coaching by discussing challenging topics for teachers. Lessons presented during the intervention workshop were discussed, and expert support was provided where participants had challenges to sustain understanding of *Planet Earth and beyond* topics.

### 2.2.9 Teachers' orientations

According to Mavuru and Ramnarian (2017), teaching is a complex process that requires teachers to transform and apply knowledge from multiple domains. Science teaching orientations have been found to be a critical component within the PCK of Science teachers. Feiman-Nemser (1986; 1987) states that a conceptual orientation reflects a coherent perspective on teaching and learning to teach that gives direction to the practical activities of educating teachers. Schram, Wilcox, Lanier, and Lappan. (1988) indicate that elementary teachers cannot teach for understanding if they themselves have never been taught to understand the conceptual foundations of teaching. Teaching orientations play a critical role in the pedagogical content knowledge of teachers (Friedrichsen & Dana, 2005). They furthermore propose that teaching orientations are not a single homologous entity and should better be presented as a complex entity with central and peripheral components. PCK relies entirely on planning and conducting of classroom teaching and reflection upon it.

Magnusson *et al*. (1999) propose nine different orientations to science teaching, namely: (1) *Process*, where teachers engage learners in activities to develop the thinking process, (2) *Academic rigour*, where teachers challenge learners with difficult problems and activities, (3) *Didactical teaching* through lecture or discussion, and questions directed to learners, (4) *Conceptual change,* where teachers engage learners in discussion and debate so that learners can construct valid knowledge claims, (5) *Activity-driven teaching*, where learners are involved in hands-on activities, (6) *Discovery*, where learners explore their thought process and interest (7) *Project-based science*, where learners engage in investigative work to generate new information, (8***)*** *Guided inquiry and open inquiry*, where learners are involved in identifying problems and solving them through investigations with and without teachers' guidance respectively, and (9) *Development*, where learners visualise understanding through models.

Orientations to Science teaching as proposed by Magnusson *et al*. (1999) were employed in this study. Teachers were engaged in learning activities to stimulate their thinking. The participants' manual developed for the intervention workshop contained a series of activities that would develop and stimulate their thinking. Magnusson *et al*. (1999) refers to this as *the process.* Activities prepared for the intervention workshop were not just simple activities;

some of them were difficult activities that required problem-solving skills. This, according to Magnusson *et al*. (1999), provides *academic rigour*. Discussions and active participation of teachers were guaranteed by a series of activities, which require teachers to respond to questions in the participant's manual. Magnusson *et al*. (1999) refer to this as application of *didactical teaching*.

All these discussions and responses to questions during discussions may have changed teachers' conceptual understanding. This conceptual claim or growth by teachers during the intervention workshop is what Magnusson *et al*. (1999) refer to as *conceptual change*. Hands-on activities, including development of models, and practical investigations were executed during the intervention workshop. This means that the intervention was *activity driven*. Activities were proposed to allow teachers to explore their thought process about and interest in *Planet Earth and beyond* concepts, promoting *discovery* to take place. The intervention was *a project-based workshop* in which teachers investigated a number of scenarios to generate new information. Problems were investigated and solutions suggested, indicating *Guided inquiry and open inquiry***.**

Cansiz and Cansiz (2016) group orientations, while Magnusson *et al.* (1999) propose orientations to Science and related to pedagogical competencies as follows:

Group 1: Process, didactic, activity-driven, all indicate a need for teachers to have much needed pedagogical CK for them to become effective educators.

Group 2: Academic rigour, discovery and inquiry as explained suggest that teachers need to have content knowledge of the subject they teach.

Group 3: Conceptual change, guided inquiry and development as explained suggest the need for continued professional development. In this way, these orientations address all three research questions guiding this study.

Koballa, Glynn and Upson (2005) present five conceptions about Science teaching, held by Science teachers, as follows: (1) presenting Science content to learners; (2) providing learners with a sequence of Science learning experiences; (3) engaging learners in hands-on Science activities; (4) facilitating the development of learners' understanding about Science; and (5) changing learners' Science-related conceptions.

In this study, similar methodological approaches as utilised by Koballa *et al.* (2005) were employed to investigate teacher's orientations to Science teaching to achieve research objectives. All five conceptions listed above, speak to all three research objectives that directed the current study.

## 2.3 PLANET EARTH AND BEYOND STRAND

### 2.3.1 Origin of the topic, Planet Earth and beyond

*A Planet*: Stern and Levison (2002) of the Southwest Research Institute suggest that a planet can be defined as a body less massive than a star but large enough for its gravity to overcome its structural rigidity and pull it into a round shape. Adding to this explanation, Soter (2007) further describes a planet as a body massive enough to dominate its orbital zone by flinging smaller bodies away, sweeping them up in direct collisions, or holding them in stable orbits. The number of planets was reduced from nine to eight, based on widely accepted explanation of a planet as proposed by Soter (2007). Initially, nine planets that were identified based on the size of objects in space included Venus, Jupiter, Mars, Earth, Neptune and Pluto. Pluto was removed from the list as it could not clear its orbital path and could also not dominate its orbital zone. For 76 years, our schools taught that Pluto was a planet (Soter, 2007).

*Earth as a Planet*: According to Soter (2007), Earth was regarded not as a planet but as the centre of the universe. This was a generally believed and accepted phenomenon by early astronomers and scientist. After Nicolaus Copernicus persuaded astronomers that the sun rather than Earth lies at the centre, they redefined planets as objects orbiting the sun, thereby putting Earth on the list and deleting the sun and moon from the list of planets. Based on suggestions made by Copernicus, the earth fitted well in the classification used to identify objects in space as planets. Earth is big enough that it eventually sweeps up or flings away any body that strays too close, such as a near-Earth asteroid. At the same time, Earth protects its moon from being swept up or scattered away. The earth is the only heavenly body so far discovered which can sustain life, as it provides clean air to breathe, water to drink, a climate neither too icy nor too torrid, food to forage, hunt or grow (Eyres, 2017). For a planet to be habitable, it must be able to buffer life from extreme (globally sterilizing) variations in temperature (Shahar *et al.,* 2019). The earth is enveloped by the atmosphere, which is made up of different gases, comprising 78% nitrogen, 21% oxygen and 1% trace gases (e.g. carbon

dioxide and water vapour). The earth, together with its atmosphere, and the outer space gave rise to the topic, *Planet Earth and beyond*, which forms part of the Grade 9 Natural Sciences Curriculum in South Africa. The word, "Planet Earth" refers to the earth as a celestial body called a planet that fits into the explanation of a planet as conceptualised by Eyres (2017). The word "beyond" refers to the solar system, outer space, and all its celestial bodies.

### 2.3.2 *Planet Earth and beyond* and the Grade 9 Natural Sciences curriculum

Outcomes Based Education (OBE) was introduced in 1997 as an education and curriculum CAPS system meant to play an important role in realising the aims of the Constitution (Act 108 of 1996), as listed: Heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights; Improve the quality of life of all citizens and free the potential of each person; Lay the foundations for a democratic and open society in which government is based on the will of the people and every citizen is equally protected by law; and build a united and democratic South Africa able to take its rightful place as a sovereign state in the family of nations (DoE, 2011). OBE was reviewed in the year 2000, leading to the first curriculum revision called the Revised National Curriculum Statement (RNCS) Grade R-9, and the National Curriculum statement Grade 10-12 (NCS). In 2009 the RNCS and NCS were further reviewed due to ongoing curriculum challenges that were experienced. The two curricula were merged to form the current National Curriculum Statement (NCS) for Grade R-12, being a policy statement for learning and teaching in South African schools. The NCS comprises a collection of documents, namely Curriculum and Assessment Policy Statements (CAPS), National Policy pertaining to the Programme and Promotion Requirements (NPPPR), and the National Protocol for Assessment Grades R-12 (DoE, 2011).

*Planet Earth and beyond* content and concepts are located in the CAPS document (DoE, 2011). The Natural Sciences CAPS document is divided into four sections. Section 1 serves as introduction to CAPS, Section 2 serves as introduction to Natural Sciences, Section 3 is called the Annual Teaching Plan (ATP), which outlines the curriculum or topics to be done in Grade 7-9, Section 4 provides guidelines on assessment. The curriculum layout in ATP is as follows: Term 1: Life and Living (formerly Biology); Term 2: Matter and materials (Chemistry): Term 3: Energy and Change (Physics) and Term 4: *Planet Earth and beyond* (Geography), which is the subject under investigation in the current study.

*Planet Earth and beyond* topics comprise the following: The earth as a system; the lithosphere; Mining and mineral resources; the atmosphere; and the birth, life and death of stars. The topics the earth as a system, and the lithosphere, were sourced from Geomorphology. The topic Atmosphere was sourced from Climatology. The topics Mining and Mineral Resources were sourced from Economic Geography. The topic the birth, life and death of stars was sourced from Astronomy. All these topics were clustered and included in the term 4 curriculum for Grade 9, and were given the name "*Planet earth and beyond*", which is the fourth strand after Life and Living, Matter and Materials, and Energy and Change. *Planet Earth and beyond* topics cut across all grades, from grade 4 to grade 12 in FET classes.

### 2.3.3 Effective teaching of *Planet Earth and beyond* in Grade 9

Harlen (1999) suggests that the effective teaching of Science is underpinned by the following when applied as a combined entity, and not implemented separately:

*(1) Practical work*: Science teachers should plan and use appropriate practical work. Practical work helps in the attainment of targeted skills, conceptual learning, scientific attitudes, the ability of learners to work as a group, and generally provides the stimulus for learners to learn about Science with interest and understanding.

*(2) The use of computers and other resources*: Programs for computer-assisted instruction (CAI), applications like word-processing, data-logging, graphing, simulations, modelling, analysing data, using databases and spreadsheets and accessing information through the Internet may be used in Science classrooms to stimulate teaching and learning. In their study on experiences of teaching anatomy online, Kelsey *et al*. (2020) suggest that the use of an interactive board, workbook activities and online resources may lead to effective teaching.

(3) *Approaches to constructivism*: Teachers have to create the atmosphere of learning with understanding in the classroom. Harlen (1986) and Leach and Scott (1995) state that "everyday ideas" have to be developed or modified into correct scientific knowledge or scientific view by learners. This conceptual development serves as the basis for explanation of scientific concepts or ideas and prediction. Learning is seen as changing learners' own ideas into one consistent with the scientific view.

(4) *Cognitive acceleration*: Intervention in the form of training has to be conducted to make sure that Science teachers are well informed to acquire the necessary skills for effective

teaching. Putnam and Borko (1997) propose that teachers need continuous guidance and support, and this can be provided through professional development.

(5) *Assessment*: Assessment should be crafted in such a way that it supports learning and should be varied to accommodate learners of different cognitive abilities and challenges. Assessment is designed to assist teaching and learning.

(6) *Planning, questioning and using language*:

(6.1) *Planning*: Better planning leads to better execution of the lesson, and results in better understanding of concepts under discussion or investigation in class. Better planning leads to effective teaching. Francesco *et al.* (2019) state that planning should include the ability to adapt and modify the short- and medium-term fixed learning objectives, according to the learners' feedback and the effectiveness of the educational action. One of the participants in the study by Francesco *et al.* (2019) commented, "If you're going into the season with a plan, you're doing alright". According to Palmer (1997), better planning would include: (1) What ideas the activity would help to develop, (2) what skills the activity would help to develop, (3) how the learners' initial ideas would be elicited, (4) what questions the teacher would ask, when and for what purpose (including asking learners what they would like to find out), (5) what classroom organisations are appropriate at different points of the lesson, (6) what equipment is needed (7) what and how instructions would be given to the learners, (8) how the learners will record and report their activities, (9) how the plenary discussions will be handled, and (10) how any change in learners' ideas and skills will be monitored.

(6.2) *Questioning*: Harlen (1999) indicates that Carlsen (1987) shows that teachers with high content knowledge encourage learners to ask more questions. Low levels of teacher understanding of the subject matter are related to asking low-level questions designed to serve the purposes of classroom management. Questions covering a variety of skills and cognitive levels have to be included in teachers' questioning approach. Learners must be encouraged to ask questions as that may assist the teacher to check their understanding and whether they follow the lesson or not, and also to build their cognitive repertoire. Harlen (1999) states that Watts *et al*. (1997) suggest that learners ask questions for exploration, consolidation and elaboration. Learners asking questions in the Science class has to be encouraged.

(6.3) *Using language*: Teachers have to ensure acquisition of language skills, as using language understood by learners to talk among themselves and to write may enhance learning. When relevant language is used, learners feel free to respond to teachers' questions, and to ask questions which signals learning. Language understood by all may lead to

effective learning and teaching. Henderson and Wellington (1998) support the view that the style of conventional scientific writing may be a barrier for the majority of pupils, which may lead to underperformance. As for technical terms, Harlen (1999) contends that Henderson and Wellington (1998) advocate the development of a 'word bank' which might be used as a spell checker for learners, revision aid for pupils and teachers, and as a way of highlighting the key words in science.

(7) *The curriculum*: For effective teaching to take place, the curriculum has to be sequenced appropriately, taking into cognisance the cognitive development of learners. Harlen (1999) attests that teachers should demonstrate an understanding of science, show greater levels of interest in teaching Science and use relevant teaching methods to teach, e.g. a learner-centered approach, as proposed by Littledyke (1997). Teachers should demonstrate understanding and confidence when teaching Science.

(8) *Teachers' understanding of Science*: Harlen (1999) agrees with the list by Shulman (1987), indicating the kinds of knowledge required to teach Science. These include: (1) content knowledge about Science and of Science, (2) general pedagogical knowledge about classroom management and organisation that transcends subject matter, (3) curriculum knowledge - the guidelines, national requirements and materials available, (4) pedagogical content knowledge about how to teach the subject matter, including useful illustrations, powerful analogies and examples, (5) knowledge of learners and their characteristics, (6) knowledge of educational contexts, (7) knowledge of educational goals, values and purposes, including the history and philosophy of education. Harlen (1999) indicates that Bennett, Wragg, Carré, & Carter. (1992) proved in their study that gains in curriculum knowledge, pedagogic content knowledge and knowledge of goals may be responsible for an increase in confidence rather than increased personal understanding of Science.

According to Francesco *et al.* (2019), effective teaching is associated with competence. Weinert (2001) attests that "competencies" can be defined as "the positive combination of knowledge, ability and willingness in the availability of the individual to cope successfully and responsibly with changing situations". If a teacher is effective, then he/she will use the combination of knowledge, ability and willingness to prepare and teach *Planet Earth and beyond* topics in changing situations, with continually changing context, thus improving his/her classroom practices. Letina (2019) in his/her study of inquiry-based teaching, indicates that even if teachers have a positive attitude and views regarding inquiry-based teaching, they will not be able to properly implement inquiry-based instruction in their

teaching practice if they lack teaching competences and the fundamental knowledge of the scientific discipline they teach.

Lysniak *et al*. (2019) suggest that teachers should create a sense of belonging among learners in order to stimulate learning and teaching in class. Teachers should use learners' names when they provide instruction, corrections, or encouragement during performance in motor skills, and use demonstrations where learners cannot demonstrate a particular skill. Breaking down things step by step is also identified as one of the strategies of effective teaching, as well as creating an accepting environment for learners of varied cognitive levels. Proper equipment, which in the Science class can be called resources and apparatus, is needed for effective teaching.

Kadbey *et al.* (2015) in their study on primary teachers' perceived challenges in teaching Science in Abu Dhabi public schools, indicate that some researchers, like Senler and Sungur (2009), studied the effect of parental involvement in the teaching of Science. Their study concluded that students whose parents are actively involved in their children's learning of science, develop positive attitudes towards Science and achieve better results in this subject. Parental involvement may therefore be one of the factors that may lead to the effective teaching of Science.

### 2.3.4 Reasons why effective teaching of *Planet Earth and beyond* in Grade 9 is necessary

*Poor performance in end-year examinations*: Chapter 4 of CAPS for Natural Sciences Grade 9 (DoE, 2011) provides the following guidelines: the end-year examination paper comprises a total of 100 marks. Questions have to be asked from Term 3 content: Energy and change (60%) and Term 4 content: *Planet Earth and beyond* (40%). If effective teaching is not done on *Planet Earth and beyond* topics, learners will lose 40% of the examination mark, which might lead to underperformance when the final year mark for a learner is compiled according to CAPS. The North West Provincial Assessment (NWPA) diagnostic report for the period 2014-2016, shows that the average performance of the Province over the specified period of three years is 29.9%. The performance of learners in questions covering "Layers of the earth" was 21.6%, and 12.3% in questions covering "Greenhouse effect". The performance of learners in questions based on "Birth, life and death of stars" was 21.5%, which might infer

underperformance according to level descriptors (DoE, 2000). The topic that showed underperformance by learners, was *Planet Earth and beyond*.

According to the programme of assessment, other formal activities are performed. However, in terms of the revised Chapter 4 for implementation in the year 2020, there is no alternative assessment. If learners do not perform well in the exam, they do not have an alternative formal assessment task that will boost their performance.

*Conceptual progression*: The layout of *Planet Earth and beyond* content and concepts in CAPS, from Intermediate phase to FET, shows conceptual progression. All *Planet Earth and beyond* topics taught in Grade 9 are also done in all Geography FET classes, from Grade 10 to Grade 12 (DoE: 2011). Effective teaching of the *Planet Earth and beyond* topics in Grade 9 may serve as a good conceptual foundation for Geography learners in grade 10-12, as the same topics are covered in FET, but at a more complex level.

*Higher learning:* The Grade 9 *Earth and beyond* topic forms the basis of what Geography learners learn in tertiary education.

*Career pathing*: *Planet Earth and beyond* topics learnt in Grade 9 may serve as motivation, and be an indicator of the choice of careers, including becoming geologists, astronomers, meteorologists, astronauts, environmental managers and astrophysicists.

### 2.3.5 Challenges affecting the effective teaching of Science

In order to ensure the effective teaching of the *Planet Earth and beyond* topics, challenges that may affect the effective teaching thereof need to be identified and dealt with. According to Kelsey *et al*. (2020), in their study of experiences of teaching anatomy online, failure to participate in discussions is also a challenge affecting effective teaching. During long lecture classes, if learners do not take notes, effective teaching is impeded. Some learners cannot learn effectively if passive activities, e.g. video-clips, are used over a long period of time. Porter *et al*. (2017) mention overcrowded classes as one of the challenges that may impede effective teaching. Kadbey *et al*. (2015) cite the language barrier as a challenge that may lead to the impediment of effective teaching and learning. Al Ghamdi and Al Salouli (2013) suggest the following as factors that may impede effective teaching: Insufficient instructional

time, limited physical space, scarcity of resources, the content in textbooks being above the level of learners' understanding, poor learner behaviour and lack of professional development. These are all barriers to the implementation of the reformed Science curriculum. This might be a challenge to teachers when teaching *Planet Earth and beyond*.

In terms of the South African context, the following are challenges that affect the effective teaching of *Planet Earth and beyond*: the structure and layout of Natural Sciences as a subject, the South African schooling system, planning, language barrier, overcrowded classes, lack of or shortage of resources, poor learner behaviour in class and lack of parental involvement.

*Structure and layout of Natural Sciences as a subject*: In terms of research, Kadbey *et al*. (2015) refer to these as issues related to curriculum. The structure and layout of content in the South African curriculum might be a barrier to effective teaching of *Planet Earth and beyond*. Four different subjects, Life Sciences, Chemistry, Physics and Geography, have been infused to form one subject called 'Natural Sciences.' It is highly possible that a Grade 9 teacher may not be an expert in all the four subjects mentioned, thus resulting in some parts of the curriculum not being fairly treated, including *Planet Earth and beyond*. Chapter 3 of CAPS (DoE, 2011) outlines the curriculum to be taught per subject per Grade. *Planet Earth and beyond* is the last topic of the year to be taught, as indicated in Chapter 3 of CAPS, as it has to be treated as Term four content. This might be one of the factors compromising effective teaching of *Planet Earth and beyond*, as most teachers are rushing to finish the curriculum, and others leave out topics that they are not familiar with.

*South African schooling system***:** The CAPS document indicates that two phases, senior phase (Grade 8 and 9), and FET (Grade 10-12) are housed in secondary schools. In this case, teachers in secondary schools have to teach Grade 8 and 9 as well as Grade 10-12. Possibilities are that those teachers may focus more on teaching Grade 10-12 classes and ignore senior phase classes, Grade 8 and 9. It might be possible that in the fourth term of the year, Grade 9 teachers who are also teaching Grade 12, may not give attention to learners in Grade 9, and may not teach *Planet Earth and beyond* to the fullest, as they might be focusing more on trial examinations and revision in Grade 12. That might impact negatively on the teaching of *Planet Earth and beyond*.

*Planning*: Harlen (1999) indicates that better planning leads to better execution of the lesson, results in better understanding of concepts under discussion or investigation in class, and ultimately better planning leads to effective teaching. When CAPS was introduced for the first time, no template on lesson planning to assist teachers, more especially newly appointed teachers, was suggested by the Department of Education. Only features of a good lesson plan were listed (DoE, 2011). If teachers may not plan for the teaching of *Planet Earth and beyond*, it might lead to poor execution of the *Planet Earth and beyond* lessons, which ultimately will hamper effective teaching.

*Language as a barrier*: Porter *et al*. (2017) indicate that the language used as a medium of instruction may be a barrier to effective teaching and learning. The use of English as a medium of instruction in South African schools may be a challenge to learners. To some learners it is a second language and the use of a second language in the acquisition of scientific concepts has proved to be a challenge which impacts negatively on effective teaching of science, and learner performance (Kadbey *et al*., 2015).

*Overcrowded classes***:** Porter *et al*. (2017) cite overcrowded classes as one of the factors that may impede effective teaching of science. Hands-on activities as well as demonstrations may not be performed in overcrowded classes when dealing with *Planet Earth and beyond* topics, which may compromise understanding them.

*Lack of or shortage of resources***:** Lysniak *et al*. (2019), suggest that resources and apparatus are needed for the effective teaching of Science. For effective teaching of *Planet Earth and beyond* to take place, relevant resources are needed. Without such resources, like the globe representing the earth, representations and technology to demonstrate revolution and rotation of the earth, video-clips to provide understanding of concepts like global warming and layers of the atmosphere, models and relevant apparatus to demonstrate separation of minerals from the soil, like ore from rocks, it will be a challenge for effective teaching and learning of *Planet Earth and beyond* to take place. Most of the schools might not have the necessary resources to be able to provide effective teaching of the topic.

*Poor learner behaviour in class:* This suggests that unpleasant learner behaviour may impede effective teaching (Kadbey *et al*., 2015). If learners' behaviour in the *Planet Earth and*

*beyond* class remains unbearable, hands-on activities that are pillars of teaching *Planet Earth and beyond* might end in chaos, thus effective teaching and learning might be compromised.

*Parental involvement***:** According to Kadbey *et al*. (2015), learners whose parents show interest and who support their children in learning Science, show improvement in learning the sciences. *Planet Earth and beyond* is a highly practical subject. If parents show interest in their children's work, they will be able to assist them, as children will be able to relate what they learn at school with reality, as explained to parents at home.

Having discussed factors that may impede on the effective teaching of *Planet Earth and beyond*, a discussion follows regarding a workshop as intervention, and a teacher professional development activity for the current study.

### 2.3.6 Workshops

It has been established that an effective approach to professional competencies of teachers is in-service professional development (Fareo, 2013; Jika & Mokhele, 2014; Ravhuhali, 2014; Ajani, 2018). Ajani (2018) and Mkhwanazi (2014) propose that in-service professional development of teachers refers to all interventions or initiatives that can enhance teachers' classroom instructions. Louise (2008) recommends that teachers should be developed on a regular basis in South Africa and Nigeria. Their responsibilities are challenging and demand regular professional development. Ajani (2018) attests that only knowledgeable and competent teachers can develop or build intelligent or skilful learners who can be problem-tasked. Adjani (2018) further states that teachers' knowledge and skills can also be updated on their subject matter through collaborations of ideas, mentorship opportunities among teachers and skills acquisition. Professional development activities are accessed through workshops, seminars, refreshers courses/retreats, conferences and other professionally inclined activities for the teachers. Participation in professional development helps to improve classroom practices and learners' academic performance (Jacuith *et al*., 2010).

With this in view, an intervention workshop was proposed as a professional development activity for the current study. Ajani (2019) further contends that teachers who participate in professional development learn new knowledge, skills or values that can improve or change their teaching methods or skills, which is referred to as 'teacher change' in the current study.

### 2.3.7 Teacher change

Kern and Graber (2018) explain the term 'teacher change' as a pedagogical change implemented by teachers. They indicate that Richardson (1998) contends that research conducted primarily in general education suggest that teachers regularly and frequently make instructional changes based on their perception of what is working for them. Kern and Graber (2018) show that teacher change may take place as a result of intrinsic or extrinsic stimulus. The confidence to attempt to make changes can be described as a type of 'self-efficacy'. Bandura (1995) defines self-efficacy as a "belief in one's capability to organize and execute the courses of action required to manage prospective situations". Kern and Graber (2018) contend that 'teacher change' becomes possible when teachers have the willingness or openness to change.

The study by Ketelhut *et al*. (2019) was conducted in the context of a year-long teacher professional experience focused on integrating Computer Technology (CT) into elementary science education. According to Ketelhut *et al*. (2019), summer programs and workshops are common formats researchers adopt to bring innovation to teachers who are typically the busiest during the academic year. These programmes were employed in their study to integrate CT in elementary science education in the USA. Ketelhut *et al*. (2019) underline that, according to Darling-Hammond *et al*. (2017), educators could benefit from prolonged professional development that allows time for teachers to grapple with new concepts, experiment in the classroom, reflect on their practice, and receive feedback from researchers. However, Kern and Graber (2018) argue that the findings of their study indicate that teacher change predominantly occurs due to self-initiated activities rather than change happening as a result of the impact of an external stimulus in the form of workshops. Ketelhut *et al*. (2019) further state that they see professional development opportunities inciting change as catalysts to engage elementary-aged children in CT. The results of the study indicate that continuous professional development through workshops helps teachers to change and transform their practice. The Integrated Model of Teacher Professional Growth, as proposed by Clarke and Hollingsworth (2002), was utilised in this study for data analysis.

**Clarke and Hollingsworth (2002) IMTPG model**

The IMTPG model of Clarke and Hollingsworth (2002) was utilised as data analytic tool in the current study. This study suggests that teachers' beliefs and knowledge are interconnected with their practice, as highlighted by the IMTPG (2002) model. If the aim of professional development is to change teacher practice, then it must simultaneously address teachers' beliefs (Ketelhut *et al*., 2019). The IMTPG model domains are interconnected and non-linear, representing multiple growth pathways. The model suggests that change occurs through reflection and enactment within and between each of the four domains. Intervention workshops, semi-structured interviews, a manual journal and portfolio of evidence were utilised to evaluate teachers' classroom practices, using the Clarke and Hollingsworth model (2002).

## 2.4 SUMMARY

This chapter discussed the literature related to classroom practices. It then provided an overview of pillars of pedagogical competence, after which it looked at the literature-based description of TCPD, CK, PK and PCK, as well as challenges that might impede the effective teaching and learning of Science. It further looked at discussions on aspects and approaches that can bring about quality in teaching and learning of Science. Finally, the literature that deliberates on pedagogical development, as well as the participation of teachers in professional development activities was reviewed. In the next chapter, the theoretical framework that informed the current study is discussed.

# CHAPTER 3

# RESEARCH DESIGN AND METHODOLOGY

## 3.1 INTRODUCTION

The previous chapter focused on the literature review, and dealt with challenges and implementation, shedding light on classroom practices of Grade 9 Natural Sciences teachers when teaching the topic, *Planet Earth and beyond*. This chapter outlines the research design and methodology, research site, participants and sampling, research process, data-gathering techniques (workshop discussions, semi-structured interviews, portfolio of evidence and journal reflections), data analysis, validity and trustworthiness and ethical considerations. A short summary concludes the chapter.

## 3.2 RESEARCH METHODOLOGY

Coe *et al*. (2017) explain research methodology as a critical component of research that specifies approaches used in the inquiry as well as the design of the study. It concerns the procedures and logic to be followed during the research process. Research methodology provides the description of the research process, outlining various stages of the exploration, which includes the selection of participants, the data collection process, data analysis, the role of the researcher and ends with a discussion of validity and reliability in qualitative research (Matete, 2012).

Qualitative research as defined by Suter (2012) aims to explain social phenomena in their natural context through verbal description and analysis of complex data, such as interviews, documents, field notes or images. It is largely inductive, with reasoning moving from descriptions of specific, detailed observations to general principles. The explanation of qualitative research as outlined by Suter (2012) is relevant to this study in the sense that a questionnaire, interviews and document analysis were used as data collection methods. Teachers were interviewed in their natural context through verbal descriptions,

In this study qualitative research methodology also focuses on discovering and understanding the experiences, perspectives and thoughts of targeted participants (teachers) and explores

meaning, purposes, or reality. It is also regarded as a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that constitute the study. At this level, qualitative research involves an interpretive, naturalistic approach to the study. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings that people bring to them. The teachers' experiences regarding classroom practices of Grade 9 Natural Sciences teachers when teaching the *Planet Earth and beyond* topics was investigated through the teachers' interview questions. The research qualitative methodology chosen showed how the research outcomes obtained were in line with provided goals and objectives of the study. Weil (2017) attests that qualitative studies are usually small-scale micro studies, which are discovery-oriented, typically yielding detailed descriptions, and revealing experiential data, hence a case study was chosen for this study as it features well with principles of qualitative methodology discussed. The next point of discussion is the research design specific case study.

## 3.3 THE RESEARCH DESIGN

The chosen research design for this study was a case study. Different researchers explain a case study in different ways as follows: a case study research is described as a systematic inquiry into an event or a set of related events which aims to describe and explain phenomenon of interest (Bromley, 1991; Maree, 2010). Rubin and Babbie (2013) view a case study as a particular examination of phenomenon. According to Henning (2010), a case study is employed to gain an in-depth understanding of the situation and meaning for those involved. In this study, a case study was employed to allow the researcher gain an in-depth understanding of grade 9 teachers' classroom practices, by exploring how their PCK of the *Planet Earth and beyond* strand concepts influence their teaching. Stake (1995) explains a case study as the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances. Creswell (2007) understands a case study to be a type of design in qualitative research, or an object of study, as well as a product of the inquiry.

Case studies also bring the researcher very close to the live practice of coaching (De Haan, 2019). They are ways to explain, describe or explore phenomena (Alpi & Evans, 2019).

Burmansah *et al*. (2019) contend that a qualitative case study serves as an approach that produces descriptive data in the form of written or oral words from interviews with people and their observed behaviour. Thus, this study focused on classroom practices of Grade 9 Natural Sciences teachers when teaching the topic *Planet Earth and beyond* (phenomenon of interest), using a case study to gain an in-depth understanding of this phenomenon and meaning for those involved.

The choice of this research design was motivated by the multiple sources of data used in this study. A case study is one of the qualitative research approaches, which dictates to the researcher to interact with participants, and get first-hand experiences from the field. This methodology is usually used for exploring and understanding the meaning of individuals or groups ascribed to a social or human problem. It gave this researcher an opportunity to dwell deeper into the roots of the phenomenon under investigation. It involved emerging questions and procedures, data collected in the participants' setting, inductive data analysis and data interpretation (Creswell, 2007).

The depth and richness of a case study description helps readers understand the case and whether findings might be applicable beyond that setting (Alpi & Evans, 2019). Creswell (2007) further emphasizes that a case study research is a qualitative approach in which the investigator explores a bounded system (a *case)* or multiple bounded systems (*cases*) over time through detailed, in-depth data collection involving multiple sources of information (e.g. observations, interviews, audio-visual material, documents and reports), and reports a case description and case-based themes. In this study, six cases (schools) were explored using multiple sources of data collection, including interviews, document analysis (Manual Journals, educator questionnaire, lesson plans, portfolios of evidence) and lesson observations.

The research design helps to provide a relevant framework needed to guide the study (Kassu, 2019). The research design is also explained as a plan or strategy that will be used to investigate the research question(s) (Johnson & Christensen, 2008). According to Robson (2011), research design is concerned with turning research questions into projects. It also deals primarily with aims, purposes, intentions and plans within the practical constraints of location, time, money and availability of staff. The researcher used these as interpretative and practical ways to explore and investigate classroom practices of Grade 9 Natural Sciences

teachers when teaching the *Planet Earth and beyond* topics: a case study was investigated through the teachers' interview questions.

Maree (2010:76) contends that the strength of case studies is that "multiple sources and techniques are used in the data-gathering process, and that case studies are used to answer the how and why questions of an investigation". Results from case studies provide insights into other similar situations and cases, thereby assisting the interpretation of other similar cases. Justification for a case study is that it offers the researcher an opportunity to gain a comprehensive (holistic) understanding of the specific phenomenon under investigation. In this instance, a case study investigation was used to explore how classroom practices of Grade 9 Natural Sciences teacher participants, which include pedagogic competencies, can be strengthened in the teaching of *Planet Earth and beyond* topics of the CAPS curriculum in the Bojanala District of the North West province. A case study as a chosen research design for this study showed how the research outcomes obtained were in line with the provided goals and objectives of the study.

## 3.4 RESEARCH ORIENTATION

This study is a qualitative study located within an interpretive paradigm. Al Riyami (2015) explains a paradigm as a loose collection of logically related assumptions, concepts or propositions that orient thinking and research (Bogdan & Biklen, 1998). The interpretivist paradigm is embedded in the fact that realities are multiple and socially constructed. It is based on a combination and utilisation of ontology and epistemology, following a particular methodology, that is, a qualitative approach. Interpretivists adopt relativist ontology, where a single phenomenon can have multiple interpretations and there is no basic process by which truth can be determined. They aim at getting a deeper understanding of the phenomenon and its complexity in its unique context, not to generalise to a whole population (Creswell, 2007).

Ontology refers to the nature of the reality in the social world, and epistemology means how one could know about that reality or information and procedures to follow to frame the study is the methodology (Creswell, 2007). Interpretivists believe that knowledge is gained inductively through interaction between research and research participants, and allows a researcher to conduct the study in its natural setting (Al Riyami, 2015). In this case the researcher and teachers (participants) interacted in order to attain report regarding classroom practices of Grade 9 Natural Sciences teachers when teaching the topic *Planet Earth and*

*beyond.* It further allowed adequate interaction between the researcher and participants, in this instance the teachers, in order to allow them to work together to construct a meaningful reality.

The interpretivist paradigm is further concerned with understanding the nature of the classroom from the subjective experiences of the individual teachers. Teachers use meaning versus understanding oriented concepts, such as lesson plans, portfolio development, interviewing or participant observation, that rely on a subjective relationship between the researcher and the teachers.

Within an interpretive paradigm, a case study was chosen for this study in order to allow the researcher to interact freely with teachers in their natural setting, being the classroom, through interviews, content discussions as well as lesson observations during an intervention workshop. Document analysis was done by using lesson plans, a portfolio of evidence and teacher bio data in identified research sites. Interviews helped to probe participants' thoughts, values, unreasonable opinions, perceptions, views, and feelings (Al Riyami, 2015). The teachers developed lesson plans and a portfolio of evidence. According to Marshall (1996), a case study is directed by the interpretive paradigm because it is used to answer humanistic "why and how?" questions instead of answering more mechanistic "what?" questions, hence a case study was chosen for this study.

Teachers who participated in this study were treated as research participants, as attested by interpretivists, and not as research objects. Different perspectives were investigated, and phenomena under investigation were looked at from different angles. Mika (2018) states that the ability to interpret and understand an interpretive paradigm from different angles enables one to be informed about the nature of knowledge in the social world (ontology); how one could know about it (epistemology) and what procedures one could follow (methodology) to frame one's study, or ways to be used to obtain knowledge. Hence the study is located within an interpretive paradigm.

## 3.5 RESEARCH PURPOSE AND OBJECTIVES

The study aimed to contribute to a research-based practice of PCK development by exploring how teachers' PCK influence the teaching of the *Planet Earth and beyond* strand concepts.

### 3.5.1 Research Question

- How does teachers' pedagogical content knowledge (PCK) influence the teaching of the *Planet Earth and beyond* strand concepts?

### 3.5.2 Sub-Questions

The following sub-questions guided this study:

- How does the teachers' orientation to Science teaching influence their pedagogical content knowledge of the *Planet Earth and beyond* strand concepts?
- In what ways do specific characteristics of the professional development programme contribute to development of the teachers' pedagogical content knowledge of the *Planet Earth and beyond* strand concepts?
- How does the Grade 9 teachers' pedagogical content knowledge manifest during their teaching of the concepts of the *Planet Earth and beyond* strand?

## 3.6 RESEARCH SITE, SAMPLING AND PARTICIPANTS

This section describes the location (site) where the research was conducted, the sampling techniques and research participants' (teachers) population.

### 3.6.1 Research site

The study was conducted in the Moses Kotane Sub-District of the North West province in the Republic of South Africa. The Moses Kotane Sub-District is one of the four Sub-Districts (Municipalities) making up the Bojanala District, namely: Moretele, Madibeng, Rustenburg and Moses Kotane. Figure 3.1 shows Kgetleng River instead as an independent Local Municipality, however, according to new demarcations, Kgetleng River is incorporated with the Moses Kotane Local Municipality. Figure 3.1 shows the position of the Moses Kotane Municipality in the Bojanala District, where the research was conducted.

### 3.6.2 Sampling

Maree and Creswell (2010:79) describe sampling as the process used to select a portion of the population for a study. A sample is chosen for a specific purpose. According to Cohen *et al*. (2005:99), there are two main methods of sampling, namely probability sampling (also known as random sampling), and non-probability sample (also known as purposive sampling). Maree and Creswell (2010) explain that purposive sampling means that

participants are selected based on some defining characteristics that enable them to provide the data needed for the study. Generally, in qualitative research, purposive sampling entails researchers handpicking the cases to be included in the sample on the basis of predefined characteristics. In this way researchers select a sample specific to their needs (Cohen *et al*., 2005). Purposive sampling was used in this study as participants were selected based on some defining characteristics that enabled them to provide the data needed for the study, e.g. the participants needed to be teaching Grade 9 Natural Sciences.

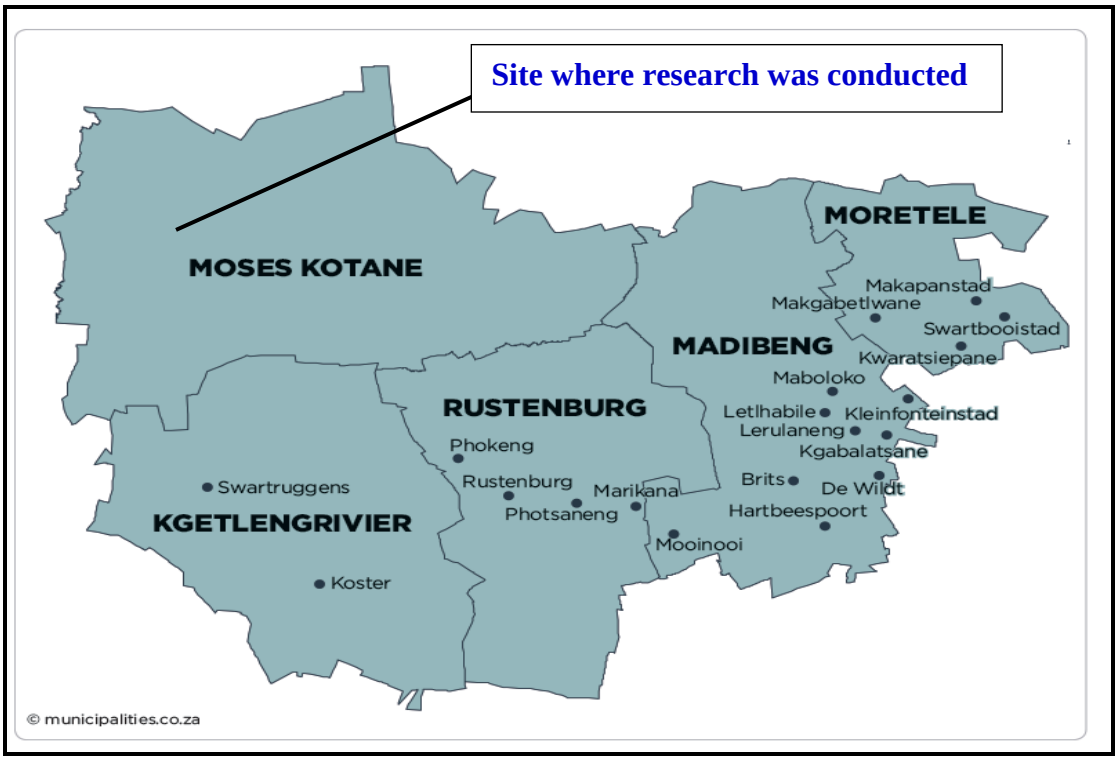



**Figure 3.1**: Bojanala District showing the position of the Moses Kotane Local Municipality (Map retrieved from *https://municipalities.co.za/contactus - 2012)*

### 3.6.3 Participants

The participants in this study were Natural Sciences teachers teaching Grade 9 (one teacher per school was purposively selected). The six participants were all from schools that participated in this study and did not have the necessary infrastructure for Science teaching, such as Science laboratories and computer laboratories. Furthermore, the six schools were classified as quintile 1 schools (small and not financially viable) and all six have not been adopted by the Maths, Sciences, and Technology department (MST) of the North West Province, formerly known as 'Dinaledi schools'. In summary, these are generally under-resourced schools, with few teachers teaching according to both the Further Education and

training (FET) and General Education and Training (GET) curricula. All six participants were selected based on their willingness to participate in this study and would be allowed to withdraw at any time.

Participants were expected to have a Diploma (Matric plus three years of study: M+3) as the lowest qualification. This method was effective since only a limited number of teachers participated as primary data sources, hence only six Grade 9 teachers participated in this study instead of having all Grade 9 teachers in Moses Kotane participating, which would have been impossible. Secondary schools that participated in this study were selected from the following clusters, as indicated in Table 3.1.

**Table 3.1:** Moses Kotane Sub-District clusters

| **Name of cluster** | **Number of teachers** |
|---|---|
| Dinaledi | 1 |
| Retladirela | 2 |
| Madikwe | 2 |
| Mogale | 1 |
| **Total** | **6** |

Participant teachers from the schools selected for this study benefited from other previous interventions by the Department of Education, such as attending study camps. Apart from these interventions, the schools portrayed realistic challenges which were met by the Senior Phase Natural Sciences teachers selected to participate in this study.

**Table 3.2:** A summary of the participants' biographical data

| **No** | **Category** | **Pule** | **Mmapula** | **Tladi** | **Motlatsi** | **Mavis** | **Mabel** |
|---|---|---|---|---|---|---|---|
| 1 | Gender | Male | Female | Male | Female | Female | Female |
| 2 | Name of school | School A | School B | School C | School D | School E | School F |
| 3 | Age | 29 | 25 | 43 | 26 | 56 | 28 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | Teaching Experience in years | 5 | 3 | 9 | 1 | 28 | 3 |
| 5 | Experience in teaching Natural Sciences (no. of years teaching grade 9) | 4 | 2 | 5 | 1 | 16 | 3 |
| 6 | Subjects done in matric | English, Setswana, Life Orientation, Maths, Geography, Physical Sciences, Life Sciences | Maths, Physics, Life Sciences, Business studies | Maths & Science | Life Sciences, Agricultural Sciences, Physics, Maths | Setswana, English, Afrikaans, Biology, Agricultural Sciences, & History | Maths, Physics, Biology |
| 7 | Educational qualifications attained | PGCE | BEd | BSc, PGCE, Certificate in Physics | BSc | UDES, ACE, FDE, BEd Hons | National Diploma in Analytical Chemistry |
| 10 | Grade teaching | 08-11 | 08-12 | 08-12 | 08-10 | 08-10 | 08-12 |

## 3.7 INTERVENTION WORKSHOP

### 3.7.1 Intervention workshop discussions

Alpi *et al.* (2019) attest that sources of evidence for case studies include interviews, documentation, archival records, direct observations, participant observation and physical artefacts. Semi-structured interviews, workshop discussions including lesson observations (during the intervention workshop), manual journal reflections, a teacher questionnaire, and a portfolio of evidence were used as data generation tools in this study.

Kekana (2016) identifies an Advanced Certificate in Education (ACE) in Natural Sciences and Education Management as one of the development programmes implemented in South Africa as an intervention. The study was aimed at investigating if graduates who successfully completed ACE in Education Management programme changed their professional practice or

not. It was found that there was a change in their professional practice based on better interpretation and implementation of policies. In this study, an intervention workshop was used as an opportunity to improve the classroom practices of Grade 9 Natural Sciences teachers when teaching *Planet Earth and beyond* topics. This is in line with Blank and Alas (2009) and Desimone (2009), who attest that professional development programmes are meant to improve teachers' knowledge and skills.

Ono and Ferreira (2010) view teacher development programmes involving one session as ineffective. In order to avoid this, the intervention workshop was conducted over four consecutive days in one venue. The workshop began by allowing participants to set their own desired workshop expectations, which was followed by a quick reflective discussion of these expectations, measured (compared) against the researcher's intervention workshop objectives.

The research context and significance of the intervention were discussed, coupled with a quick orientation through documents used during the workshop, these being the participant manual, facilitator manual, manual journal, lesson plan templates as well as lesson observation templates. Figure 3.2 shows a list of expectations as listed by the participants. Figure 3.2 was then compared with workshop objectives as listed in Figure 3.3.

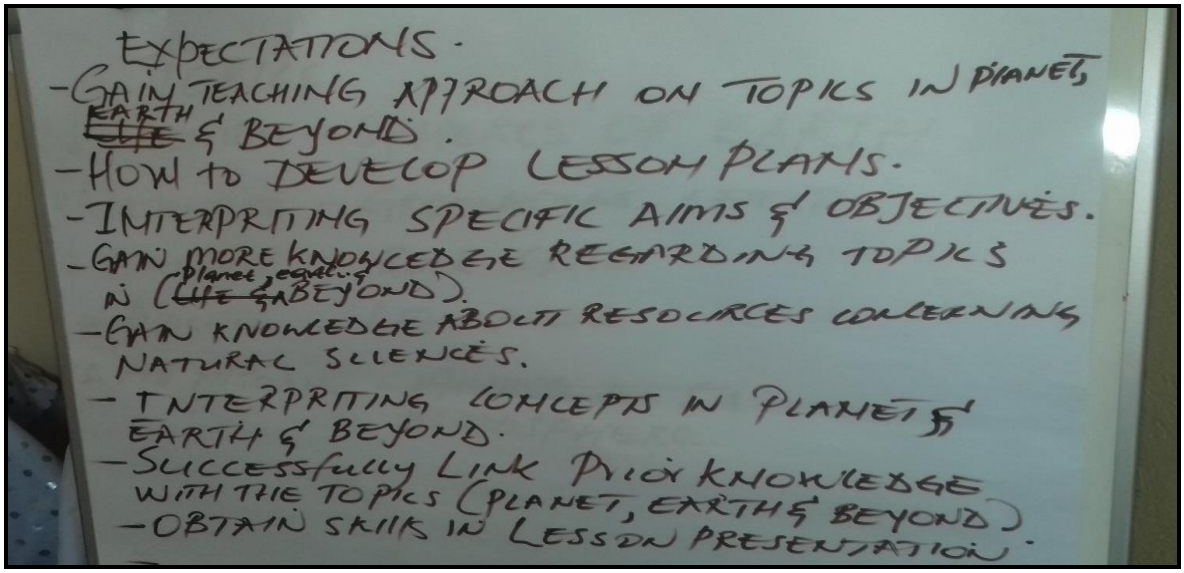



**Figure 3.2:** Workshop expectations

The researcher outlined the workshop objectives as listed in Figure 3.3, and measured them against participants' expectations. It was realised that participants' objectives and the researhcer's workshop objectives were aligned.

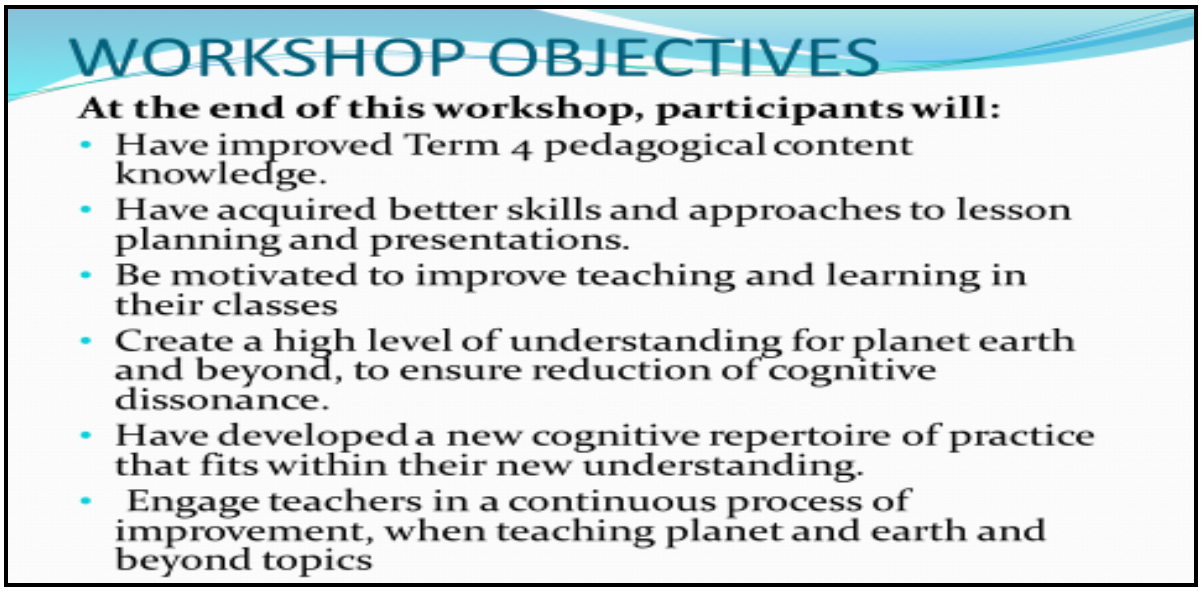



**Figure 3.3:** Workshop objectives

Based on the workshop expectations discussion, it was evident that participants needed to be assisted in the developing of lesson plans based on CAPS, the relevant approach to be used to teach various topics of *Planet Earth and beyond*, lesson presentation skills, and interpretation of specific aims. All these are referred to in this study as pedagogical content knowledge, gaining more knowledge with *Planet Earth and beyond* topics, and interpreting *Planet Earth and beyond* topics. Participants' workshop expectations corresponded directly with all three research objectives and were the same as workshop objectives planned by the researcher.

The discussion of workshop expectations was followed by a quick orientation of documents to be used during the workshop, including the lesson plan template, lesson observation discussion template, teacher bio data template, the manual journal, and the participants' and facilitator's guides. These assisted participants to understand how to use these documents with ease during the workshop. The lesson plan templates were distributed among participants, and they were told to prepare lesson plans that they would use to present the lesson, based on one (1) topic of the *Planet Earth and beyond* strand, on day four, which was

the last day of the intervention workshop. All the other listed events were attended to on day one (1) of the intervention workshop.

On day two, ground rules were discussed with participants, followed by a vigorous discussion of the following *Planet Earth and beyond* topics: Spheres of the earth and the lithosphere. Other *Planet Earth and beyond* topics were discussed on day three, which included the Rock cycle, Extracting ores, Refining minerals, Mining in South Africa, the Greenhouse effect and the Birth, life and death of stars.

The approach followed when discussing these topics was that participants worked in pairs during activities to respond to the question. Discussion in pairs was followed by a whole classroom discussion, which was consolidated by the use of video-clips and a PowerPoint presentation by the researcher.

On day four participants were given time to prepare and present a lesson on topics of their choice but pertaining to the *Planet Earth and beyond* strand. All participants used lesson plan templates given to them on day one. The lesson plan template was already integrated with specific aims and Science process skills as prescribed by CAPS. In summary, the following were skills and objectives targeted during the intervention workshop:

**Table 3.3:** Skills and objectives during intervention workshop

| **Skill** | **Objective** |
|---|---|
| Content Discussion | To determine participants' content knowledge (CK & PCK) of *Planet Earth and beyond* topics. |
| Conducting "Hands-on" practical activities | To determine participants' ability to integrate hands-on activities in lessons to enhance understanding and to learn to improvise in case there was a shortage of relevant learning resources. |
| Lesson Planning | To determine participants' planning of *Planet Earth and beyond* lessons, content, utilization of relevant resources. |
| Lesson Presentation | To determine participants' planning of *Planet Earth and beyond* lessons, content, utilization of relevant resources, use of relevant |

| | |
|---|---|
| | teaching approach, confidence level, and attitude. |
| Lesson Observation | To provide a platform on which participants can learn to share good practices, be able to reflect on their presentations and come up with suggestions for improvement. |

### 3.7.2 Semi-structured interviews

Interviews are explained by Johnson and Christensen (2008) as data-collection techniques in which an interviewer asks an interviewee questions. That is, the interviewer collects the data from the interviewee, who provides the data. Bertram and Christiansen (2015) explain interviews as a conversation between the researcher and the respondent, whereby the researcher sets the agenda to ask the respondent questions and obtain answers. For this study, semi-structured interviews were used based on the flexibility of the data-generation procedure and the relevance of the data to be collected. Semi-structured interviews are usually conducted in a face-to-face setting, which permits the researcher to seek new insights, ask questions, and assess phenomena in different perspectives (Kassu, 2019). The purpose of the interviews was to obtain information regarding experiences of Grade 9 teachers and their confidence level when teaching *Planet Earth and beyond* topics. The researcher asked the teachers' questions and they responded in a face-to-face situation and an audio-tape recorder was utilised for recordings. The interviews were conducted at a designated place within reach of all the participants.

Through semi-structured interviews the researcher managed to gain a deeper understanding of participants' perception about *Planet Earth and beyond* topics, their confidence level when coming to the teaching of *Planet Earth and beyond* topics, how much they knew about *Planet Earth and beyond* topics, and topics that participants identified as challenging in the *Planet Earth and beyond* strand. According to Wiersma and Jurs (2005), interviews should be conducted in such a way that the necessary information is obtained efficiently in a business-like atmosphere because qualitative research is "researcher dependent". This means that the researcher is the instrument, and makes the decisions about which data to collect and/or who to interview. In this study the focus was on Grade 9 teachers teaching the topic *Planet Earth and beyond*. Interviews were audio-recorded and transcribed verbatim. Neuman (2006) states that recording ensures completeness of the verbal interactions and provides material for a reliability check. In addition to the voice recorder, the researcher took notes.

According to Neuman (2006), this helps to formulate questions and probes and to record non-verbal communication, which facilitates data analysis. The length of the interview was determined by the type of participants and their level of interest and understanding of the subject of the study.

### 3.7.3 Portfolio of Evidence

According to Chang *et al*. (2013), portfolios simply reinforce the knowledge management that universities have been involved in ever since their establishment. The purpose of the portfolio of evidence in this study was to establish teachers' classroom practices. The portfolio of evidence included inter alia participants' background, school background, as well as planned informal tasks. The inclusions were meant to provide an opportunity for the researcher to observe changed and improved pedagogy, and to gain a better understanding of concepts that developed after intervention.

Monitoring and moderation of participants' work, which might have had an influence on their classroom practices, were meant to be observed using a portfolio of evidence. According to Mokhtaria (2015), the type of portfolio of evidence that manifests after the learning has been completed and provides feedback that sums up the learning and teaching process (of learning, at the end of instruction), is known as a summative portfolio. In this study, a summative portfolio of evidence was used as an opportunity to create material for both reflection and assessment purposes, as echoed by Gibson *et al*. (2018).

### 3.7.4 Manual journal reflections

The Royal Melbourne Institute of Technology, (RMIT, 2006), explains reflective journals as a personal record of an individual learning experience. Reflective journals are a useful student-centered activity that provides opportunities for self-education (Lindroth, 2015). Creswell (2007) states that when researchers ask participants in a study to keep journals, additional field issues emerge. Based on this, the manual journal template was developed and distributed to all the participants.

The manual journal was divided into the following sections:

- Daily notes, where participants were given space to write notes as discussions proceeded the during intervention workshop.
- Challenging topics, where assistance was required.

- Glossary of terms, where participants were requested to write down difficult concepts during the intervention workshop and explain them, in an attempt to close the content gap.
- New information learnt – where participants noted down new content learnt that they did not know before attending the intervention workshop.
- Misconceptions and corrective measures – Participants were instructed to identify and note down misconceptions they had about certain *Planet Earth and beyond* topics and indicate how those misconceptions were rectified. Identified misconceptions were dealt with as a classroom discussion. All participants were allowed to make inputs, and to explain how they understood concepts under discussion. The utilisation of the manual journal helped participants to remain focused on content discussion, helped to clear misconceptions, and to close the content gap that was identified during the pre-intervention workshop, and from the analysis of the teachers' bio data. At the end of the workshop participants had written their personal notes because of the utilization of the manual journals.
- Participants were also requested to suggest activities that could be included in future professional development programmes.

## 3.8 RESEARCH PROCESS

The study was conducted in a series of five rigorous steps. The study started with a critical analysis of research journals, called the literature review, related to the topic, classroom practices of teachers when teaching Natural Sciences strands, as a way to get the broader background or to widen the base or the context of the study. This was followed by pre-intervention interviews. Pre-intervention interviews were followed by the intervention workshop during which engagement with content was done, and participants were given an opportunity to prepare and present lessons that helped to answer all three research questions. Reflections on planned and presented lesson plans during the intervention workshop helped participants to respond to research questions 2 and 3. Participants were also given an opportunity to complete the workshop evaluation form, which contained questions that helped further to answer research questions 1 to 3. At the end of the pre-intervention workshop, post-intervention interviews were conducted, in which participants were asked the very same questions they had been asked during the pre-intervention interviews. This helped to answer research questions 1 and 3. The last step of the research was analysis of the following documents: the teacher questionnaire, drawn lesson plans, the manual journal and the portfolio of evidence. This was done in order to ensure that any gap with regard to one research question not responded to, was closed. This helped participants to respond to all three research questions comprehensively.

## 3.9 DATA ANALYSIS

### 3.9.1 Purpose of data analysis

Data analysis entails the breaking down of the data into constituent parts to obtain answers to the research questions. The purpose of analysis was to reduce data to an intelligible and interpretable form so that the relations of the research problems could be studied, and conclusion drawn (De Vos *et al*., 2011). Analysing data on its own cannot answer research questions, which is why the researcher felt that an interpretation of the data was necessary. The researcher compared the results and inferences that were drawn from the Grade 9 teachers and from data to journals.

### 3.9.2 Qualitative data analysis

The data collected from the interview schedules were analysed by qualitative procedures, since this type of data cannot be quantified easily. Neumann (2006) states that qualitative data are in the form of text, written words, phrases or symbols of describing or representing people, actions and events in social life. Punch (2005) maintains that qualitative research concentrates on the study of social life in the natural setting. Its richness and complexity mean that there are different ways of analysing social life; therefore, there are multiple perspectives and practices in the analysis of qualitative data.

Henning *et al*. (2010) further explain data analysis in a qualitative research as an on-going, emerging and interactive or linear process. It is a process of cleaning, transforming, and modelling data to discover useful information or to discover required information. According to Maree (2010), qualitative data analysis is usually based on an interpretative philosophy that is aimed at examining meaningful and symbolic content of qualitative data.

Before the actual data analysis process started, data were transcribed verbatim, which means that texts from interviews, observational notes or memos were typed into word-processing documents. After data had been collected using different techniques already outlined, the researcher ensured that only relevant data to the research were used. The researcher focused on responses that answered the inquiry and ensured that focus was not lost on the objectives

of the phenomenon under investigation. Through data analysis, researchers try to make sense of what is happening and identify themes emerging from the data as the participants explain the situation (Mika, 2018).

For this study, in order to analyse data, the simultaneous process in a growth network adapted from Wongsopawiro *et al*. (2017), which is a modification of Clarke and Hollingsworth's (2002) IMTPG model, was used as the analytic tool. The model focuses on four different domains, which are: (1) the Personal Domain (PD); (2) the External Domain (ED); (3) the Domain of Practice (DP); and (4) the Domain of Consequence (DC). Figure 3.4 illustrates the IMTPG model.

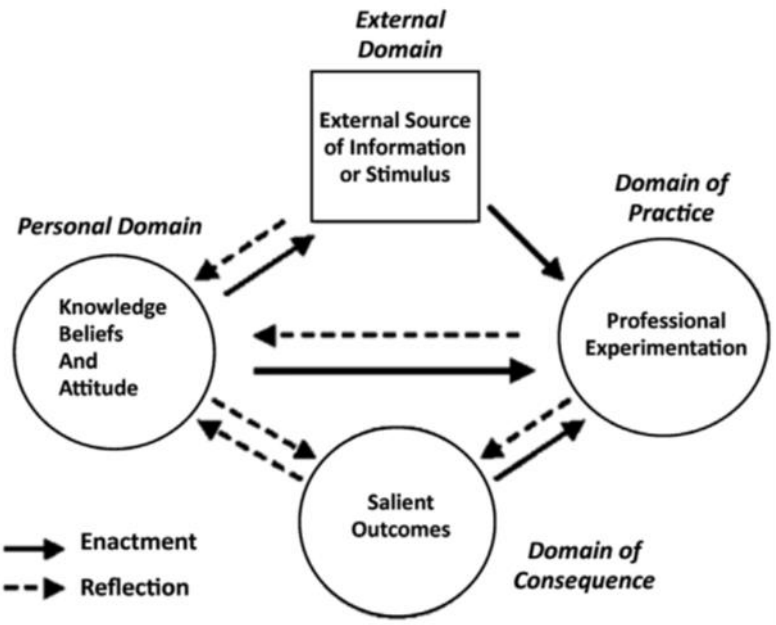



**Figure 3.4:** Clarke and Hollingsworth's (2002) IMTPG model adapted as analytic tool

After transcription, all data were examined and selected for indications of teacher change. To record the changes, the following statements were used:

- Changes in cognition included statements such as *I have learned that, I know how to, I understood why, etc.*
- Changes in attitude or beliefs included statements such as *I feel that now I can, I believe now that, I am confident in, I think now I can, etc.*
- Changes in perceived or intentional behaviour included statements such as *Now I am doing, I used to do … but now I am doing … I tend to do more … I am doing things differently now, etc.*

  Following procedures done by Wongsopawiro *et al*. (2017), a pictorial representation (pictogram) was constructed for the development of each PCK component, showing relationships between the domains of the IMTPG.

To strengthen the internal validity of the analysis, the selection and categorisation of the patterns of change were conducted independently by the researcher and a colleague working in the area of PCK (Cohen *et al*., 2000), and the results obtained were compared. In a few cases where there was a difference, the discrepancy was discussed until an agreement was reached. This model was a useful analytical tool for understanding and reinforcing shifts in teachers' classroom pedagogical competencies and practices, by outlining the processes of alterations. An emphasis on professional learning was important for empowering teachers through valuing their voices and perspectives (Gore & Gitlin, 2004). This enriches the data and provides invaluable depth and insights. Data analysed were from pre- and post-intervention interviews, the completed educator bio data by participants, completed evaluation forms from the intervention workshop, portfolio of evidence, manual journal, completed lesson plan templates, and completed lesson discussion templates.

## 3.10 DATA MANAGEMENT

Galetto (2016) defines data management as an administrative process that includes acquiring, validating, storing, protecting and processing required data to ensure the accessibility, reliability and timeliness of the data for its users. According to Peersman (2014), good data management includes effective processes of consistency, collecting, recording and storing data securely. All data collection tools, such as interview notes, manual journals, portfolio of evidence, teacher bio data and workshop evaluation forms from participants were kept safely in a file as hard copies. Soft copies of all data collection instruments were kept and stored in

one folder as back-up. Pre- and post-intervention interviews were audio-recorded. All interviewee responses were transcribed verbatim, typed and kept as soft copies. All data collected were treated with confidentiality. Data, including the participant guide, facilitator guide and PowerPoint presentation used during the intervention workshop can be accessed and availed for verification, and also for others to use.

For the purpose of the qualitative data analysis, the Miles and Huberman (1994) Framework for Qualitative Data Analysis (The Flow Model) was used. They define the qualitative data as consisting of three categories of activity flow, namely:

- Data reduction;
- Data display; and
- Conclusion drawing and verification.

### 3.10.1 Data reduction

Since large quantities of descriptive information from interviews were produced, the information was organised, which can bring about data reduction. Data reduction refers to the process of selecting, focusing, simplifying, abstracting and transforming the data that appear in written-up field notes or transcriptions (Miles & Huberman, 1994). This occurs continually throughout the life of the research project. According to Punch (2005), the objective of data reduction is to produce the data without a significant loss of information. He argues that the later stages of data analysis involve conceptualising and explaining, since developing abstract concepts is also a way of reducing data.

In this study, the researcher searched for teachers' patterns of thinking, words or phrases that appeared regularly or appeared to be trustworthy regarding the teaching of the topic *Planet Earth and beyond*. The words describing such were coding categories. This assisted in coming up with themes discussed as responses to research questions guiding the study, those being the background of participants who teach Natural Sciences – specifically *Planet Earth and beyond*, orientations to science teaching, challenges of teaching *Planet Earth and beyond*, and pedagogical content knowledge of teaching *Planet Earth and beyond*. Furthermore, six teachers were used and specifically those teaching Natural Sciences Grade 9.

### 3.10.2 Data display

Data display is an organised, compressed assemble of information that permits conclusion drawing action. Miles and Huberman (1994) argue that data display helps the researcher to understand what is happening and enables him or her to do something that is either further analysis or taking action. This was done in the form of graphs, diagrams and/or charts to assemble organised information into an immediately accessible compact form so that the analyst could see what was happening and draw conclusions. For example, results analysis was organised in graphs and tables to show the effectiveness of the intervention workshop.

### 3.10.3 Verification

At this stage, the researcher noted regularities, patterns, explanations, possible configurations and cash flows. Conclusions were drawn in the form of prepositions. They were tentative, pending further work and were sharpened during the process. Once conclusions were drawn, they needed to be verified as the analysis proceeded. According to Miles and Huberman (1994), the meaning emerging from the data needs to be tested for plausibility, sturdiness, conformability and validity, e.g. comparing data collected through the questionnaire, intervention evaluation forms and the portfolio of evidence.

The interviews were transcribed from the voice recorder and prepared in visual written presentations from targeted Grade 9 teachers. Responses of participants were transcribed verbatim. No changes were made as data were transcribed. Only participant responses were captured as they were, without inputs from the researcher. The researcher read, organised and interpreted the transcriptions to make sense of the data. Newman (2006) indicates that a qualitative researcher analyses data by organising it into categories on the basis of themes, concepts or similar features and this was the basis applied by the researcher. Interview responses were categorised into themes.

## 3.11 STRATEGIES TO ENHANCE RELIABILITY AND VALIDITY

Fraenkel *et al*. (2012) say that reliability refers to the consistency of scores or answers from the administration of an instrument to another, and from one set of items to another. Schumacher and McMillan (2001) further explain that reliability refers to the consistency of

the measurements, as well as the extent to which the results are similar with regard to different forms of the same instruments or occasions of data collection.

In this study, a conceptualisation of constructs was done using simple clear language free from errors in the questionnaires and in the interviews with the participants. To ensure reliability, preliminary versions of both the interview schedule and the questionnaire were proofread before using them in the study, to assess the impact of content knowledge and pedagogy regarding the Grade 9 teachers when teaching the *Earth and beyond* topic. In addition, to enhance reliability, a standard condition of data collection was used, that is, respondents were given the same questions and the language was simple and appropriate.

Fraenkel *et al*. (2012) state that validity refers to the appropriateness, meaningfulness, correctness and usefulness of the specific references that a researcher makes based on the data he or she collects. According to Wiersma and Jurs (2005), the validity of research involving questionnaires depends on the response rate and the quality of the response. They define the response rate as the percentage of respondents returning the questionnaire and feel that the quality of the responses depends on the completeness of the data. Therefore, to enhance the response rate, follow-up checks were made with the participants.

To further emphasise the validity and reliability of the research the following were verified, namely the validity, trustworthiness, credibility, transferability, dependability and conformability of the project.

### 3.11.1 Validity and trustworthiness

Matete (2012) explains validity as the research's ability to truly measure that which it was intended to measure. Validity is broadly defined as the state of being well-grounded or justifiable, relevant, meaningful, logical, confirming to accept principles or the quality of being sound, just, and well- founded. Validity is concerned with the accuracy and truthfulness of scientific findings (Cypress, 2017). It includes the degree to which the results of the study are truthful. According to Cypress (2017), a valid instrument or measure should actually measure what it is supposed to measure. In this study the questionnaire was the relevant instrument for the study.

Cypress (2017) explains trustworthiness as the quality, authenticity and truthfulness of findings of qualitative research, and relates to the degree of trust or confidence readers have in results. According to Maree (2010), trustworthiness indicates whether the researcher is able to persuade the audience that the findings are worth paying attention to and that the research is of high quality. In this study, to ensure validity, the researcher submitted the instruments to the research supervisor to ensure validity of the data collection instruments, and also to check if the data collection instruments were responding to the research questions which guided the study. The researcher was also guided by an intensive literature review in Chapter 2, relevant to this study. A variety of data collection techniques such as pre- and post-interviews, evaluation forms for the intervention workshop, prepared lesson plans by participants using a template provided, a manual journal, portfolio of evidence, and educator bio data helped to ensure the validity and trustworthiness of this study. This was done to ensure that these instruments complemented each other. All gaps were closed as a way to ensure that the validity and trustworthiness of the research project were reached.

The use of different approaches or instruments to collect data, as a way of ensuring validity and trustworthiness, is referred to as triangulation by Golafshani (2003) and Csikszentmihalyi and Larson, (2014). Polit and Beck (2004) describe triangulation as the use of multiple referents to draw conclusions about what constitutes the truth. To ensure validity, triangulation was obtained through method triangulation, data triangulation and the use of multiple data sources. Schumacher and McMillan (2001) hold the view that different strategies may yield different insights about the topic and increase the credibility of the findings.

A comparative study of pre-and post-interviewee responses, using the same set of questions during semi-structured interviews, assisted to ensure the validity and trustworthiness of the study. Participants were interviewed independently as individuals and not as a group to ensure the validity and trustworthiness of the outcomes of interviews. Participants were given the same template for the manual journal, the same template to guide them to draw lesson plans, the same template to complete the teacher bio data and the same index to guide them to develop portfolios of evidence. This was done to ensure validity and trustworthiness.

### 3.11.2 Transferability

According to Babbie and Mouton (2010), transferability refers to the extent to which the findings can be applied in other contexts. This implies that findings of this study may be transferred to teachers who attended the intervention workshop and participated in the study. Based on this, all documents developed for the study, including the teacher questionnaire, manual journals, and participant and facilitator guides were shared with participants.

### 3.11.3 Conformability

According to Guba (1981), triangulation is associated with an action that results in conformability. In this study, to ensure conformability, multiple sources of data were used to gather information. Interviews, teacher bio data, an intervention workshop, manual journals, and a portfolio of evidence were used to gather data, which were interpreted, coded and categorised into themes to identify existing patterns. This was to ensure validity, referred to as conformability by some researchers.

### 3.11.4 Dependability

According to Maree (2010), dependability refers to the degree to which the reader can be convinced that the findings did indeed occur as stated by the researcher. Silverman (2014) argues that when researchers look at an object from more than one perspective, they gain comprehensive knowledge about the study. In order to ensure the dependability of participants' responses, all participants in this study were further requested to submit individual bio data, a manual journal, lesson plans presented during intervention workshop, and a portfolio of evidence, which included lesson plans used at school level after the intervention workshop. Kekana (2016) believes that the use of overlapping methods leads to dependability. Multiple data collection methods may be used to understand teachers' classroom practices, as echoed by Creswell (2007). This was used to understand classroom practices of Grade 9 teachers when teaching *Planet Earth and beyond* topics, as well as a way to ensure dependability.

### 3.11.5 Credibility

Maree (2010) defines credibility as an indication that the conclusions from data collected in terms of interviews, observations and lesson plans are accurate. In order to

ensure credibility, interviews were audio-recorded and transcribed; each audio-clip was replayed in the presence of the participant to ensure accuracy. Audiotapes were listened to several times and transcribed immediately after interviews. Interview protocol and observation protocols were established.

A common lesson plan template was developed bearing in mind features of a good lesson plan, as explained during CAPS orientation workshops. This was done to ensure that all lesson plans developed, submitted and presented by participants were CAPS aligned. The common template was developed for lesson observations by participants during the intervention workshop to ensure that lessons were observed in the same way, using the same instrument. Participant and facilitator guides used during the intervention workshop were developed based on the CAPS Annual Teaching Plan (ATP), which provided topics to be taught per term. This was to ensure that relevant content relating to the *Planet Earth and beyond* strand was discussed during the intervention workshop. All data collection instruments were submitted to the supervisor for quality assurance, and to ensure relevance to the research aim and research questions.

## 3.12 ETHICAL CONSIDERATIONS

In order to ensure that the rights and welfare of participants were protected, the relevant documents were sent to the North-West University's Ethics Committee for evaluation, and to check if there was any form of ethical biases in all the instruments used, included the proposal and data collection instruments. The study was conducted only after the ethical clearance certificate was issued, as assurance that the Ethics Committee was satisfied with ethical consideration related to this study. A request for permission to conduct the study was sent to the head of the Department of the North West Provincial Government before data collection. The permission letter was forwarded to the Director of Bojanala District, school principals and identified research participants.

In this study, the researcher ensured that what happened during the study would be solely for the sake of the study. Leading statements, during reporting, which may have led to the

confidentiality, anonymity and privacy of participants being violated, were avoided during reporting. Participants were also made aware of their rights as participants, including the fact that they had the right to withdraw from the study at any time is they so wished. Invitation letters to participants to participate in the study were sent well ahead of time to give participants enough time to decide if they wanted to participate in the study or not.

All participants' information and responses shared during the study were kept private and the results were presented in an anonymous manner. The usage of video-recordings was avoided in order to protect participants' identities. All recorded audio-clips were destroyed immediately after they had been transcribed verbatim. All hard copies will be destroyed after five years and will in the interim be kept under lock and key in the supervisor's cupboard. The researcher ensured that the study was continuously conducted according to the Ethics and Research Statement provided by the Faculty of Education of the North-West University (Maree et al., 2010).

The rights of the participants were protected at all times and their anonymity was guaranteed. Names of participants and participating schools were coded and used instead of actual names. Participants were informed about the purpose of conducting this research. Sensitivity was exercised in that, while conducting the scientific research, general norms and values were taken into consideration. The research findings were made known to the participants so that they could be in a position to participate in future research, and finally the researcher ensured mutual understanding between himself and the participants.

According to Bolarinwa (2015) one of the most common tasks often encountered in social science research is ascertaining the validity and reliability of a measurement tool, and to ensure that the investigation should be conducted in an ethical manner. As Sieber (1992) asserts, sound ethics and sound methodology go hand in hand. The researcher therefore adhered to the ethical principles and also gave the necessary guidelines of how the respondents' rights were protected in this study. The principles of the ethical research were followed by applying the measures discussed below.

### 3.12.1 Participants' informed consent

Participants were furnished with consent forms to complete and these were submitted before the intervention workshop. The consent forms consisted of the description of the research

study, biographical information of the researcher and the supervisor of the study, duration of interviews, the intervention workshop, lesson observation and time to submit planning documents. A thorough explanation was provided regarding the responsibilities of participants, benefits and voluntary participation.

### 3.12.2 Ethical clearance

Ethical clearance was received from the North-West University Ethics Committee prior to data collection. The researcher made sure that ethical principles were adhered to during the study.

### 3.12.3 Participants' anonymity

The participants in the study were requested to complete the informed consent form and were informed that their privacy and right to remain anonymous would be respected throughout the research, and that information shared would be treated as confidential. This was also reflected in the consent forms completed and signed by participants before the commencement of the study. Pseudonyms were used as a way to keep participants' identities anonymous and confidential.

### 3.12.4 Participants' transparency

Transparency was ensured by openly discussing the purpose, objectives and goals of the research with all the participants. The researcher did not withhold information about the true nature of the research. This was also included in the consent forms completed and signed by participants.

### 3.12.5 Honesty and uprightness

The evaluation of the research was carried out with honesty and uprightness expected in research. There was no fabrication, falsification or misrepresentation of evidence, data,

findings and conclusions. The researcher communicated the findings in a clear, transparent, straightforward and appropriate language to all stakeholders.

### 3.12.6 Voluntary participation

Participants were made aware that their participation in the study was voluntary, and that they had the right to withdraw from participating at any time.

### 3.12.7 Participants' respect, safety, dignity and self-worth

The researcher respected and safeguarded the safety, dignity and self-worth of all the research participants by being mindful of the cultural, religious, gender and other significant differences present in the research population. Safety was ensured by making sure that participants were not placed at risk or harm of any kind.

### 3.12.8 Permission to conduct the research

Permission to conduct the research was obtained from the following: North West Department of Education, Bojanala District, sub-districts and participating schools.

## 3.13 SUMMARY

In this chapter, the research orientation of and approach to the study, the research goal, objectives and research questions, research site, sampling, research procedures and data collection strategies were discussed. The validity and reliability of data collected during the study were emphasised. Issues pertaining to ethical considerations, how the researcher ensured confidentiality and protection from harm of participants were maintained. All these factors served as pillars of data collection. In the next chapter, the results of data collected from pre-and post-intervention interviews, the intervention workshop evaluation forms, teacher bio data, manual journals, portfolio of evidence, lesson plan templates and lesson demonstration, discussion templates, are presented and analysed.

# CHAPTER 4

# DATA PRESENTATION, ANALYSIS AND DISCUSSION

## 4.1 INTRODUCTION

The main aim of the study was to explore how teachers' PCK of the *Planet Earth and beyond* strand concepts influenced their teaching. In this chapter, the researcher presents findings of the study from the orientation workshop discussions, semi-structured interviews (pre-intervention and post-intervention) and document analysis (portfolio of evidence, lesson plans, teacher questionnaire and manual journal). Data collected were meant to answer the following research questions:

- How does the teachers' orientation to science teaching influence their pedagogical content knowledge?
- How does the Grade 9 teachers' pedagogical content knowledge manifest during the intervention?
- In what ways do specific characteristics of the professional development programmes contribute to development in the teachers' PK and PCK?

In this study one-on-one semi-structured interviews held before the intervention workshop are referred to as pre-intervention interviews, and one-on-one semi-structured interviews held at the end of the intervention workshop are referred to as post-intervention interviews. Six teachers participated in the pre-intervention and post-intervention semi-structured interviews, including an intervention workshop, manual journals and the development of a portfolio of evidence over a period of four weeks. The same set of questions (interview protocol) was used to generate data during the semi-structured interviews held before and after the intervention workshop. The reason why two sets of semi-structured interviews were held was to check the impact of the intervention workshop; whether there was a shift in knowledge, beliefs and attitude in teaching *Planet Earth and beyond* topics. It further checked whether or not any form of professional growth was brought about by the intervention workshop. The emphasis was also on whether the intervention workshop had managed to provide data to answer or not answer all three research questions as reflected above.

The four data collection methods [interviews, lesson presentation, observations and document analysis (manual journal, lesson plans and portfolio of evidence)] used in this study produced verbal data (qualitative text) only and no quantitative data were collected, as this study was purely qualitative in nature. Data was transcribed verbatim, examined and selected for indications of teacher change, using Clarke and Hollingsworth's (2002) Interconnected Model of Teacher Professional Growth (IMTPG). All the statements from the three different sources were triangulated to ensure reliability.

## 4.2 USING THE CLARKE AND HOLLINGSWORTH (2002) IMTPG MODEL

The Clarke and Hollingsworth model (IMTPG) (2002) was proposed as a tool for analysing teachers' professional growth. Four different domains were established in this model, which encompasses the teachers' world and thus they play a role in teachers' learning.

**Table 4.1:** Domains model

| Domain | Explanation |
|---|---|
| 1. Personal Domain | Contains teachers' knowledge, beliefs and attitudes |
| 2. External Domain | Serves as the external sources of information or the external stimuli |
| 3. Domain of Practice | Involves professional experimentation |
| 4. Domain of Consequence | Contains salient outcomes |

Figure 4.1 shows how Clarke and Hollingsworth's (2002) IMTPG model was modified and utilised in this study.

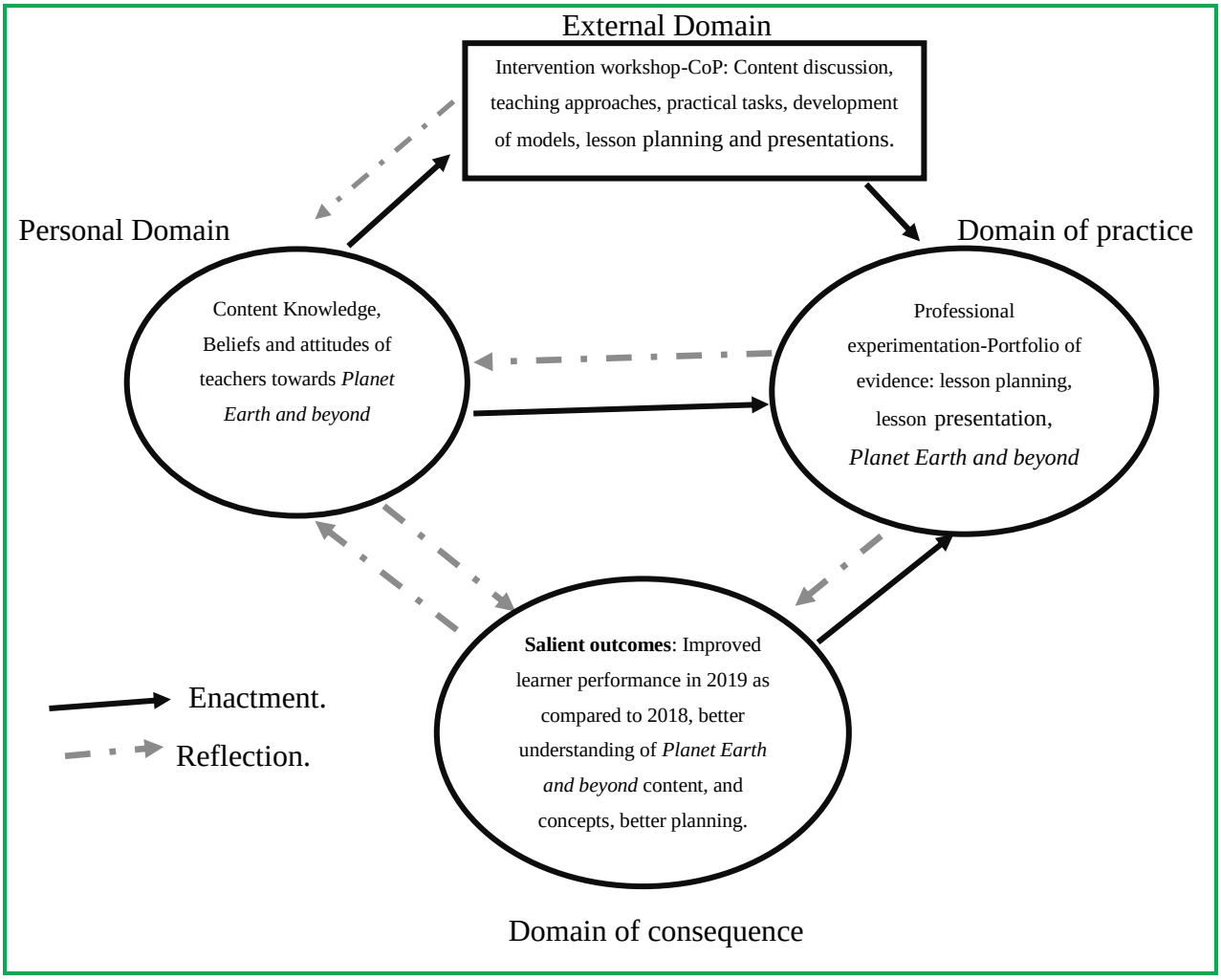



**Figure 4.1:** Adapted Clarke and Hollingsworth (2002) IMTPG model

This model was used because it offers the opportunity to study different patterns of change leading to teachers' growth (Clarke & Hollingsworth, 2002). Change in one domain was translated into a change into another domain through mediating processes of enactment and reflection. In this study the external domain consisted of three sub-domains. Zwart (2007) proposes two sub-domains (the context of the specific professional development programme and the more general external sources of information) to examine whether teachers' knowledge changes as a result of taking part in a professional development programme (in this case, reciprocal peer coaching). In this study the external domain was subdivided into six sub-domains, namely content discussion, teaching approaches, practical tasks, development of models, lesson planning and presentations. The domain of practice was further sub-divided into two sub-domains, namely planning and teaching.

Clarke and Hollingsworth (2002) suggest that pathways for change appear through mediating processes of enactment and reflection. These pathways can result in either a change sequence or a growth network. Change sequence occurs when a change in one domain leads to a change in another domain, supported by enactive or reflective links. A growth network is a more complex and on-going change in more than one domain. In order to study how a change in one domain triggers a change in another domain, a customary model was used. The mediating process of enactment and reflection suggested by Justi and Van Driel (2006) is illustrated on Table 4.2 below.

**Table 4.2**: Criteria used in this study to establish relations in the IMTPG (adapted from Justi and Van Driel (2006))

| **Relationship** | **Mediation** | **Criteria for establishment** |
|---|---|---|
| 1. From PD to ED | Enactment | When a specific aspect of teachers' initial content knowledge, curricular knowledge or PCK on *Planet Earth and beyond* influenced what they did or said during one of the learning activities in which they took part. |
| 2. From ED to PD | Reflection | When something that happened during the learning activities modified the teachers' initial content knowledge, curricular knowledge or PCK on *Planet Earth and beyond.* |
| 3. From ED to DP | Enactment | When something that happened during the learning activities influenced something that occurred in teaching practice |
| 4. From PD to DP | Enactment | When a specific aspect of the teachers' cognitions or beliefs, i.e. initial content knowledge, curricular knowledge or PCK on *Planet Earth and beyond* influenced something that occurred in teaching practice. |
| 5. From DP to PD | Reflection | When something that teachers did in their teaching practice modified their content knowledge, curricular knowledge or PCK on *Planet Earth and beyond* (cognitions or beliefs) without reflection on classroom outcomes first. |
| 6. From DP to DC | Reflection | When the teachers noticed and reflected on something that they or their students did in teaching practice that caused specific outcomes (such as student learning, teacher control, student motivation, and student development). |
| 7. From DC to DP | Enactment | When a specific outcome made the teachers state how they would modify the associated teaching practice in the future, or when a specific outcome made the teachers change their practice at that moment (reflection-inaction). |
| 8. From DC to PD | Reflection | When teachers reflected on a specific outcome, thus changing a specific aspect of their previous content knowledge, curricular knowledge, or PCK on *Planet Earth and beyond,* or when a teacher's evaluative reflection on the salient outcomes led to a change in cognition knowledge, curricular knowledge or PCK on *planet earth and beyond.* |
| 9. From PD to DC | Reflection | When a specific aspect of the teachers' knowledge, curricular knowledge or PCK on *Planet Earth and beyond* helped them in reflecting on or analysing a specific outcome of their teaching practice. |

**Note:**

PD - Personal Domain.

ED - External Domain.

DP - Domain of Practice

DC - Domain of Consequence

**Teachers participating in the study were indicated through the following pseudonyms:**

Teacher 01: Pule

Teacher 02: Mmapula

Teacher 03: Tladi

Teacher 04: Motlatsi

Teacher 05: Mavis

Teacher 06: Mabel.

The adapted criteria from Justi and Van Driel (2006) were used to determine if there were any relationship between different domains of the IMTPG (2002). It was then determined in which domain the entry point occurred, and how this affected the other domains. Pictorial representation (pictogram) was applied for the development of each PCK component, underpinning good classroom practices, showing relationships between the domains of the IMTPG model. One pictogram for each PCK component, underpinning classroom practices, per teacher or per theme was created. From this point forward, presentation is according to the research questions. Five themes were generated from data analysis. Research question (i) was addressed by three themes, research questions (ii) and (iii) were addressed by one theme each.

## 4.3 RESEARCH QUESTIONS

### 4.3.1 Research question (i): How does the teachers' orientation to Science teaching influence their pedagogical content knowledge?

This research question was responded to using the following three themes: Teachers' orientation to Science teaching, knowledge of instructional strategies, and knowledge of student assessment on *Planet Earth and beyond*.

#### 4.3.1.1 Teachers' orientation to Science teaching

Orientations towards Science teaching in this study refers to the understanding of conceptual foundations of teaching *Planet Earth and beyond* topics, the teachers' ability to transform and apply knowledge from multiple domains, the teachers' beliefs and goals of teaching *Planet*

*Earth and beyond*, as well as relevant teaching methods to be employed when teaching *Planet Earth and beyond* topics. Data on teachers' orientation towards Science teaching are shown in Figure 4.2.

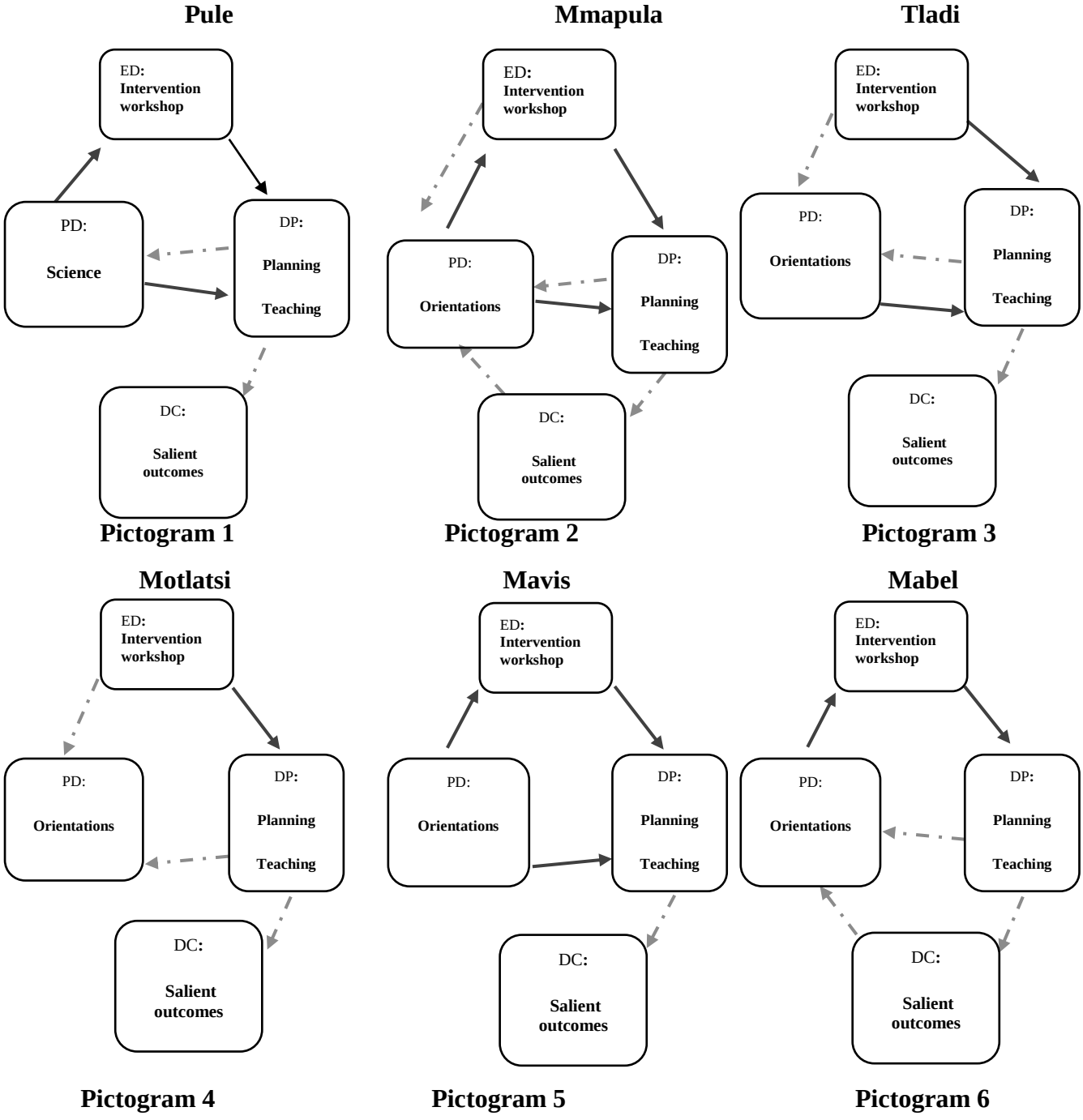



**Figure 4.2**: Pictorial representations of teachers' orientations towards *Planet Earth and beyond* teaching

**Pule**

Figure 4.2: The entry point in pictogram 1 was at the ED. Pule did not do *Planet Earth and beyond* at university, but through experience gained by attending the professional development workshop that was presented before the intervention workshop, as reflected in PULE's teacher questionnaire. Pule managed to acquire skills that were used to prepare and present a demonstration lesson during the intervention workshop. Pictogram 1 shows a growth network with enactment of PD on ED, ED on DP, and PD on DP. During lesson demonstrations conducted during the intervention workshop, PULE demonstrated confidence and understanding of the topic that was taught. A variety of teaching approaches was used and the participants (acting as learners) engaged enthusiastically from beginning to end of the demonstration. Questions asked by Pule as the presenter were responded to. This shows that features of a good lesson plan were understood and discussed during the intervention workshop as prescribed by CAPS. This resulted on reflective behaviour observed from ED to PD, and DP to PD.

Before the intervention workshop, when Pule was asked which teaching methodologies he preferred, he indicated that he preferred presentations with hands-on activities. However, during post-intervention interviews, Pule opted for a more learner-centered approach, these being discussions and the question and answer method (Source: interviews). This can be viewed as the change triggered by the intervention workshop on Pule's teaching approaches. This was confirmed by data received from Pule's portfolio of evidence when Pule said, "*I have learnt different teaching methods and approaches during the intervention workshop ...I have managed to share teaching strategies I learnt during the workshop. I have also inducted another new educator at my school on how to teach the topic and also how to develop daily lesson plans for Natural Sciences."*

Before the workshop, Pule indicated that he was able to prepare lesson plans as per the CAPS prescripts, infusing specific aims, process skills and relevant assessment, but he was less confident that he was well-orientated to Science teaching. However, during the intervention workshop, Pule felt his lesson planning skills as per the CAPS prescripts improving; he started learning different teaching methods and approaches, and felt that the training material (participant guide lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop. After the intervention workshop, Pule felt strongly that he had a better understanding of planning lessons, that he would use lesson plan templates used and discussed during the intervention workshop, and that his skills for

preparing and doing practicals (including development of models) had improved. Pule was convinced that he had acquired enough skills to make him a better teacher, and that the intervention workshop served as a good orientation to science teaching (Source: Workshop evaluation form). Newly acquired content and concepts from the intervention workshop changed Pule's attitude, improved his confidence level, and led to a general improvement in learner performance, from 66% in 2018 to 90% in 2019, marking a 24% improvement in 2019.

**Mmapula**

The entry point in pictogram 2 was at the ED. Mmapula did not do *Planet Earth and beyond* at university, but through experience gained by attending the professional development workshop that took place before the intervention workshop, as reflected in Mmapula's teacher questionnaire. Mmapula managed to acquire skills that were used to prepare and present a demonstration lesson during the intervention workshop. Pictogram 2 showed a growth network, with PD enactment on ED, PD enactment on DP, and ED enactment on PD. Mmapula's lesson demonstration during the intervention workshop showed that he came into the intervention workshop with certain skills on lesson preparation and presentation, which were sharpened by discussions held during the intervention workshop. The lesson was presented with confidence, and there was coherence between activities planned for the lesson. Mmapula started by outlining the objectives of the lesson to the learners, followed by touching a little bit on topics done in the previous grade to check prior knowledge. Mmapula demonstrated confidence and understanding of the *Planet Earth and beyond* topic, the greenhouse effect and global warming. Relevant teacher and learner activities were chosen that backed up specific aims and science process skills targeted for the lesson.

Mmapula conducted a practical investigation on global warming, which stimulated understanding and interest among participants (acting as learners). Skills for lesson planning and lesson presentation learnt by Mmapula during the intervention workshop stimulated a reflection on teachers' beliefs and attitude (ED PD) towards planning for *Planet Earth and beyond* topics and also DP on PD. This was marked by the ability of Mmapula to conduct a practical investigation, leading participants (acting as learners) during lesson demonstrations. The practical investigation enhanced understanding and showed confidence and understanding of phenomenon under investigation by the presenter (Mmapula). She presented

five more lesson plans, which covered all the features of a good lesson plan as prescribed by CAPS. The lesson plans demonstrated growth in lesson planning skills.

During the pre-intervention interviews, Mmapula indicated that the teaching method that he had been using before the intervention workshop was mostly the lecture method, due to the lack of resources. However, during the post-intervention interviews Mmapula indicated that after the intervention workshop he could see that he could use the laptop and the projector, and he could design some models. He had therefore decided to adopt the learner-centered approach, where she could ask learners questions during the presentation of the lesson, which would allow the learners to also ask the questions and be involved in the designing of the models. That, according to Mmapula, would make the lesson interesting and learners could gain a lot (Source: Interviews).

After attending the intervention workshop, data received from the portfolio of evidence indicated that Mmapula gained knowledge of how to apply various teaching methods to accommodate learners of various categories, i.e. the lecture method, models, presentations and worksheets. It was also clear that he managed to learn how to design models to improve learner performance, and that they could be taught how to do lesson plans on *Planet Earth and beyond* topics.

Data received from Mmapula's workshop evaluation form revealed that, before the intervention workshop, Mmapula was not confident of her ability to prepare lesson plans as per the CAPS prescripts infusing specific aims, process skills and relevant assessment. However during the intervention workshop Mmapula strongly felt her lesson planning skills as per the CAPS prescripts improving, she started learning different teaching methods and approaches, and discovered that the training material (participant guide lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop. Data received from the workshop evaluation form further revealed that after the intervention workshop Mmapula strongly felt that she had a better understanding of planning lessons, that his skills for preparing and doing practicals (including development of models) had improved, that she had acquired enough skills that would make him a better teacher, and that the intervention workshop served as a good orientation to science teaching. He furthermore believed that the intervention helped with the acquisition of both pedagogy, content and concepts to deal with *Planet Earth and beyond* topics. Newly acquired content and concepts

from the intervention workshop changed Mmapula's attitude, improved her confidence level, and led to a general improvement in learner performance, from 75% in 2018 to 78% in 2019, marking a 3% improvement in 2019.

**Tladi**

The entry point in pictogram 3 was the External Domain, as Tladi learnt to prepare a lesson plan for *Planet Earth and beyond* for the first time during the intervention workshop. Pictogram 3 showed a change sequence of ED on PD, which stimulated a reflection of ED on PD, leading to enactment of PD on DP. Tladi displayed lesson planning skills learnt during the intervention workshop during her presentation of a demonstration lesson. She started planning lessons as per the CAPS prescripts from what was learnt during intervention workshop, which had never been done before. Specific aims and science process skills were infused, which were pillars of a good lesson plan as per the CAPS document. Specific aim 1 targeted the lesson and, observing one of the Science process skills targeted for the lesson, was not supported by any activity during the lesson. Tladi was advised by peers when discussing the lesson presented during the intervention workshop that the topic, "Spheres of the atmosphere" chosen for the demonstration lesson should be reviewed as "Layers of the atmosphere", since contents and activities done during the lesson spoke to layers of the atmosphere and not spheres of the atmosphere.

One more lesson was developed and submitted through the portfolio of evidence, which showed good features of a lesson plan as per the CAPS prescripts. Data received during post-intervention interviews from Tladi show that there was an acquisition of lesson planning skills, a change in attitude and knowledge of how to plan for *Planet Earth and beyond* lessons. During pre-intervention interviews, when Tladi was asked about which teaching methodologies worked best for her in the teaching of *Planet Earth and beyond* topics, Tladi mentioned discussions and group work. However, during post-intervention interviews, when asked the very same question, Tladi said the following, *"Eh … a lot of demonstration has to be done because sometimes you talk of earth, some learners do not even know how the earth looks like…."* Data received from Tladi's portfolio of evidence stated, "*From the lessons presented by my fellow participants I gained different ways to present lessons under planet earth and beyond from lessons presented by fellow participants. The workshop also gave me an understanding of different pedagogies to be used when teaching the topic, planet earth and beyond."*

Before the intervention workshop, Tladi indicated that she was unable to prepare lesson plans as per the CAPS prescripts, infusing specific aims, process skills and relevant assessment. However, during the intervention workshop she started feeling that her lesson planning skills as per the CAPS prescripts were improving, that she started learning different teaching methods and approaches, and that the training material (participant guide lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop. After the intervention workshop she stated, *"I felt that I had a better understanding of planning lessons, felt that my skills for preparing and doing practicals (including development of models) had improved, and I believed that I had acquired enough skills that would make me a better teacher, that the intervention workshop served as a good orientation to science teaching, and that the intervention helped me with the acquisition of both pedagogy, content and concepts to deal with planet earth and beyond topics."* (Source: Tladi's workshop evaluation form). Newly acquired content and concepts from the intervention workshop changed Tladi's attitude, improved his confidence level, and led to a general improvement in learner performance, from 29% in 2018 to 50% in 2019, marking a 21% improvement in 2019.

**Motlatsi**

The entry point for pictogram 4 was the External Domain. Motlatsi had less than 10 months' experience in the teaching fraternity at the time of the intervention, as reflected in her questionnaire and portfolio of evidence. Motlatsi was exposed to lesson planning as per the CAPS prescripts for the first time at the intervention workshop. Pictogram 4 showed a change sequence with enactment of ED on DP, which influenced the beliefs and goals of Motlatsi to teaching of *Planet Earth and beyond* (DP reflection on DC), and (DP reflection on PD). One more lesson plan, entitled the *Rock cycle,* was submitted through the portfolio of evidence, which displayed features of a good lesson plan as suggested during the CAPS orientation workshops. The lesson plan reflected hands-on practical investigations using samples of rocks which was an element missing in the lesson presented during a demonstration lesson at the intervention workshop. Activities included in the lesson plan supported the specific aims and science process skills targeted.

During interviews, Motlatsi was asked which teaching methodologies worked best for her in the teaching of *Planet Earth and beyond* topics. This is what she had to say after attending

the intervention workshop, "*The method that works for me is actually teaching by using videos because it is easier to explain after looking at the videos, so once the learners look at videos they can capture and even if when you ask a question, … they don't prefer theory that much".* This suggests that Motlatsi opted to use the learner-centered approach after attending the intervention workshop. Motlatsi further said the following, "*When I taught this topic Planet Earth and beyond I made some demonstration on certain topic such as the Rock cycle and afterwards I told my learners to go outside in groups to collect different types of rocks* (Source: Portfolio of evidence). This came as evidence cementing Motlatsi's attestation of opting for the learner-centered approach after attending the intervention workshop.

Before the intervention workshop, Motlatsi was strongly confident that she was able to prepare lesson plans as per the CAPS prescripts, infusing specific aims, process skills and relevant assessment. However, during the intervention workshop, Motlatsi said, "*I feel that my lesson planning skills as per CAPS prescripts have improved, and I have started learning different teaching methods and approaches…*" After the intervention workshop, Motlatsi wrote: "*I had a better understanding of planning lessons, and I felt that my skills for preparing and doing practicals (including development of models) have improved, and that I have acquired enough skills that will make me a better teacher."* She also believed that the intervention workshop served as a good orientation to Science teaching, and strongly felt that the intervention workshop helped with the acquisition of both pedagogy, content and concepts to deal with *Planet Earth and beyond* topics (Source: Motlatsi workshop evaluation form). Newly acquired content and concepts from the intervention workshop changed Motlatsi's attitude, improved her confidence level, and led to a general improvement in learner performance, from 84% in 2018 to 91% in 2019, marking a 7% improvement in 2019.

**Mavis**

The entry point for pictogram 5 was the Personal Domain. Mavis went into the workshop with massive knowledge and skills of planning and presenting lessons that had been acquired over many years of teaching, as shown in Mavis's questionnaire and portfolio of evidence. A growth network was observed with enactment from PD on ED, ED on DP and PD on DP. Mavis demonstrated an understanding of lesson preparation and presentations as guided by CAPS. As a result, during the demonstration lesson presented by Mavis during the intervention workshop, participants (acting as learners) were very active throughout the lesson. Five more lesson plans covering all *Planet Earth and beyond* topics were submitted

through the portfolio of evidence, but the lesson plans did not indicate specific aims and Science process skills targeted as required by CAPS. This means that Mavis relied on her experience when drawing those five lesson plans and left out the inclusion of specific aims and Science process skills as directed by CAPS, hence enactment from PD on DP was observed. The ability of Mavis to draw and submit five more lesson plans in a portfolio of evidence, excluding the lesson plan that was drawn for the purpose of lesson demonstrations during the intervention workshop, was observed as reflective behaviour of DP on DC.

During interviews, Mavis indicated that the teaching methodology that worked for her was a learner-centered approach augmented by demonstrations, and that she felt more comfortable to use them after attending the intervention workshop. Mavis indicated the following portfolio of evidence under general comments, "*The material we received - lesson plan templates and presentation skills, have helped in scheduling lessons for learners which helped them learn and understand what needs to be covered for the syllabus in time. I have gained new presentation skills that are effective in keeping learners interested in lessons presented in class. My learners' marks are the result of the knowledge and skills gained from the workshop".*

Before attending the intervention workshop, Mavis indicated that she was able to prepare lesson plans as per the CAPS prescripts, infusing specific aims, process skills and relevant assessment. However, during the course of the intervention workshop she further contended that she felt confident that her lesson planning skills as per the CAPS prescripts were improving, that she started learning different teaching methods and approaches, and that the training material (participant guide lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop. After the intervention workshop Mavis confessed, "*By attending the intervention workshop, I developed a better understanding of planning lessons, and strongly felt that my skills for preparing and doing practicals (including development of models) have improved. …, that the intervention workshop served as a good orientation to science teaching and felt strongly confident that the intervention workshop helped with the acquisition of both pedagogy, content and…"* (Source: Mavis workshop evaluation form). Newly acquired content and concepts from the intervention workshop changed Mavis's attitude, improved her confidence level, and assisted Mavis to maintain 94% learner performance, in 2019, which was previously achieved in 2018, due to her experience in the teaching of the subject.

**Mabel**

The entry point in pictogram 6 was the Personal Domain. A change sequence was observed with enactment of PD on ED, and ED on DP. When Mabel participated in the intervention workshop, she had already acquired some skills on lesson planning and lesson presentations through the experience accumulated over a period of three years as a teacher. However, the already acquired skills were sharpened during the intervention workshop, leading to enactment of ED on PD. Mabel's lesson plan indicated that all specific aims were addressed, and all specific outcomes were backed up by teacher and learner activities that transpired during the lesson presentation. Science process skills targeted included accessing and recalling information, observing, comparing and communicating. All these skills were developed successfully, with the exclusion of observing and measuring. There was no activity in which participants (acting as learners) observed or measured anything. The teaching approach that was followed during the demonstration lesson by Mabel was predominantly a direct lecture method. At the end of Mabel's presentation she was advised to consider following a more learner-centered approach, which would allow learners to participate actively in class. Mabel submitted four more lesson plans through the portfolio of evidence, which reflected that a learner-centered approach was used and which marked an improvement in Mabel's teaching strategies. It also influenced her beliefs and goals to teaching, hence reflection of PD on DC, and DC on PD.

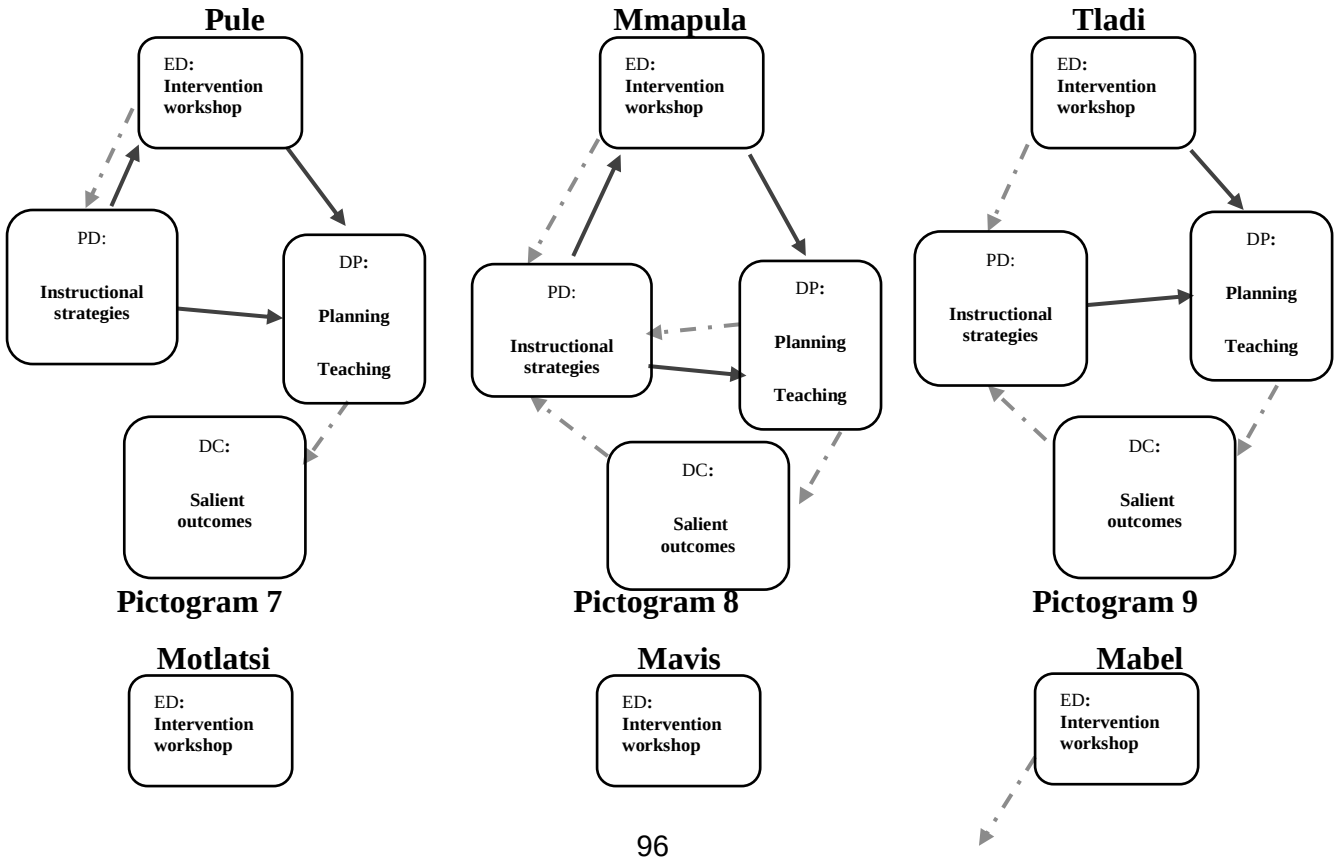
It seems as if Mabel's change in beliefs, goals and attitude after the intervention workshop was triggered by well-crafted material used during the intervention workshop, and discussions with fellow participants, hence Mabel indicated the following in her portfolio of evidence, "*The templates for lesson preparations are also of great help. It is easy to prepare and present a lesson".* Newly acquired content and concepts from the intervention workshop changed Mabel's attitude, improved her confidence level, and led to a general improvement in learner performance, from 66.7% in 2018 to 89.47% in 2019, marking a 22.8% improvement in 2019.

During pre-intervention interviews, Mabel had indicated that her preferred teaching method was the direct instruction method. However, during post-intervention interviews she opted for a more hands-on approach – meaning that she indicated that she preferred the learner-

centered approach over the direct lecture method she had preferred before attending the intervention workshop. Before the workshop participant Mabel had indicated, "*I am confident that I was able to prepare lesson plans as per CAPS prescripts infusing specific aims, process skills and relevant assessment".* However, during the intervention workshop Mabel indicated that she felt that her lesson planning skills as per the CAPS prescripts were improving, that she started learning different teaching methods and approaches, and strongly felt that the training material (participant guide lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop. After the intervention workshop, Mabel was strongly confident that she had developed a better understanding of planning lessons, that her skills for preparing and doing practicals (including development of models) had improved, that she had acquired enough skills that would make her a better teacher, and that the intervention workshop served as a good orientation to Science teaching. Mabel indicated that the intervention workshop helped with the acquisition of both pedagogy, content and concepts to deal with *Planet Earth and beyond* topics.

#### 4.3.1.2 Knowledge of instructional strategies

Knowledge of instructional strategies refers to preparing and planning for a lesson, conducting lessons using appropriate teaching strategies relevant for *Planet Earth and beyond*, and the development and use of appropriate instructional materials. Data on teachers' knowledge of instructional strategies are shown in Figure 4.3.



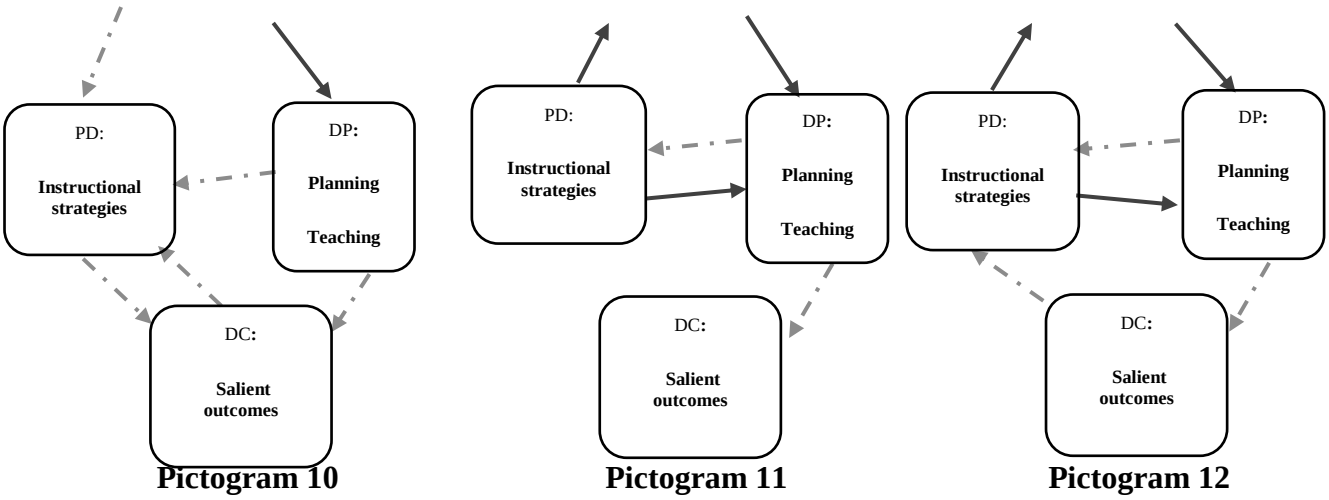



**Figure 4.3**: Pictorial representations of development of instructional strategies

**Pule**

In Figure 4.3, pictogram 7 a central growth network was observed with PD enactment on ED, PD enactment on DP, and ED enactment on DP. ED enactment on DP resulted in reflection on DC. PD enactment on ED caused changed beliefs and goals about instructional planning, lesson presentations, development of instructional material, observed as reflection of ED on PD. Breaking it down, the entry point is the PD. It seems Pule went into the intervention workshop with a certain level of understanding of planning and presenting, based on a lesson plan that Pule submitted and presented during lesson demonstration lessons conducted during the intervention workshop. Skills and knowledge sharpened during intervention workshop, resulting in improved lesson planning as per CAPS. During his lesson demonstration, Pule showed a high level of understanding and confidence, which led to active participation of all participants (acting as learners).

After the lesson presentation, Pule discussed the lesson with other participants, which led to Pule realising that specific aim 1 included as a targeted specific aim for the lesson, but hands-on activities done during the lesson suggested the inclusion of specific aim 1 for that lesson. A practical task of comparing different types of rocks was done. However, instructions thereof (worksheet) were not availed. Pule peers were advised to always develop and submit instructional material with a lesson plan. Pule submitted scripted lesson plans from the National Education Collaboration Trust (NECT) and did not continue using skills learnt from

the intervention workshop. However, NECT lesson plans submitted were CAPS compliant (PD enactment on DP).

Pule submitted and confirmed availability of all planning documents (Source: Pule's portfolio of evidence) for effective teaching of *Planet Earth and beyond* topics, which suggested that understanding of how planning, and which resources were needed for planning properly for the teaching of *Planet Earth and beyond* topics were unearthed during the intervention workshop. Pule indicated the availability of the following instructional material and other resources: Policy documents (CAPS, NPPPR, and NPA), textbooks, workbooks, a projector and a white board (Source: Pule's questionnaire). Pule also indicated a shortage of other instructional material, e.g. material needed for doing experiments, demonstrating to learners (Source: Pule's post-intervention interviews), and that after the intervention workshop he was able to improvise and do experiments as well as create models to enhance understanding of *Planet Earth and beyond* topics.

After attending the intervention workshop, during interviews, Pule indicated that his preferred teaching method was discussions, which is a reflection that he moved from a teacher-centered approach to a learner-centered approach after intervention. Pule further indicated during pre-intervention interviews, "*I was reading books, researched through internet and asked more experienced teachers to keep abreast with knowledge acquisition and strategies to teach learners.*" Pule indicated that there was a need to use relevant instructional strategies to ensure understanding of *Planet Earth and beyond* concepts. When asked about consequences of not adequately teaching *Planet Earth and beyond* topics after having attended the intervention workshop, Pule explained, "*Eh … if you do not adequately teach eh … Planet Earth and beyond, it will impact on learners in a negative way, because learners are doing Physical Sciences, learners are doing Chemistry in FET phase, so this will affect learners, even beyond the high school level into their career, they will not be sure of what they have learnt in the senior phase grades… So, if you don't teach adequately, eh … your morale will be down in class, eh … every aspect of your lesson that you want to pass to the learners, will be at a lower level"* (Source: Post-intervention interviews). Pule further made the following recommendation after attending the intervention workshop, "*My recommendations would be ehh, let us have more workshops. Ehh it starts with the teachers. Ehh more workshops to the teachers, on the topic, ehh, let us also have resources that we will use in class so that learners can learn better".*

After attending the intervention workshop, Pule submitted his portfolio of evidence. This is what he indicated under general comments, "*Presentations during the workshop were helpful as they were informative to me as an educator learning from other educators on how the teach certain content and concepts … I have learnt different teaching methods and approaches. Training material and videos that were played in sessions were useful as it made it easier to understand, diagrams where visible and informative to me the participant…".* This suggests that the intervention workshop helped to change Pule's goals, beliefs and attitude, improving his instructional strategies. It is also reflected in Pule's evaluation form that, before intervention, he was confident in using the correct pedagogy in his class, that he was able to prepare lesson plans as per the CAPS prescripts infusing specific aims, Science process skills and relevant assessment, and that he did not hate teaching *Planet Earth and beyond* topics. During the intervention workshop, Pule indicated that the presentations were useful to his needs as a teacher. He stated that he strongly felt that he would use this the information gained to help his Science class, that he would implement the skills learnt in his class with immediate effect, and that he was able to improvise and do experiments, as well as create models to enhance understanding of the *Planet Earth and beyond* topic.

Pule also indicated that that he had started learning different teaching methods and approaches as the intervention workshop progressed. He further stated that the training material (participant guide, lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop. After attending the intervention workshop, Pule felt confident that he had a better understanding of planning lessons, and that he would use the lesson plan templates used and discussed at the intervention workshop. Pule further contended that comments made by colleagues during lesson demonstrations were helpful, and he would infuse them in his planning in future. He strongly felt that his skills for preparing and doing practicals (including developing models) had improved, and that he would use training materials used during the intervention workshop, including videos in his class (Source: Pule's workshop evaluation form). This serves as an indication that the intervention workshop assisted in shaping Pule instructional strategies, as his following comment proves, *"I have acquired enough skills that will make me a better educator. Colleagues were very helpful together with the facilitator to make things simple for me to learn easier. We need to have more practical tasks in our class than theory" (*Source: Pule's workshop evaluation form).

**Mmapula**

Figure 4.3, pictogram 8, showed changes in Mmapula's knowledge of instructional strategies. The entry point was PD. A central growth network was observed with PD enactment on ED and DP, ED enactment on PD, causing reflection of DP on PD and DC, and reflection of ED on PD. It seemed Mmapula had general limited background of how to plan and present a lesson based on the *Planet Earth and beyond* topics. Mmapula declared that before the intervention workshop, he had been using the correct pedagogy to teach *Planet Earth and beyond*, prepare lesson plans as per CAPS prescripts, infusing specific aims, science process skills and assessment (PD enactment on ED). Lesson planning and presentation skills were further polished during the intervention workshop (ED enactment on DP).

Information that Mmapula possessed about planning and presenting lessons influenced the DP (PD enactment on DP, which was improved by what was learnt during the intervention workshop, moulding beliefs, goals and confidence level by Mmapula when it came to lesson planning and presentations (reflection of ED on PD, and DP on PD and DC). During the intervention workshop, Mmapula started preferring the learner-centered approach that she did not use before the intervention workshop (Source: Mmapula's post-intervention interviews; Mmapula workshop evaluation form). Mmapula managed to successfully lead participants during the demonstration lesson, through a practical investigation that required participants (acting as learners) to have deep understanding and knowledge of global warming and the greenhouse effect, before the practical investigation could be executed. This practical activity was thought-provoking, required critical thinking skills and stimulated classroom participation. Mmapula submitted five well-structured lesson plans, which were CAPS compliant, covering all *Planet Earth and beyond* topics.

During pre-intervention interviews, Mmapula had indicated that she used the lecture method as her teaching approach. However, after attending the intervention workshop, Mmapula changed from using the lecture method and opted for the learner-centered approach, hence she said the following about the teaching approach he preferred*, "Before this intervention, it was just ehh … eh … ehh … a lecturer method. But now after this ehh … intervention we can now see that we can use the laptops, we can use the projector, we can design some models, we can also … we have also been taught to be learner-centered… So it makes the lesson*

*interesting and learners can gain a lot".* Mmapula further indicated that she was informing herself as a way of improving her PCK by reading textbooks. However, after attending the intervention workshop, Mmapula said, *"... after this intervention, we can see that we have been given a lot. We have been taught how to find information from the ... the ... internet, and we have also been given some software intervention which you can use to teach, and also collaborating with colleagues..."* (Source: Post-intervention interviews).

This suggests that Mmapula's instructional strategies changed for the better after attending the intervention workshop. Mmapula also warned that possible consequences of not adequately teaching the *Planet Earth and beyond* topics may lead to underperformance, hence she said, *"... So actually when the learners are not taught well, they will have a disadvantage. And from the teacher's point of view, ehh ... you cannot afford to have learners fail, because the objective as teachers, we want our learners to pass, so they can end up demotivating the teacher at the end".* This suggests that Mmapula understood that improved instructional strategies lead to improved understanding and performance from the side of learners, and provide teachers with confidence to teach content in a more comfortable way. Mmapula further recommended that the Department of Education organise workshops in which both content and pedagogy could be treated, as a way to improve teachers' instructional strategies (Source: Post-intervention interviews).

After the intervention workshop, Mmapula submitted her portfolio of evidence. In the portfolio of evidence Mmapula wrote the following: "*During my teaching of grade 9 term 4 2019 I managed to use the following gained from the workshop: Videos of educators teaching during workshop, materials from the workshop used as notes, class works designed by teachers were given to learners, models designed by educators at the workshop, lesson plans designed by educators and tests designed by educators at the workshop. I also managed to use the knowledge gained from the workshop for other subjects, i.e. Physical sciences grade 11: Mining in South Africa, Life Sciences grade 11: Global warming and Life Science grade 12: Human impact to the environment".* This can be viewed as an improved PCK that Mmapula acquired from the intervention workshop. On his workshop evaluation form Mmapula indicated that before attending the intervention workshop she was confident that she was using the correct pedagogy, that she was able to prepare lesson plans as per the CAPS prescripts, infusing specific aims, Science process skills and relevant assessment and that she did not hate teaching *Planet Earth and beyond* topics. However, as the intervention

workshop progressed, there was a remarkable change in goals, beliefs and instructional strategies, hence Mmapula started to feel strongly that the presentations were useful to his needs as a teacher, that he would use the information gained from the intervention workshop to help her Science class, that she would implement the skills learnt during the intervention workshop in her class with immediate effect, that she was able to improvise and do experiments, as well as create models to enhance understanding of the *Planet Earth and beyond* topics by virtue of attending the intervention workshop. She also learnt that the pair and share session during a lesson was useful, that by attending the intervention workshop he started learning different teaching methods and approaches, and that the training material (participant guide, lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop.

After attending the intervention workshop, Mmapula confirmed that she was strongly confident that she had a better understanding of planning lessons, she would use lesson plan templates used and discussed at the intervention workshop, that comments made by colleagues during lesson demonstrations were helpful, and that she would infuse them in her planning in future, that she felt that her skills for preparing and doing practicals (including developing models) had improved, that she did not hate teaching *Planet Earth and beyond* after attending the intervention workshop and that she would use training materials including videos received from the intervention workshop in her class. (Source: Mmapula's workshop evaluation form). All of these can be attributed to the impact of the intervention workshop on Mmapula's instructional strategies, changing them for the better, hence Mmapula said the following in her workshop evaluation form, *"I have acquired enough skills that will make me a better educator. Colleagues were very helpful together with the facilitator to make things simple for me to learn easier. We need to have more practical tasks in our class than theory".*

**Tladi**

Figure 4.3, pictogram 9, showed a change sequence with enactment of ED on DP, and enactment of PD on DP, causing a reflection on DC, and ED on PD. TLADI had lesson planning and presentation skills that were acquired before attending intervention skills, but had never planned and presented any lesson on *Planet Earth and beyond* before the intervention workshop (Source: Pre-intervention interviews). Knowledge of planning influenced DP (PD enactment on DP), but lesson presentation and presentation skills were

further developed by what was learnt at the intervention workshop (ED enactment on DP), causing a change in Tladi's beliefs, knowledge and attitude on instructional strategies that surfaced during the intervention workshop demonstration lesson (reflection of DP on DC). Before intervention, it seemed as if participant Tladi preferred teacher-centered learning coupled with a few hands-on tasks, which was the teaching approach that Tladi disregarded after attending the intervention workshop and opted for the learner-centered approach (Source: Post-intervention interviews). Tladi managed to effectively use lesson plan templates provided and discussed during the intervention workshop. Usage and understanding thereof helped Tladi to gain confidence and enabled her to plan a CAPS compliant lesson plan and present it with confidence. Tladi listed all instructional material needed for proper planning, as a result of better understanding of planning and lesson presentation skills acquired during the intervention workshop. (Source: Tladi's questionnaire; Tladi's portfolio of evidence).

Tladi started infusing the use of representations such as posters, PowerPoint presentations and video-clips in her presentation (Source: Tladi's post-intervention interviews; Tladi's workshop evaluation form). When Tladi was asked which teaching methodology he preferred, he indicated that he preferred discussions and group-work. However, after attending the intervention workshop. When asked the very same question he insisted on preferring group work, but went a step further by including hands-on practical tasks, or use of representations that he did not use before attending the intervention workshop. The suggestion to use models is something that Tladi learnt at the intervention workshop, showing a change in instructional strategies. Tladi further suggested that textbooks should be used in conjunction with video-clips to enhance understanding (Source: Interviews). Tladi also made the following recommendation to the Department of Education after attending the intervention workshop, "*The most important one is to conduct workshops so that learners … teachers acquire more information based on this topic Ah … jaa, again, it's the workshops, because on the workshops the teachers acquire different teaching strategies on how to teach this topic and they also gain information. So if they have information, they will be able to teach learners" (*Source: Post-intervention interviews).

Tladi warned that if *Planet Earth and beyond* topics are not adequately taught, it will have a negative influence on learners, because for final examinations learners are only assessed on Term 3 and Term 4, so if they are not thoroughly taught, obviously they will not be able to

respond to questions. The word "adequate" may be seen as referring to having knowledge of instructional strategies. Tladi indicated the following in her portfolio of evidence, "*From the lessons presented by my fellow participants I gained different ways to present lessons under planet earth and beyond. So the workshop also gave me an understanding of different pedagogy to be used when teaching the topic"*. This can be viewed as confirmation of a change in Tladi's instructional strategies.

Before the intervention workshop, Tladi was not certain if he was using the correct pedagogy in class, and if she was able to prepare lesson plans as per CAPS prescripts infusing specific aims, Science process skills and relevant assessment. During the intervention workshop, Tladi felt strongly that the presentations would be useful to her needs as a teacher. She further indicated that he would use the information gained to help his Science class, and that he would implement the skills learnt in his class with immediate effect. He attested that he was able to improvise and do experiments, as well as create models to enhance understanding of *Planet Earth and beyond* topics, that he found the pair and share session useful, that he started learning different teaching methods and approaches and that the training material (participant guide, lesson plan templates, lesson observation templates) was useful and relevant for the intervention workshop.

After the intervention workshop, Tladi confirmed that he had a better understanding of planning lessons, and that she would use lesson plan templates used and discussed at the intervention workshop, and that comments made by colleagues during lesson demonstrations were helpful. He further stated that she would infuse them in her planning in the future. Tladi felt that his skills for preparing and doing practicals (including developing models) had improved. He strongly felt that he no longer hated teaching *Planet Earth and beyond* after the intervention workshop, and indicated that she would use training materials received during the intervention workshop, including video-clips, in her class. Generally, according to Tladi, the intervention workshop was beneficial to him, hence he concluded by saying, *"**"A week long training of educators should be organized so that teachers may get enough time to engage and acquire understanding of planet earth and beyond topics"* (Source: Tladi's workshop evaluation form).

**Motlatsi**

Figure 4.3, pictogram 10, showed a growth network with enactment of ED on DP, causing a reflection of DP on DC and PD, and stimulating a reflection of DC on PD and PD on DC. Breaking it down, the entry point was ED. Motlatsi went into the intervention workshop without planning and presentation skills for the topic *Planet Earth and beyond* (Source: pre-intervention interviews). Motlatsi was less experienced in the teaching fraternity. It seemed as if the intervention workshop was the only training on pedagogy and content related to *Planet Earth and beyond* that Motlatsi received. Through training received at the intervention workshop, Motlatsi managed to understand the lesson plan template used for planning, and to use it to plan for her demonstration lesson (ED enactment on DP). The topic presented was Layers of the earth. Motlatsi used PowerPoint to mitigate content and concepts related to layers of the earth, and showed diagrams of the layers of the earth. This used of representations was one of the skills that Motlatsi learnt from the intervention workshop, which was observed as reflection of DP on PD and ED on PD. Motlatsi discussed lesson presentation with fellow participants at the end of the presentation. Parts of the feedback received from fellow participants were that, even though she managed to engage participants (acting as learners), the lesson was more teacher-centered. Motlatsi should consider adopting a learner-centered approach that would give room for active learner participation that was observed as reflection of DP on DC.

Motlatsi was further advised by fellow participants to always prepare a worksheet with instructions for learners to develop a model representing layers of the earth. She was encouraged to support specific aims and Science process skills with teacher and learner activities. One of the activities suggested was a model, as fellow participants believed that the use of a model would trigger curiosity and enhance learners' learning. Motlatsi submitted another lesson plan (in a portfolio of evidence) in which it was reflected that she used a learner- centred approach. Classwork assessing the lesson presented was attached to the lesson plan and submitted in a portfolio of evidence. Motlatsi indicated that the voice should be projected loudly to ensure that all learners, including those with hearing impairments, would hear or be able to read lips while the lesson was being presented. She even reflected on lessons presented at school, indicating that learners found it difficult to understand the interaction between different layers of the earth, but in order to mediate, Motlatsi used pictures obtained from the intervention workshop (Source: Motlatsi's portfolio of evidence). This was observed as DC reflection on PD, and PD reflection on DC.

During interviews, Motlatsi indicated that her preferred teaching approach was the teacher-centered method, and the use of representations (video-clips). According to Motlatsi, it was easier to explain *Planet Earth and beyon*d concepts after learners had seen a video-clip based on the concept to be explained (Source: Interviews). Motlatsi also indicated that for a teacher to be able to develop relevant instructional strategies, the teacher needed to be informed continuously on *Planet Earth and beyond* topics. Motlatsi stated that she informed herself about *Planet Earth and beyond* concepts, which ultimately enabled her to gain knowledge of instructional strategies, and the "know-how" of developing instructional material. According to Motlatsi, knowledge of instructional strategies would lead to adequate teaching of *Planet Earth and beyond* topic (Source: Interviews).

After attending the intervention workshop, Motlatsi made the following recommendation, "*... there should be more experiments based on this topic… Another thing is that there should be more practicals based on this."* This suggests that after the intervention workshop Motlatsi understands that practical activities are instructional strategies that should be used for the effective teaching of *Planet Earth and beyond* topics.

Motlatsi indicated the following in her portfolio of evidence, *"When I taught this topic Planet Earth and beyond I made some demonstration on certain topic such as the Rock cycle and afterwards I told my learners go outside in groups to collect different types of rocks. For topic such as the -birth, life and death of stars I used video clips so that learners can understand more…. I also made models to explain to the learners, different layers of the Earth and different layers of the atmosphere. When teaching mining and extraction of mines I used video-clips as well …. I am still teaching Natural Sciences Grade 9 due to motivation received during my participation in the intervention workshop"* (Source: Motlatsi's portfolio of evidence). This suggests that Motlatsi developed knowledge of instructional strategies during the intervention workshop.

Before the workshop, Motlatsi indicated that she was strongly confident in using the correct pedagogy in her class, and that she was able to prepare lesson plans as per CAPS prescripts infusing specific aims, Science process skills and relevant assessment, and that she hated teaching *Planet Earth and beyond* topics. However, during the intervention workshop, Motlatsi became confident that the presentations made were useful to her needs as a teacher, that she would use this the information gained to help her Science class, that she would implement the skills learnt in the class with immediate effect, that she was able to improvise

and do experiments, as well as create models to enhance understanding of *Planet Earth and beyond* topics, that she found the pair and share session useful, started learning different teaching methods and approaches, and that training material (participant guide, lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop.

After the intervention workshop, Motlatsi was strongly confident that she had a better understanding of planning lessons, that she would use lesson plan templates used and discussed at the intervention workshop, that comments made by colleagues during lesson demonstrations were helpful, and that she would infuse them in her planning in the future, that she felt her skills for preparing and doing practicals (including developing models) had improved, that she no longer hated teaching *Planet Earth and beyond* after the intervention workshop, and that she would use training materials including videos in her class. After attending the intervention workshop, this is what Motlatsi had to say, *"I gained enough skills that make me a better teacher. I am now confident teaching Planet Earth and beyond. There is a lot of improvement in learner performance."*

**Mavis**

Figure 4.3, pictogram 11, showed a growth network with enactment of PD on ED and DP, with ED enactment on DP, resulting in a reflection of DP on PD and DC. The entry point in pictogram 17 was the PD. It seemed as if Mavis had knowledge and understanding of lesson planning and presentations, planning documents and the development of instructional material, before attending the intervention workshop (PD enactment on ED). However, on her workshop evaluation form, Mavis indicated that she was not confident that she was using the correct pedagogy in class. Mavis developed five more lesson plans after attending the intervention workshop. The usage of the different lesson plans templates did not allow the infusion of specific aims and science process skills as per CAPS prescripts (PD enactment on DP). During the intervention workshop, MAVIS managed the use of instructional strategies she had acquired before attending the intervention workshop in order to plan and present a demonstration lesson (ED enactment on DP). Mavis kept participants very active, even though the lesson was more teacher-centred than learner-centred.

At the end of the demonstration lesson, Mavis received feedback from fellow participants (acting as learners). Mavis was advised to develop a worksheet for a practical demonstration during presentation and to allow learners to carry out the practical activity of separating gold from sand (extracting ores) instead of it being done as demonstration. This was seen by fellow participants as shifting from a teacher-centred approach to a learner-centred approach. According to fellow participants, a practical investigation conducted by learners would have been more effective to enhance an understanding of the physical separation of minerals from ore, than a demonstration carried out by the presenter.

Planning skills learnt from the intervention workshop were incorporated into Mavis's knowledge base, leading to changed and improved knowledge, beliefs, skills, attitude and the confidence level in Mavis's instructional strategies, observed as reflection of DP on DC and PD. During pre-intervention interviews, when asked about the teaching method that worked best for Mavis, she indicated that her preferred teaching methodology was the learner-centered approach. However, when asked the very same question during post-intervention interviews, Mavis indicated that her preferred teaching approach was the learner-centered approach with demonstrations (Source: Interviews).

Mavis went further to indicate that she used the internet to inform herself about *Planet Earth and beyond* concepts for acquiring knowledge of instructional strategies. However, during post-intervention interviews, Mavis said the following, "*Acquiring a lot of information, ok, it needs improvisation of the resources, and to use models, you must use the … drawings and charts as you present the topic, because there is where now, where learners needs to be shown, if you talk about the stars, the birth of stars up until to the death of a star, learners need to have a picture."* This suggests that after attending the intervention workshop, Mavis may have developed knowledge of instructional strategies that she did not have before attending the intervention workshop. Mavis indicated that it was vital to have knowledge of instructional strategies for effective teaching of *Planet Earth and beyond* topics, otherwise, if this strand was not adequately taught, it would affect the performance of learners, even in FET classes (Source: Interviews).

During post-intervention interviews, Mavis made the following recommendation to the Department of Education, "*… So the government needs to allocate content workshops, the*

*same as Maths and other subjects that are taken care of, and they must also give us the … there are some other resources, workbooks, charts, for content development."*

Participant Mavis indicated the following in her portfolio of evidence, **"***The workshop gave me a different attitude for teaching Natural Sciences … The workshop has motivated me to continue teaching Natural Sciences to grade 9s in 2020. I have gained new presentation skills that are effective in keeping learners interested in lessons presented in class. My learners' marks are the result of the knowledge and skills gained from the workshop*" (Source: Mavis's Portfolio of evidence).

Participant Mavis's workshop evaluation form indicated that before the workshop, she had not been confident about using the correct pedagogy in her class**,** or that she was able to prepare lesson plans as per CAPS prescripts infusing specific aims, Science process skills and relevant assessment, and that she strongly felt that she hated teaching *Planet Earth and beyond* topics. However, during the intervention workshop Mavis became strongly confident that the presentations made were useful for her needs as a teacher, that she would use the information gained to help her science class, that she would implement the skills learnt in her class with immediate effect, and felt that she was able to improvise and do experiments, as well as create models to enhance understanding of *Planet Earth and beyond* topics, but felt that she did not start learning different teaching methods and approaches. Mavis felt strongly that the training material (participant guide, lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop.

After the intervention workshop Mavis indicated that she had a better understanding of planning lessons, that she was strongly confident that she would use lesson plan templates used and discussed at the intervention workshop, that comments made by colleagues during lesson demonstrations were helpful, and that she would infuse them in her planning in the future, that she felt that her skills for preparing and doing practicals (including developing models) had improved, that she no longer hated teaching *Planet Earth and beyond* and that she would use training materials received during the intervention workshop, including videos, in her class. In her general remarks on the workshop evaluation form, she said the following, ***"****I recommend that other challenging topics like balancing of equations etc. must be treated in a workshop like this one. Enough time should be allocated for such a workshop, at least five days should be allocated"* (Source: Mavis's workshop evaluation form).

**Mabel**

Figure 4.3, pictogram 12, showed changes in Mabel's instructional strategies. The entry point was the PD. A growth network was observed in pictogram 18 with enactment of PD on ED and DP, and enactment of ED on DC, stimulating a reflection of DP on DC and PD, reflection of DC on PD, and reflection of ED on DP. It seemed as if MABEL went into the intervention workshop with a limited understanding and knowledge of planning and presenting lessons on *Planet Earth and beyond* (PD enactment on ED), which influenced the lesson planned and presented during the intervention workshop (ED enactment on DP). During the lesson demonstration Mabel followed a teacher-centred approach, which indicated that it had been her preferred approach before the intervention workshop (Source: Pre-intervention interviews. Mabel's teaching practices remained unchanged, leading to enactment of PD on DP.

After the lesson presentation, fellow participants discussed the lesson during the feedback sharing session. One of the suggestions was to augment lessons with the use of representations such as video-clips and other visual aids to make the lesson more interesting, enhance understanding of the topic discussed, being *The birth, life and death of stars*. Mabel had appropriate instructional material in the form of worksheets. The lesson plan template discussed during the intervention workshop was utilised for planning a subsequent demonstration lesson, which assisted MABEL to draw CAPS compliant lesson plans, with specific aims and science process skills infused. It also showed which teacher and learner activities would be executed and how the topic was done. That was observed as reflection of ED on PD and reflection of DC on PD.

After the intervention workshop, Mabel submitted a portfolio of evidence with four more lesson plans, using the lesson plan template discussed and used during the intervention workshop. The ability of Mabel to develop CAPS compliant lesson plans after the intervention workshop was observed as reflection of DC on PD. The researcher also observed that after the intervention workshop, Mabel decided to no longer follow the teacher-centred approach and opted for the learner-centred approach (Reflection of DC on PD). (Source: Post-intervention interviews). When asked which teaching methodologies worked best for her in the teaching of the *Planet Earth and beyond* topics, Mabel indicated that she used the

direct instruction method, but when asked the very same question after attending the intervention workshop, she stated,*" I think the learner centered method will be best for this eh …. strand because it will help learners to engage and also to grasp the concepts even better when they do hands on practical activities."* This suggests that the intervention workshop had influenced Mabel's instructional strategies. She also indicated that for effective instructional strategies to be developed, teachers need to read textbooks and consult the internet to obtain information on, among other, instructional strategies, that would help them to prepare to teach *Planet Earth and beyond* topics adequately (Source: Interviews). This would ensure that learners who would be doing Geography in Grade 10 were adequately prepared.

When Mabel was asked what recommendations she would offer to the Department of Education for future efforts to improve performance, CK and PCK, she said *"I think the Department should try to give educators content training only on the different strands so that they can be able to have a better understanding of each strand and to deliver it better to the learners"* (Source: Post-intervention interviews). This suggest that Mavis developed an understanding that the teacher's knowledge of instructional strategies leads to better articulation of concepts to the learners, resulting in learners having a better understanding of concepts.

In Mabel's portfolio of evidence, under general comments, she made the following remarks, ***"****The topics such as the rock cycle, the birth, life and death of stars were challenging but after the workshop I understood them better and with the help of video-clips that were used during the workshop, I was also able to use them in class to help learners understand the topics and concepts better…. The manuals that were prepared for the workshop are user friendly and easy to use. The concepts are explained very well and are easy for learners to remember".*

This can be viewed as evidence that now Mabel has knowledge of instructional strategies, which includes the use of video-clips to enhance understanding, the use of lesson plan templates discussed during the intervention workshop, and also the use of manuals to provide information and enhance understanding of *Planet Earth and beyond* topics. Data received from Mabel's workshop evaluation form revealed that, after the intervention workshop, Mabel was confident in using the correct pedagogy in her class, she was able to prepare

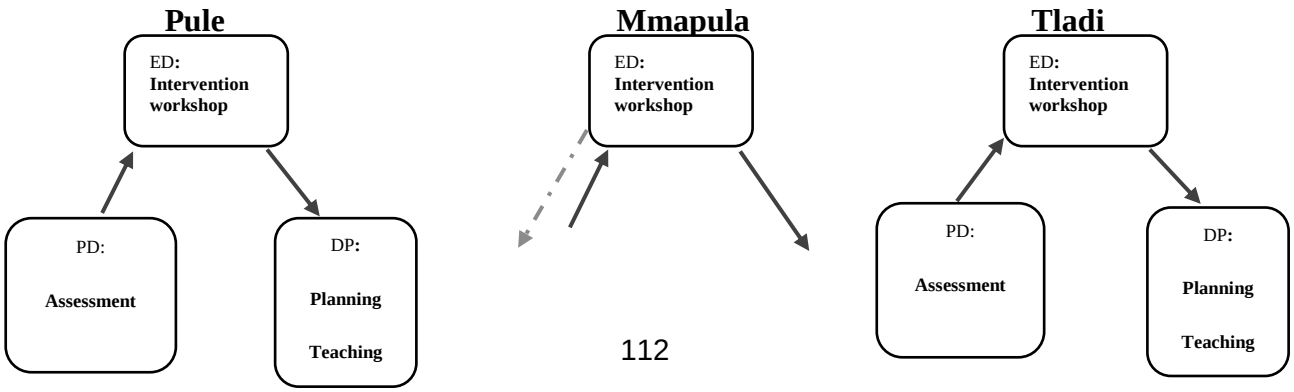
lesson plans as per CAPS prescripts infusing specific aims, Science process skills and relevant assessment, and indicated that she did not hate teaching *Planet Earth and beyond* topics.

During the intervention workshop, Mabel indicated that the presentations made were useful to her needs as a teacher, that she was strongly confident that she would use the information gained from the intervention workshop to help her Science class. She also indicated that she would implement the skills learnt in her class with immediate effect, that she would be able to improvise and do experiments, as well as create models to enhance understanding of *Planet Earth and beyond* topics. She furthermore indicated that she had started learning different teaching methods and approaches, and that the training material (participant guide, lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop.

After the intervention workshop, data received indicated that Mabel was strongly confident that she had a better understanding of planning lessons, and that she would use lesson plan templates used and discussed at the intervention workshop. She further indicated that comments made by colleagues during lesson demonstrations were helpful, and she would infuse them in her planning in the future. Mabel was strongly confident that her skills for preparing and doing practicals (including developing models) had improved, and that she no longer hated teaching *Planet Earth and beyond* topics. She also indicated that she was going to use material received from the intervention workshop, including video-clips, in her class.

#### 4.3.1.3 Knowledge of student assessment on *Planet Earth and beyond*

Knowledge of student assessment refers to the teachers' knowledge to use different methods to assess learning when teaching *Planet Earth and beyond* topics. These include the ability to develop instructional strategies relevant for the assessment of *Planet Earth and beyond*, for example formal standardised tests and examinations, class work, homework, observation sheets, checklists, hands-on practical tasks, including the development of models. Data on teachers' knowledge of student assessment is shown in Figure 4.4 below:



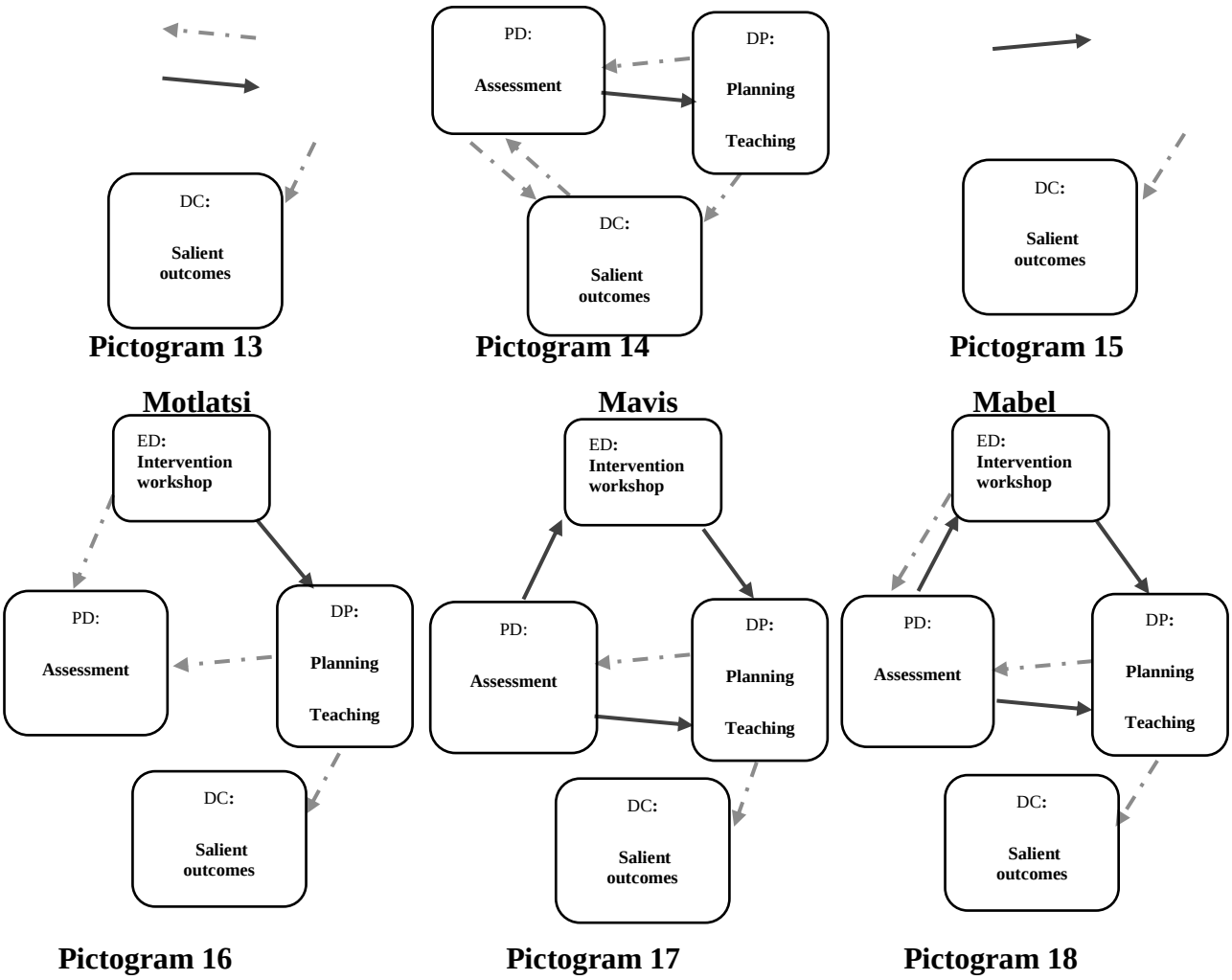



**Figure 4.4**: Pictorial representations of teachers' knowledge of assessment of *Planet Earth and beyond*

**Pule**

Figure 4.4, pictogram 13 showed a growth network with enactment of PD on ED and DP and with enactment of ED on DP, stimulating a reflection of DP on DC. The entry point in pictogram 13 was the PD. Pule showed understanding of the programme of assessment and which tasks had to be administered to assess *Planet Earth and beyond* content and concepts (enactment of (PD on ED). Pule's knowledge of how to assess *Planet Earth and beyond* was reflected on DC, when PULE managed to follow the programme of assessment as requested by DBE (enactment of PD on DP). During the intervention workshop, Pule learned to infuse assessment with lesson presentations to enhance understanding, which influenced how he assessed *Planet Earth and beyond* topics after intervention (enactment of ED on DC). This enhanced Pule's ability to administer a practical investigation, a research project and a test on *Planet Earth and beyond* content and concepts.

During a demonstration lesson conducted by Pule, a practical hands-on activity about the classification of rocks was conducted, which triggered interest and enhanced understanding (reflection of DP on PD) and also projected Pule as having understanding of the topic that was presented about boosting learners' confidence level and developing their interest (Source: Pule lesson demonstration report). On top of all the formal assessment tasks done by PULE, he managed to administer seven informal tasks to check learners' understanding of *Planet Earth and beyond* topics. Instructions thereof were accompanied by memoranda. One of the skills developed through informal tasks was graph interpretation (reflection of DP on DC). An observation made was that all informal tasks covered consisted of low and middle order questions, only, leaving out high order questions which were thought-provoking and helped to prepare learners for formal assessment. Pule's changed attitude, beliefs and goals of assessment strategies resulted in learners displaying good performance in 2019, as compared to 2018, where his learners moved from 66% in 2018 to 90% in 2019.

**Mmapula**

The entry point in figure 4.4, pictogram 14 was the PD. It seemed as if Mmapula went into the intervention workshop with the understanding of the programme of assessment to be followed to assess *Planet Earth and beyond* topics, as dictated by chapter 4 of CAPS (enactment of PD on ED). Mmapula managed to administer a practical investigation, a research project and a test as per CAPS requirements (enactment of PD on DC). During the intervention workshop, it was emphasised to the participants that learners understand concepts better if whatever was learned was assessed. Informal assessment had to be administered as a build-up to formal assessment. Cognitive levels, science process skills and specific aims need to be considered when developing assessment tasks, both informal and formal. Mmapula developed a practical investigation on the topic Global warming, which was administered during Mmapula's demonstration lesson (Source: Mmapula's lesson demonstration report).

The practical investigation developed participants' (acting as learners) observation skills to draw a graph and enhanced understanding of the concepts the greenhouse effect and global warming (enactment of ED on DC). After the intervention workshop, Mmapula submitted seven class works and when tracing cognitive levels, class works submitted covered low,

middle and high order questions. All lesson plans submitted were backed up by written class works (Source: Mmapula's Portfolio of evidence). No memoranda were submitted for class works written, only instructions were availed through the portfolio of evidence. The ability of MMAPULA to implement what was learnt during the intervention workshop was observed as a reflection of ED on PD and of DP on DC and PD, and DC on PD. MMAPULA showed mastery of content and learners showed an improvement in performance on *Planet Earth and beyond* content and concepts. Mmapula's changed attitude, beliefs and goals of assessment strategies resulted in learners displaying good performance 2019.

**Tladi**

The entry point in figure 4.4, pictogram 15 was the PD. A growth network was observed with PD enactment on ED and DP with ED enactment on DP, causing a stimulus of DP on DC. Tladi showed understanding of assessment strategies to be employed when assessing *Planet Earth and beyond*, which influenced the approach of assessing the strand without changing or increasing the number of assessment tasks employed to do so (enactment of PD on DP). Assessment strategies already known were further discussed during the intervention workshop, helping Tladi to realise that knowledge of assessment was in line with what was prescribed by CAPS chapter 4 (enactment of PD on ED). Tladi successfully administered a practical investigation, a research project and a formal assessment as prescribed in the Grade 9 programme of assessment (enactment of ED on DP) during and after the intervention workshop, including when discussing lesson plan templates used for lesson demonstrations.

It was highlighted that for proper teaching and learning to take place, each concept taught had to be assessed and that informal assessment tasks should be used as preparation for the administration of formal assessment. That required participants to indicate how lessons presented were to be assessed, whether formally or informally. Tladi submitted nine informal tasks written by learners, which were used to check their understanding of *Planet Earth and beyond* content and concepts, even though marking memoranda or rubrics for informal assessment conducted were not submitted (Source: Tladi's Portfolio of evidence). That was observed as a changed behaviour of supporting teaching with assessment to ensure understanding (reflection of DP on DC). Tladi's changed attitude, beliefs and goals of assessment strategies resulted in learners' displaying improved performance in 2019 as compared to 2018.

**Motlatsi**

The entry point in figure 4.4, pictogram 16 was the ED. A change sequence was observed with enactment of ED on DP, causing a reflection of ED on DP and a further reflection of DP on DC and PD. It seemed that Motlatsi went into the ED with little or no knowledge of student assessment, as Motlatsi had been in the teaching fraternity for only a few months and had never conducted any assessment of *Planet Earth and beyond* content and concepts (Source: Motlatsi's Portfolio of evidence & Questionnaire). Knowledge and assessment strategies learnt during the intervention workshop influenced Motlatsi's practices in class (enactment of ED on DP). It was observed that Motlatsi managed to successfully administer a practical investigation, a research project and assessment, which were strategies that Motlatsi learned during the intervention workshop (enactment of ED on DP).

During intervention, Motlatsi indicated that she was now able to improvise and do experiments, as well as models to enhance understanding of *Planet Earth and beyond* topics and further indicated that after attending the intervention workshop she felt that skills for preparing and doing practicals, including development of models, had improved (Source: Motlatsi's workshop evaluation form). After intervention, lesson plans were submitted with evidence of informal assessment of *Planet Earth and beyond* content and concepts. A total of four informal tasks were submitted, as a result of discussions and recommendations made during the intervention workshop (Source: Motlatsi's Portfolio of evidence). Acquired skills enabled Motlatsi to develop class works to evaluate concepts learnt (reflection of DP on DC). Learnt strategies led to a changed attitude, goals and objectives (reflection of DP on PD).

**Mavis:**

Figure 4.4, pictogram 17 showed a growth network with enactment of PD on DP and ED and enactment of ED on DP, causing a reflection of DP on PD and DC. The entry point was the PD. It seemed as if MAVIS had a certain level of skills and understanding about assessment before intervention, which influenced how he conducted assessment during the intervention workshop and in the DP, which he did not change even after having attended the intervention workshop (enactment of PD on DP). MAVIS managed to successfully follow the programme of assessment and administered a practical investigation, a research project and a test (enactment of ED on DP). During the intervention workshop, Mavis managed to conduct a

practical investigation during the demonstration lesson. That was observed as a new skill that Mavis learnt during the intervention workshop that demonstrated changed beliefs, skills and knowledge (reflection of DP on PD). The newly acquired skills of assessment, assisted Mavis to maintain a good performance of her learners in 2019.

Mavis indicated that during the intervention workshop, he felt that he was able to improvise and do experiments, as well as create models to enhance understanding of *Planet Earth and beyond.* He further indicated that it felt that his skills for preparing and doing practicals had improved (Source: Mavis's workshop evaluation form). Mavis managed to develop and administer seven informal tasks that were used to assess understanding of *Planet Earth and beyond* content and concepts and also used as preparation for formal assessment. Class works were sourced from previous question papers and displayed a balancing of cognitive levels as per CAPS, chapter 4. Questions set in informal tasks covered low, middle and high order questions. Skills developed and assessed through informal tasks covered case studies, graph interpretation and calculations.

**Mabel**

A growth network was observed in figure 4.4, pictogram 18, with enactment of PD on ED and DP and enactment of ED on DP, causing a reflection of ED on PD, and a reflection of DP on DC and PD. The entry point in pictogram 30 was the PD. It seemed Mabel went into the intervention workshop with a limited understanding of assessment strategies (enactment of PD on ED), which were sharpened and moulded during the intervention workshop (enactment of ED on DP). Knowledge and understanding of assessment acquired before intervention influenced MABEL's assessment practices after intervention (enactment of PD on DP). During the intervention workshop, MABEL's curricular knowledge and assessment skills were sharpened, leading to confidence gain, an ability to develop practical investigations and leading learners to the successful development of a model showing layers of the earth. This resulted in a change in goals, beliefs, and an improved attitude towards *Planet Earth and beyond* topics (Source: Mabel's lesson observation report). This was observed as reflection of ED on PD.

Mabel administered a practical investigation to demonstrate the greenhouse effect, a research project and a formal test, which led to an improved 2019 learner performance as compared to

2018. In 2018 the school performed at 58% and at 62% in 2019, which was the highest performance Mabel's school had ever achieved in the last four years (reflection of DP on DC). That 4% improvement was only registered after MABEL attended the intervention workshop (Source: Mabel's Portfolio of evidence). Mabel submitted five informal tasks administered to check knowledge and understanding of *Planet Earth and beyond* content and concepts on learners. This assisted Mabel to gain more confidence and to changed attitudes, beliefs and goals, hence an improvement in the overall learner performance in NS for 2019 (Source: Mabel's Portfolio of evidence). That was observed as DP reflection on PD.

### 4.3.2 Research question 2: How did the Grade 9 teacher's Pedagogical Content Knowledge manifest during the intervention?

This research question was responded to, using data generated to develop the theme, Knowledge of Science curricula.

#### 4.3.2.1 Knowledge of Science curricula

Knowledge of Science curricula refers to teachers' knowledge of goals and objectives for students in *Planet Earth and beyond* topics. It includes knowledge about the topic at hand, a variety of instructional tasks, resources and programmes that are relevant to teaching *Planet Earth and beyond*, and challenges experienced when teaching *Planet Earth and beyond* topics.

Data on teachers' knowledge of Science curricula is shown in figure 4.5 below:

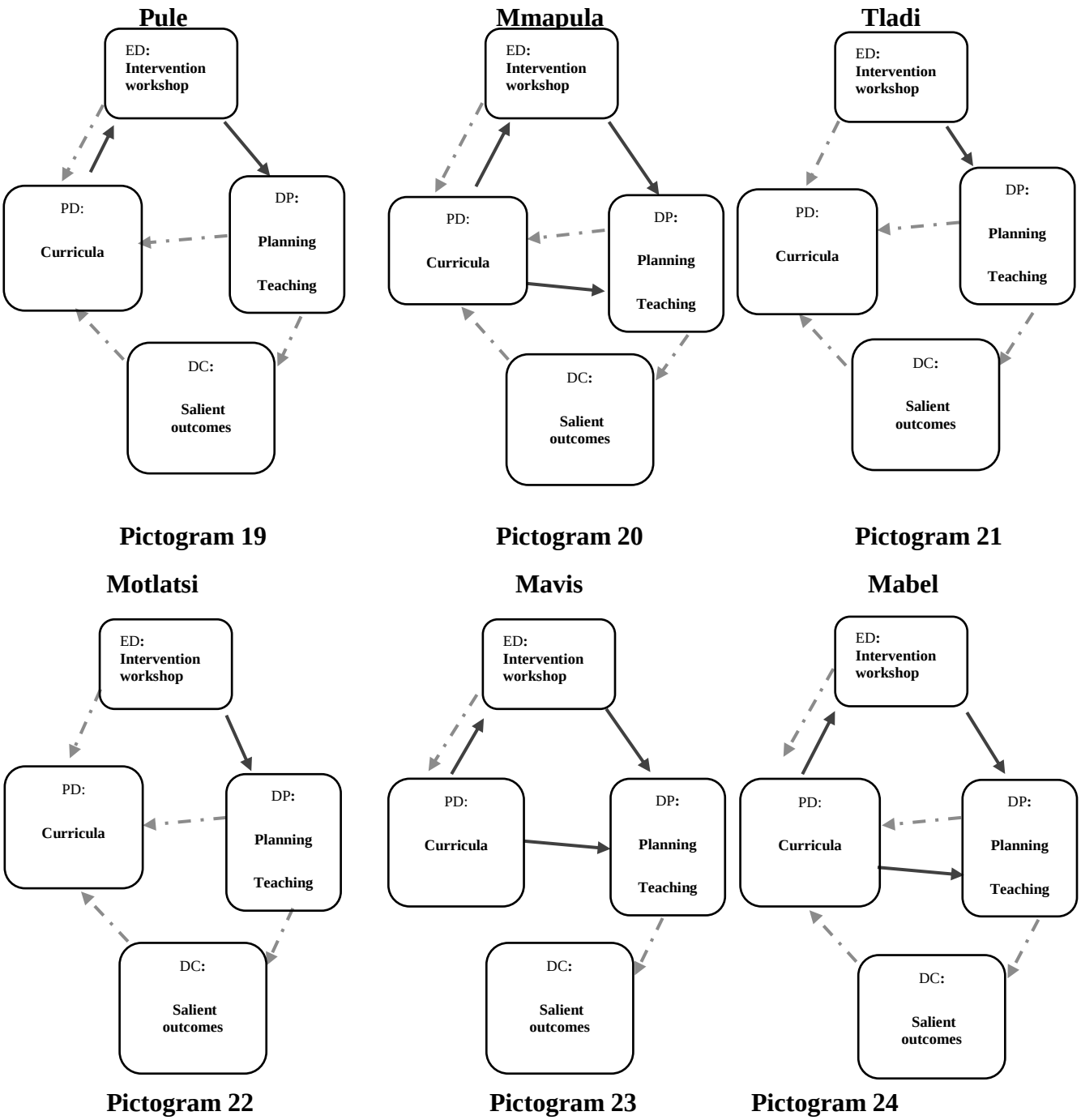



**Figure 4.5**: Pictorial representations of development of *Planet Earth and beyond* curricula

**Pule**

When investigating pathways related to knowledge of Science curricula in figure 4.4, pictogram 19 showed changes in Pule's knowledge of Science curricula after attending the

intervention workshop. A change sequence was observed with enactment of ED on DP, and PD on ED, stimulating a reflection of ED on the DP, DP on DC, DC on PD and DP on the PD. Breaking this down, Pule did not do *Planet Earth and beyond* in matric nor at tertiary level and even though he did Natural Sciences at university, *Planet Earth and beyond* topics were not part of the modules at tertiary level (Source: Pule questionnaire). During pre-intervention interviews Pule was asked, *what comes spontaneously to your mind when you hear the key words "Planet Earth and beyond?"* Mmapula replied as follows, "*Eh ... planet earth ehh is a broad subject eh ... what comes to my mind it, ehh living is one of the first things that come to my mind. Eh ... Sharing is one of the things eh ... those are mainly two words that come into my mind. Living and sharing*."

The response indicated that no overview of *Planet Earth and beyond* topics had been acquired, which reflected a lack of knowledge of Science curricula for participant Pule before the intervention workshop. The entry point in this pictogram was the external domain, as Pule was exposed to content covering all *Planet Earth and beyond* topics at the intervention workshop. He therefore participated at the intervention workshop with little or no prior knowledge of the subject matter. Through the intervention workshop, CK acquired boosted his understanding and confidence level that were displayed in the demonstration lesson, thus ED influencing his PD and his DP, leading to changed behaviour shown by a reflection of PD on DC. During pre-intervention interviews, when Pule was asked if he saw himself suitably qualified to teach Natural Sciences, he indicated that he was qualified to teach NS, as the subject had been part of his BSc modules at university. However, when asked the very same question during post-intervention interviews, he indicated that although he did NS at tertiary level, *Planet Earth and beyond* had not been part of the content. Pule was asked if he found professional development programmes he had attended before attending the intervention workshop to be informative and fruitful as increased CK for teachers, which the teacher would automatically pass on to the learners. However, when asked the same question during post-intervention interviews, he replied, "*Yes, but this one that we have just attended, ehh ... has given me the knowledge enough to pass on a message or the content to the learners, so it has been helpful, eh ... although we have attended a few eh ... content training in term 4, last year we attended, I think again in 2017 content training of 2017 in Natural Sciences, but this one, specifically have helped a lot."* This suggests that Pule developed knowledge of Science curricula during the intervention workshop.

During post-intervention interviews, Pule further said the following, "*The topic as a whole, it has a variety of eh …, eh …, it has a variety of ehh, ehh, I do not know what to call it, gaps that are there on teachers. So, ehh, for us teachers, we need to focus and read more, and try and research more about the topic, so that we can take this knowledge to our learners."* Pule also made the following comments in the portfolio of evidence he submitted after attending the intervention workshop, *"The workshop intervention has increased my level of knowledge on the topic Planet Earth and beyond. Before the workshop I was struggling, trying to explain all the concepts to learners. But now I am confident that I can teach learners with excellence. I have seen improvement on learners as the topic was taught, content and concepts, as well as relevant teaching approaches content and concepts, as well as relevant teaching approaches. Presentations during the workshop were helpful as they were informative to me as an educator learning from other educators on how to teach certain content and concepts…."* This suggests that Pule went into the intervention workshop with some knowledge of Science curricula, which he had acquired by attending professional development programmes prior to the intervention programme, but his knowledge of Science curricula was boosted by the intervention programme, considering that Pule did not do *Planet Earth and beyond* topics at tertiary level.

Data received through Pule's manual journal indicates that Pule learnt new information at the intervention workshop, which includes the following: Why the earth looks blue; definition of concepts of the hydrological cycle (condensation, evaporation, run-off, and precipitation); 97% salty water, 3% fresh water; Composition of gases of the atmosphere; Pluto – a dwarf planet; What causes a leap year; Layers of the earth; Life cycle of stars. A total of 56 concepts were noted and defined, covering all *Planet Earth and beyond* topics (Source: Pule's Manual Journal).

According to Pule's evaluation form, before the intervention workshop he had a full understanding of the following *Planet Earth and beyond* topics and could teach them with confidence: The earth as a system and spheres of the earth; Lithosphere; Rock cycle; the atmosphere; and the Greenhouse effect. He indicated that he was less confident in teaching the following topics: Mineral resources (Extracting ores, Refining minerals, mining in South Africa). However, as the intervention workshop progressed, Pule learnt how to improvise and do experiments as well as create models to acquire knowledge and enhance understanding of *Planet Earth and beyond* concepts and topics. After the intervention workshop, Pule felt that

his subject knowledge and skills had improved, and was strongly confident that he had a full understanding of the following *Planet Earth and beyond* topics and could teach them with confidence after attending the intervention workshop: The earth as a system and spheres of the earth, Lithosphere, The rock cycle, Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), The atmosphere, Greenhouse effect, and the Birth, life and death of stars.

Pule felt that he was more confident than before to teach *Planet Earth and beyond* topics, that the intervention workshop had helped him with the acquisition of both pedagogy, content and concepts to deal with the teaching of *Planet Earth and beyond.* Pule made the following remarks under general comments in his workshop evaluation form, *"The intervention workshop was helpful in increasing our knowledge of the topic, planet earth and beyond. I am going to share the information I have learnt with other Natural Sciences educators. With the motivation I got from the intervention workshop, it was easy to communicate and share the content I learnt."*

**Mmapula**

The entry point for pictogram 20 was the Personal Domain. MMAPULA went into the intervention workshop with knowledge of some of *Planet Earth and beyond* topics, namely global warming, greenhouse effect and mining in South Africa as a result of what had been learnt at university. A growth network was observed in pictogram 20, with enactment of PD on ED, and PD on DP. Other *Planet Earth and beyond* topics were learnt during the intervention workshop, namely Birth, life and death of stars and negative impact of mining on the environment. The acquisition of new content and concepts led to a reflection of ED on PD, DP on PD, DP on DC and DC on PD. Mmapula managed to infuse content and concepts learnt during the intervention workshop into existing knowledge, beliefs and goals on his PD, and to use newly acquired content and concepts in lesson planning and lesson presentation. Mmapula demonstrated confidence and understanding of content and concepts during a demonstration lesson offered during the intervention workshop. This assisted Mmapula to develop worksheets and practical investigations that led to the general improvement of learner performance, from 75% in 2018 to 77% in 2019, marking a 2% improvement in 2019. This suggests that through the intervention workshop Mmapula's knowledge of Science curricular had improved. During interviews, Mmapula indicated that she was suitably

qualified to teach Natural Sciences, even though she did not do *Planet Earth and beyond* during his tertiary education (Source: Teacher questionnaire & Interviews). Mmapula, like Pule, indicated that she had attended professional development programmes that helped to develop her curricular knowledge before attending the intervention workshop. However, this is what Mmapula had to say after attending the intervention workshop, "*Yes, the professional development workshops I attended before were informative, I managed to get some information, and also including this one, I take it as a workshop it has been for three days, and I rate it as the best workshop I have ever attended of NS, because we had enough time to discuss everything, we had enough time to be taught how to design a lesson… So, I gained a lot."* During pre-intervention interviews, Mmapula recommended that professional development workshops should be continued to keep educators, both experienced and inexperienced, informed with curricular knowledge, including teaching them to be creative, to help them learn to make models to enhance understanding of *Planet Earth and beyond* concepts.

In Mmapula's portfolio of evidence, she made the following remarks, "*I managed to use the knowledge gained from the workshop about the following topics: The rock cycle and the types of rocks, Layers of the atmosphere, mining in South Africa, the birth, life, and death of stars and global warming. I also managed to use the following in term 4 2019, gained from the intervention workshop: Videos used during workshop, materials from the workshop (taken as notes through the manual journal), classwork designed by teachers developed for lesson demonstrations during intervention workshop, models designed by educators at the workshop, lesson plans designed by educators during intervention workshop and tests designed by educators during intervention workshop. I also managed to use the knowledge gained from the workshop for other subjects, i.e. Grade 11 Physical sciences: mining in South Africa; Grade 11 Life Sciences: Global warming; and Grade 12 Life sciences: Human impact on the environment."* This suggests that Mmapula gained knowledge of Science curricula during the intervention workshop, which was also reflected in his manual journal. New information acquired during the intervention workshop included the birth, life and death of stars, what are archaeologists, what is meant by coke, the negative impact of mining on the atmosphere, what is a galaxy, how much fresh water do we have as opposed to salty sea water, electrolysis, differences between an anode and a cathode, the atmosphere and importance of the atmosphere, and the difference between variable and permanent gases of

the atmosphere. A total of 51 concepts learnt during the intervention workshop was noted down and defined.

Data received from Mmapula's workshop evaluation form revealed that before the intervention workshop, Mmapula had been less confident in teaching *Planet Earth and beyond*. She did not have a full understanding of the following *Planet Earth and beyond* topics and could not teach them with confidence: The earth as a system and spheres of the earth, Lithosphere, The rock cycle, Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), The atmosphere, the Greenhouse effect, and the Birth, life and death of stars. However, during the intervention workshop Mmapula strongly felt able to improvise and do experiments as well as create models to enhance knowledge and understanding of *Planet Earth and beyond* topics and concepts.

After the intervention workshop, Mmapula became strongly confident that her subject knowledge and skills had improved, and she had developed a full understanding of the following *Planet Earth and beyond* topics and could teach them with confidence: The earth as a system and spheres of the earth, Lithosphere, The rock cycle, Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), The atmosphere, the Greenhouse effect, and the Birth, life and death of stars. Mmapula felt that she was more confident to teach *Planet Earth and beyond* topics, and that the intervention workshop helped him with the acquisition of both pedagogy, content and concepts to deal with the teaching of *Planet Earth and beyond*. Under general comments, Mmapula stated the following, *"The intervention workshop was good and I gained a lot of content knowledge, which I will use as I teach the children."* All these suggest that the intervention workshop helped and boosted Mmapula's knowledge of science curricula.

**Tladi**

The entry point in pictogram 21 was the External Domain. A change sequence was observed with enactment of ED on PD, leading to a reflection of DP on PD, ED on PD, DP on DC, and DC on PD. Breaking it down, it means Tladi had no background knowledge of *Planet Earth and beyond* topics before attending the intervention workshop. Tladi confessed during pre-intervention interviews and through the portfolio of evidence, under general comments, that a

Geography colleague had been teaching the *Planet Earth and beyond* topic on his behalf for the past two years. Tladi did not do *Planet Earth and beyond* topics in matric, or at tertiary level (Source: Portfolio of evidence; Interviews and Tladi's questionnaire responses). The intervention workshop assisted Tladi to acquire content knowledge and concepts of *Planet Earth and beyond*, as well as lesson planning and presentation skills. This resulted in Tladi planning and presenting a lesson on *Planet Earth and beyond* for the first time during an intervention workshop demonstration lesson, which led to changed goals, beliefs and attitude on his PD. TLADI started to teach *Planet Earth and beyond* for the first time in class after attending the intervention workshop, which showed that her confidence level and understanding of *Planet Earth and beyond* content and concepts had improved, resulting in reflection of DP on DC, which ultimately led to Tladi becoming more confident, more comfortable and starting to enjoy teaching *Planet Earth and beyond* to learners for the first time since the beginning of her teaching career. This was observed in pictogram 9 as reflection of DC on PD. TLADI's newly acquired content and concepts about *Planet Earth and beyond* topics during the intervention workshop, her changed attitude and improved confidence level led to improved PCK for Tladi, as well as the general improvement of learner performance, from 29% in 2018 to 50% in 2019, marking a 21% improvement in 2019.

During interviews, Tladi indicated that he saw himself to be suitably qualified because she did Natural Sciences at tertiary level, but indicated that he did not do *Planet Earth and beyond* topics. During pre-intervention interviews she also indicated that she had never attended any professional development programmes before attending the intervention workshop as a participant. However, when asked about professional development programmes during post-intervention interviews, this is what Tladi had to say, "*I have never attended any workshop about planet earth and beyond before. The intervention workshop is my first professional development programme about planet earth and beyond for me. I found it to be very fruitful, cause when I came here, I only knew 20% of the content from planet earth and beyond, but now I can confidently say 80, … 80% of it, now I can be able to teach it without, some without even referring to the book, so it was very helpful."* This suggests that through the intervention workshop, Tladi developed knowledge of the Science curricula, specifically for *Planet Earth and beyond*. This is supported by what was written in Tladi's manual journal, according to which new information that Tladi acquired during the intervention workshop included: the earth as a system, 97% of water is salty water as

compared to 3% fresh water, Pluto, the dwarf planet, layers of the earth, what is a galaxy, and layers of the atmosphere. A total of 38 concepts learnt during the intervention workshop were noted down and defined. Tladi further made the following remarks in her portfolio of evidence, "*The workshop attended was very fruitful. I can honestly say before attending the workshop I had very little understanding on the section 'Planet Earth and Beyond'. From the video-clips that were used during workshop I was able to acquire knowledge and understand of the topic. At the start of the workshop I had so many misconceptions relating to the topic."*

In Tladi's workshop evaluation form**,** before the intervention workshop, it was indicated that Tladi was not confident of teaching *Planet Earth and beyond,* and she did not have a full understanding of the following *Planet Earth and beyond* topics: The rock cycle, Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), and could not teach them with confidence. However, he had a full understanding of the following *Planet Earth and beyond* topics: The earth as a system and spheres of the earth, Lithosphere, The atmosphere and the Greenhouse effect, and that she could teach them with confidence. Tladi strongly disagreed that before the intervention workshop she had a full understanding of the topic, the birth, life and death of stars, and that she had no confidence in teaching that topic. It was further indicated that during the intervention workshop Tladi started to learn to improvise and do experiments as well as models to enhance understanding of *Planet Earth and beyond* topics. He seemed to be strongly confident that she had acquired knowledge and understanding of *Planet Earth and beyond* content and concepts. According to Tladi, after the intervention workshop**,** she felt that her subject knowledge and skills had improved, that she had developed a full understanding of the following *Planet Earth and beyond* topics and could teach them with confidence: The earth as a system and spheres of the earth, Lithosphere, The rock cycle, and Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), The atmosphere, Greenhouse effect, and the Birth, life and death of stars.

Generally, Tladi started feeling that she was more confident to teach *Planet Earth and beyond* topics**,** and that the intervention workshop had helped her with the acquisition of both pedagogy, content and concepts to deal with the teaching of *Planet Earth and beyond*. The intervention workshop clearly helped to develop Tladi's knowledge of Science curricula, hence she made the following comment during post-intervention interviews*: "More time*

*should be allocated for content training, since most of the teachers are struggling to teach planet earth and beyond topics."*

**Motlatsi**

Figure 4.5, pictogram 22 depicts a growth sequence with enactment of ED on DP, triggering a reflection of DP on DC, DP on PD and DC on PD. It seemed Motlatsi went into the intervention workshop with an underlying lack of knowledge of the *Planet Earth and beyond* curriculum, and teaching was more teacher-oriented, even though she managed to engage participants (acting as learners) during the demonstration lesson offered during the intervention workshop. Motlatsi indicated that assistance was needed with the following *Planet Earth and beyond* topics: Mining in South Africa, Refining of minerals, Extracting ores and the Birth, life and death of stars (Source: Motlatsi's questionnaire; Motlatsi portfolio of evidence). After the intervention workshop, it was observed that Motlatsi's confidence level, attitude and acquisition of content and concepts had been boosted, resulting in improved learner performance of 91.59% in 2019, which came to 6.17% improvement, compared to 85.42% which was achieved in 2018 (DP reflection on DC). Motlatsi indicated that she would be teaching NS again because of a newly boosted confidence level and mastery of *Planet Earth and beyond* topics gained at the intervention workshop (Source: Workshop evaluation form).

During interviews, Motlatsi declared that she was suitably qualified to teach Natural Sciences, but also confirmed that she did not teach any module related to *Planet Earth and beyond*. She further indicated that she had never attended any professional development programme in which *Planet Earth and beyond* topics were treated. She even suggested that resources should be secured for effective teaching of *Planet Earth and beyond*. All these suggests that before the intervention workshop Motlatsi had no knowledge of the Science curricula related to *Planet Earth and beyond* topics. During post-intervention interviews, Motlatsi was asked if she thought professional development programmes she had attended before were informative and fruitful. Motlatsi replied as follows, "*I have never attended any workshop about planet earth and beyond before. The intervention workshop is my first professional development programme about planet earth and beyond for me. Yes, I do, because I actually gained a lot based on the topics I was struggling with, e.g. the mining in South Africa and the extraction of eh … .eh … minerals. I have also gained experience on*

*how to present a lesson to learners based on this topic, planet earth and beyond, as well as the life cycle of stars."*

Motlatsi was asked if there was anything else that she wanted to add, to which she responded as follows, *"Ok, well, for now, after this intervention I don't feel like there is a thing that I have to add, because I am actually satisfied with the knowledge that I have gained in this intervention."* This suggests that Motlatsi developed knowledge of Science curricula related to *Planet Earth and beyond* during the intervention workshop. Motlatsi made the following remarks in her portfolio of evidence: *"Intervention workshop I attended helped me a lot as a new Natural Sciences teacher because it was my first time teaching the topic planet, earth and beyond and there was a lot of improvement because in 2018 the pass percentage was 85.42% and in 2019 pass percentage was 91.59%. I am still teaching Natural Sciences Grade 9 due to motivation received during my participation in the intervention*." According to entries in Motlatsi's manual journal, she had acquired new information during the intervention workshop. This included: why the earth appears to be blue in colour, the impact of human activities on the lithosphere including disadvantages of mining on the environment, the differences between the lithosphere and the asthenosphere, the rock cycle, extraction of mineral resources, the Greenhouse effect and Global warming. All these provide a strong indication that Motlatsi developed knowledge of Science curricula related to *Planet Earth and beyond* during the intervention workshop (Source: Motlatsi's Manual Journal).

Data received from Motlatsi's intervention workshop evaluation form reveal that before the intervention workshop, she had been confident in teaching *Planet Earth and beyond,* and was strongly confident that she had a full understanding of the following *Planet Earth and beyond* topics: Lithosphere, Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), The rock cycle, The atmosphere and the Greenhouse effect, and could teach them with confidence. During the intervention workshop**,** Motlatsi indicated that she started learning to improvise and do experiments as well as create models to enhance understanding of *Planet Earth and beyond* topics**,** and felt that she had acquired knowledge and understanding of *Planet Earth and beyond* content and concepts. After attending the intervention workshop, Motlatsi was strongly confident that her subject knowledge and skills had improved, and that she had developed a full understanding of the following *Planet Earth and beyond topics* and could now teach them with confidence: The earth as a system and spheres of the earth, Lithosphere, The rock cycle, and Mineral resources (Extracting ores,

Refining minerals, Mining in South Africa), The atmosphere, the Greenhouse effect, and the Birth, life and death of stars.

Motlatsi felt more confident to teach *Planet Earth and beyond* topics than before and felt that the intervention workshop helped her with the acquisition of both pedagogy, content and concepts to deal with the teaching of *Planet Earth and beyond*. Knowledge of Science curricula was demonstrated by Motlatsi's remarks during the post-intervention workshop: *"I have gained enough skills that made me a better teacher. I am now confident in teaching planet earth and beyond in my class. Significant improvement in learner performance has been achieved."*

**Mavis**

Figure 4.5, pictogram 23 showed a growth network with PD enactment on ED, with ED enactment on DP, and PD enactment on DP, stimulating a reflection of DP on DC, and reflection of ED on PD. The entry point in pictogram 23 is the ED. Mavis did not do *Planet Earth and beyond* topics in matric or at the university, but accumulated *Planet Earth and beyond* content and concepts over time as an experienced educator (Source: Mavis's questionnaire: Mavis's portfolio of evidence). Mavis used knowledge accumulated from previous intervention programmes, which she used in her DP (PD enactment on DP). Her knowledge before attending the intervention workshop was further improved and increased during the intervention workshop. What was learnt during the intervention workshop was infused into practices, thus leading to a reflection of DP on DC, and reflection of her ED on PD, leading to a boost in her confidence level and being able to articulate content to learners during lesson presentations. During Mavis's demonstration lesson, she managed to display a high level of confidence and deep understanding of *Planet Earth and beyond* content and concepts. MAVIS managed to keep the participants (acting as learners) active throughout her presentation. Improved knowledge and skills were reflected in her class performance that managed to maintain a 94% pass rate in 2019 which was also attained in 2018.

During interviews, Mavis was asked if she was suitably qualified to teach NS, and she replied in the affirmative. She further indicated that she did not do *Planet Earth and beyond* as part of her major subjects at university or in high school. Knowledge of Science curricula related to *Planet Earth and beyond* was acquired by attending professional development programmes, and for more than 15 years teaching Natural Sciences. Mavis was further asked

if she had found professional development programmes that she attended to be fruitful and informative, and she responded by indicating that this had been the case. However, when asked the same question after attending the intervention workshop, during post-intervention workshop, she said: "*The ones that I attended, they were not fruitful, due to the fact that they were mixed with, you'll find that when we were attending workshops they were mixed with monitoring and moderations, and they were just, no time for us to unpack most of the topics and subtopics. According to me, the intervention workshop we have just attended was very fruitful. We tried to unpack most of the concepts, and we were demonstrating, alternating, and as we were presenting, different individuals presenting, it was giving us a lot of insight, because you would listen to some of your fellow members approaching the topic in a different way that we've been approaching it, and we were advising each other that this is a kind of a teaching method that we must always use may when teaching this kind of a topic"* (Source: Interviews*)*. This suggests that Mavis's knowledge of Science curricula was sharpened by the intervention workshop.

Mavis also made the following remarks in her portfolio of evidence under general comments: "*The workshop gave me a different attitude for teaching Natural Sciences. The content that was presented was informative. The presentations helped me notice my strengths and improve on my weaknesses. The workshop has motivated me to continue teaching Natural Sciences to grade 9s in 2020."* According to the entries in Mavis's manual journal, she acquired new information during the intervention workshop, which includes**:** Water as a habitat, birth, life and death of stars, drawing of a Venn diagram to represent the biosphere, human activities affecting the hydrosphere, and composition of gases of the atmosphere. Mavis noted down 38 concepts and defined them in her manual journal. This further supports the idea that for knowledge of science curricula was sharpened by the intervention workshop.

Mavis's workshop evaluation form indicates that, before she attended the intervention workshop, she felt less confident in teaching *Planet Earth and beyond* topics and did not have a full understanding of the following *Planet Earth and beyond* topics: The earth as a system and earth's spheres, The rock cycle, the Greenhouse effect and the Birth, life and death of stars, and she could not teach them with confidence. She indicated that she had a full understanding of the following *Planet Earth and beyond* topics*:* Mineral resources

(Extracting ores, Refining minerals, mining in South Africa) and the atmosphere, and that she could teach them with confidence. As the intervention workshop progressed, MAVIS started feeling that she was able to improvise and do experiments as well as models to enhance understanding of *Planet Earth and beyond* topics and that she had acquired knowledge and understanding of *Planet Earth and beyond* content and concepts.

After the intervention workshop, Mavis felt that her subject knowledge and skills had improved, that she had a full understanding of the following *Planet Earth and beyond* topics and could teach them with confidence: The earth as a system and spheres of the earth, Lithosphere, The rock cycle, and Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), The atmosphere, the Greenhouse effect, and the Birth, life and death of stars. She felt that the intervention workshop helped her with the acquisition of both pedagogy, content and concepts to deal with the teaching of *Planet Earth and beyond*. MAVIS also commented as follows under general comments in her workshop evaluation form, *"I am very thankful that I participated in in this type of workshop. It was very informative. I recommend that other challenging topics outside planet earth and beyond must be treated in the same way, like in this kind of workshop I have just attended, which will also last for at least five days."*

**Mabel**

Figure 4.5, pictogram 24 shows a central growth network, with enactment of PD on Ed, enactment of PD on DP, and enactment of ED on DP, resulting into a reflection of ED on PD, DP on PD, DP on DC, and PD. The entry point in pictogram 12 is the PD. It seems Mabel had limited knowledge of the *Planet Earth and beyond* curriculum before participating in the intervention workshop, which was accumulated over a period of three years of her teaching career. She also admitted that she did not feel confident about knowledge of the topics: The rock cycle, and the Birth, life and death of stars. (Source: Mabel's Questionnaire and Portfolio of evidence). Pictogram 12 indicates that Mabel increased her curricula knowledge the through intervention workshop, (ED enactment on DP) which she used to improve her articulation of *Planet Earth and beyond* topics during her demonstration lesson. Better understanding of content knowledge influenced her lesson planning and presentations, causing a reflective improved behaviour and attitude on her DC and on her PD, helping her to

improve her general attitude towards the teaching of *Planet Earth and beyond*, and her teaching approaches.

During pre-intervention interviews, when Mabel was asked if she saw herself to be suited to teach Natural Sciences, Mabel responded that she was suitably qualified to teach Natural Sciences, since she did Natural Sciences as part of her modules in her PGCE. However, she also indicated that at tertiary level in her PGCE, she focused on chemistry and not *Planet Earth and beyond.* When Mabel was asked if she found the professional development programmes that she had attended before to be fruitful and informative, she indicated that she thought they had been fruitful, but to have the content training not including moderations. This would give teachers more time apart from content training only, as they would be able to absorb the information better. It was difficult for teachers to grasp more information about content as content training was mixed with moderations. When asked the very same question during the intervention workshop, she responded as follows, "Yes, *they helped me to improve on the aspects of the topics that I wasn't really clear about on planet earth and beyond topic. The intervention workshop as well has been very informative and fruitful. A lot of information has been shared, and a lot of feedback on how to do some of the things … so it has been a very eh … fruitful experience and very informative"* (Source: Post-intervention interviews). This suggests that Mabel's knowledge of Science curricula was sharpened during the intervention workshop, hence she made the following remarks in her portfolio of evidence after attending the intervention workshop, "*The intervention workshop was interesting, informative and eye opening. I have gained a lot of confidence in content delivery since attending the workshop. The topics such as the rock cycle, the birth, life and death of stars were challenging but after the workshop I understood them better and with the help of video clips that were used during the workshop, I was also able to use them in class to help learners understand the topics and concepts better. The concepts are explained very well and are easy for learners to remember".*

According to Mabel's entries in her manual journal, she acquired more information during intervention workshop, which included**:** The rock cycle, the earth as a system, Birth, life and death of stars, How to draw a lesson plan following CAPS. Mabel noted down 33 concepts and defined them in her manual journal. This revelation from the manual suggests that

knowledge of Science curricula related to *Planet Earth and beyond* was acquired during the intervention workshop.

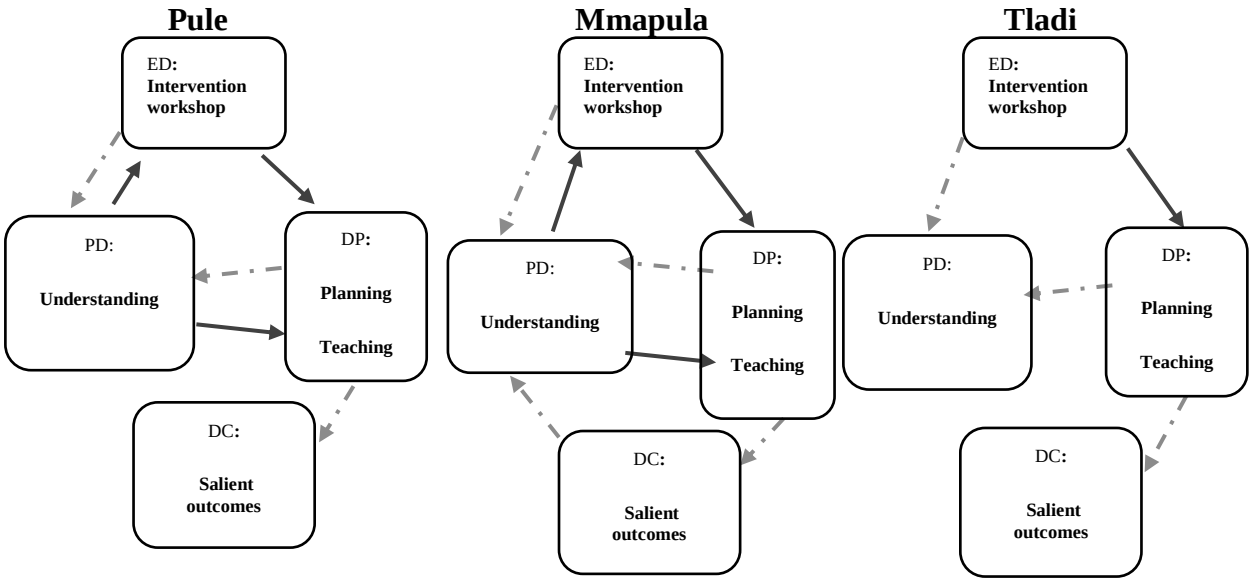
Mabel's workshop evaluation form indicated that, before the workshop, she was confident in teaching planet earth and beyond, that she had a full understanding of the following planet earth and beyond topics: The earth as a system and earth's spheres, the Greenhouse effect, and that she could teach them with confidence. However, she indicated that she was not confident in teaching the following *Planet Earth and beyond* topics: The rock cycle and the Birth, life and death of stars. Mabel was confident that she was well orientated to Science teaching, that the workshops she attended before did not assist with understanding of *Planet Earth and beyond* topics' content and concepts, as well as relevant teaching approaches However, during the intervention workshop, Mabel felt that she was able to improvise and do experiments as well as create models to enhance understanding of *Planet Earth and beyond* topics, and that she had acquired knowledge and understanding of *Planet Earth and beyond* content and concepts. Mabel also declared that after attending the intervention workshop, she felt confident that her subject knowledge and skills had improved, that she had a full understanding of the following *Planet Earth and beyond* topics and could teach them with confidence: The earth as a system and spheres of the earth, Lithosphere, The rock cycle, Mineral resources (Extracting ores, Refining minerals, Mining in South Africa), The atmosphere, the Greenhouse effect, and the Birth, life and death of stars.

Mabel felt more confident to teach *Planet Earth and beyond* topics as compared to before attending the intervention workshop. She felt that the intervention workshop helped her with the acquisition of both pedagogy, content and concepts to deal with the teaching of *Planet Earth and beyond*. Mabel made the following remarks under general comments on her workshop evaluation form, ***"****The intervention workshop was informative and interesting. I learnt a lot and feel more confident in teaching planet earth and beyond especially the rock cycle, and the birth, life and death of stars."* (Source: Mabel's workshop evaluation form). Clearly, from all these findings, it can be declared that the intervention workshop assisted Mabel to acquire knowledge of science curricula related *to Planet Earth and beyond.*

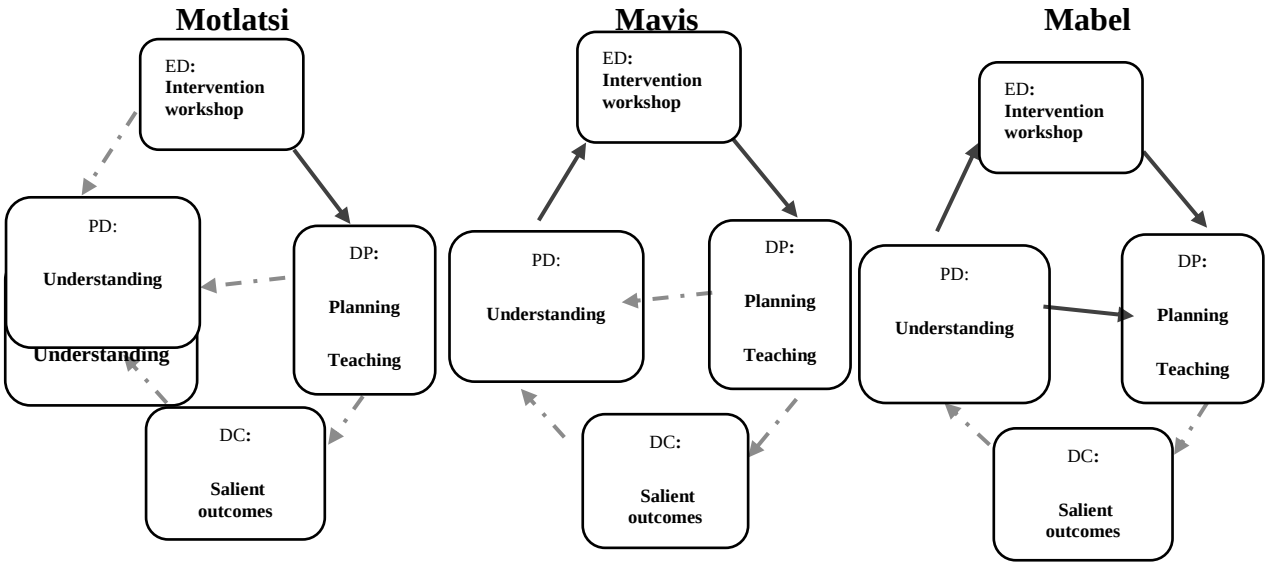
### 4.3.3 Research question 3: In what ways do specific characteristics of Professional Development contribute to development in teachers' PK and PCK?

#### 4.3.3.1 Knowledge of student understanding of Science

Knowledge of student understanding of Science in this study refers to knowledge of *Planet Earth and beyond* content and concepts, and the ability of a teacher to identify areas of *Planet Earth and beyond* that learners found difficult to understand. The ability to identify possible misconceptions and to identify and employ relevant strategies to address areas of difficulty were also dealt with. Dealing with misconceptions to enhance understanding of *Planet Earth and beyond* topics was stressed. Data on teachers' knowledge of learner understanding of Science is shown in figure 4.6 below:




**Pictogram 25** **Pictogram 26** **Pictogram 27**



**Pictogram 28** **Pictogram 29** **Pictogram 30**

**Figure 4.6**: Pictorial representations of teachers' knowledge of learners' understanding of science

**Pule**

A growth network was observed in figure 4.6, pictogram 25 for Pule, with enactment of PD on ED and DC, and ED enactment on DC, causing a reflection of ED on PD, DP on PD and DC. Pule displayed knowledge of learners' understanding of content and mastery of certain Science process skills. Pule grouped participants during the lesson demonstration and gave them instructions to study and compare types of rocks using a worksheet. Participants (acting as learners) identified different characteristics of rocks following instructions on the worksheet. The activity allowed learners to develop knowledge and understanding of different types of rocks before PULE introduced the rock cycle. Through that activity, participants (learners) gained knowledge of types of rocks that underpin the understanding of the process of the rock cycle. The following Science process skills were developed: Comparing, sorting and classifying. Pule noted the following misconceptions: Learners failing to notice the difference between steam and water vapour, to differentiate between a planet and a star, to differentiate between extrusive and intrusive landforms, and to differentiate between revolution and rotation, which were all clarified during the intervention workshop (Reflection of ED on PD, and DC on PD).

Before intervention, Pule identified the following as difficult concept for learners: Mining in South Africa; he added the Birth, life and death of stars during the intervention workshop (Source: Pule's pre-intervention interviews; Pule's post-intervention interviews). During the intervention workshop, 56 difficult concepts were noted and explained to ensure that learners understood (Pule's Manual Journal). Pule indicated that he managed to clarify all the misconceptions and assisted learners to understand topics and concepts that had been difficult for them to understand. Through the use of hands-on practical investigations, video-clips and posters knowledge of students' understanding of science was developed (Reflection of DP on PD and DC). Pule also used the National Education and Collaboration Trust's (NECT)

scripted lesson plans as well as resource packs, which made *Planet Earth and beyond* topics easy to understand.

During pre-intervention interviews, Pule was asked if he experienced challenges when teaching Planet Earth and beyond, to which he replied, "*Topics are ok, mostly the resources are not here because learners need to see what you are talking about. So if you do not have a globe or a resource that can help learners to understand learners to what you are talking about, it is a challenge on its own. When we talk about planet earth and beyond, obviously there has to be planets in the form of figures or diagrams, or maybe in a form of paper, eh… so that learners can see what you are talking about, when you are talking about maybe planets in our ecosystem".* This suggests that Pule understood that for learners to understand *Planet Earth and beyond* concepts, resources like a globe and models need to be used to enhance understanding. During post-intervention interviews, Pule suggested that in order to overcome the challenges he mentioned, he would work with learners to build models, referring to textbooks and other sources to ensure that learners understood the concepts better.

Pule was further asked to identify the most difficult part of *Planet Earth and beyond*, even for the learners, and he responded as follows, "*There are so much challenges, challenging topics, eh … mostly I would say maybe minerals, minerals in South Africa, resources, mineral resources eh … is one of the topics that are challenging, eh … and they need eh … extra preparations on my side in order for me to teach learners correctly"* (Source: Pre-intervention interviews). When asked the very same question after attending the intervention workshop, Pule responded in the following manner, "…*at first, Life and death of stars was a problem, but after this workshop, ehh … the research …, I have overcome that. So, so far I am okay with every part of eh … planet earth and beyond".* This suggests that the intervention workshop assisted Pule to develop knowledge understanding of *Planet Earth and beyond* concepts.

During post-intervention interviews, when Pule was asked to share his view that many Natural Sciences teachers have, that it is a challenge to teach *Planet Earth and beyond.* This is what Pule had to say, "*Eh … this topic is not challenging as such, eh … preparations to be*

*done when going to the class. So if you don't prepare, if you don't study, if you don't research, eh … you are going to find it difficult to teach, and obviously learners will see that, and you will also notice, and you will start to believe the … the … topics are difficult*." (Source: Post-intervention interviews). This suggests that Pule started becoming aware that teaching *Planet Earth and beyond* requires relevant PCK, and that teachers themselves need to have knowledge of Science curricula for them to be able to teach science effectively.

**Mmapula**

A growth network was observed in figure 4.6, pictogram 26 for Mmapula, with enactment of PD on ED and DP and ED enactment on DP, causing a reflection of ED on PD, DP on PD and DC and a reflection of DC on PD. Mmapula displayed knowledge of learners' understanding of *Planet Earth and beyond* content and concepts as well as the mastery of certain Science process skills. Mmapula grouped participants during the lesson demonstration and distributed a worksheet with instructions to be carried out as practical investigation to demonstrate the greenhouse effect. Participants (acting as learners) demonstrated understanding of the following concepts: The Greenhouse effect and Global warming after the successful execution of a practical investigation, which enhanced understanding of the two concepts. It gave room for the following targeted Science process skills: Accessing and recalling information, raising questions, predicting, hypothesizing and investigating. Difficult concepts, including *inter alia* the following, were noted and explained: the greenhouse effect, ozone layer, afforestation, deforestation, and ozone depletion, and 45 more terms covering all *Planet Earth and beyond* topics. (Source: Mmapula's lesson observation report).

All these difficult concepts were noted and explained to ensure that they did not result in a misconception of any form (Mmapula's manual journal). Mmapula noted the following misconceptions: Learners failing to notice the difference between steam and water vapour, to differentiate between a planet and a star and the use of arrows in flow diagrams, which were all clarified during the intervention workshop (reflection of ED on PD, and DC on PD). Before intervention, Mmapula identified the following as a difficult concept for learners: the Birth, life and death of stars (Source: Mmapula's pre-intervention interviews) and this topic was dealt with during the intervention workshop, during which Mmapula managed to make it easier for learners to understand the topic (Source: Mmapula's manual journal). Mmapula

indicated that he managed to clarify all the misconceptions and assisted learners to understand topics and concepts that had been difficult to understand through the use of practical investigations, video-clips, posters and PowerPoint presentations (Reflection of DP on PD and DC). Mmapula used a teacher-centred approach, using models and other representations to ensure that learners understood and gained knowledge of *Planet Earth and beyond* content and concepts.

During pre-intervention interviews, when Mmapula was asked if he experienced challenges when teaching *Planet Earth and beyond* topics, he indicated that the challenge was teaching the topic, *Birth, life and death of star.* However, when he was asked the same question after attending the intervention workshop, this is what Mmapula had to say*, "I have met challenges because of some lack of resources, and materials to demonstrate and also lack of knowledge especially the areas of birth and death of stars. The challenges of knowledge, I think I have managed 100% now the content is now there, and also I have gained some knowledge of how to design some models, and to be creative and develop some models which I was not aware of, which can actually also help the learners, like the model of the globe, and the model to represent layers of the earth. It has been so easy. So I think now I have managed to cover the gaps. I mean the resources, we've been taught to be creative, like we did not know that we may use some simple resources to make models like using a glass, put some beans in a glass followed by some stones to represent layers of the atmosphere, and that can actually enhance the learners understanding of layers of the atmosphere. Some of the resources, they are surrounding us. It's only that we were not taught or we did not get the knowledge of how to use them before attending the intervention workshop".*

This suggests that during the intervention workshop Mmapula managed to learn how learners learn and understand Science. This was supported by what he said when asked to indicate what he found to be the most difficult part of *Planet Earth and beyond*, after attending the intervention workshop. Mmapula said*, "Before this intervention, it was life, birth and death of stars, and also the layers of earth. I think that was the only part which I had some challenges. Now after the intervention I think I managed to grasp a lot… So some of the things now have been corrected. And also the life and death of star, it has been so, demonstrated very well like ehh, the … the growing of a human being from birth until old, until death. So I, I am now equipped in the manner that I managed to get a lot of information around this area."*

Mmapula was asked the following question after attending the intervention workshop: Many NS teachers say that teaching *Planet Earth and beyond* topics is challenging. What are your views about this, more especially after coming from this kind of intervention? Mmapula responded as follows, *"Ja, it has been a challenge since it involves a lot, and ehh … from the way how I have learnt from this intervention I see that teaching planet earth and beyond, it needs mostly ehh … models. Models they enhance the … the … understanding of learners. So I think that it should be included, so that it becomes diverse. The method of teaching this topic it must be diverse, not only focusing on one method so I think these teachers, they are mostly centering their teaching on lecture method, where the teacher is giving learners the information. …"* (Source: Post-intervention interviews). This shows that Mmapula now not only uses knowledge of learner understanding of Science in Grade 9 only, but also in FET classes.

**Tladi:**

Figure 4.6, pictogram 27 showed changes in Tladi's knowledge of learners' understanding of Science. The entry point in pictogram 27 was the ED. It seemed Tladi lacked understanding of learners' understanding of Science, as Tladi had never taught *Planet Earth and beyond* for the past 3 years while teaching Natural Sciences. He relied on the Geography teacher who taught *Planet Earth and beyond* instead (Source: Tladi pre-intervention interviews). A change sequence was observed with enactment of ED on DP, triggering a reflection of ED on PD, stimulating a reflection of DP on DC and PD. All strategies that might be employed to help learners understand *Planet Earth and beyond* content and concepts were learnt at the intervention workshop (Enactment of ED on DC).

This resulted in Tladi developing confidence to plan and present the first lesson on *Planet Earth and beyond* for the first time during the intervention workshop. It seemed Tladi went out of the intervention workshop understanding and knowing how learners understood and learnt science, specifically *Planet Earth and beyond*. Tladi managed to identify the Birth, life and death of stars as a challenging topic, and managed to come up with ways on how to mediate this (Source: Tladi's Questionnaire; Tladi's Manual Journal). Reflection of DP on

DC and PD was observed as Tladi's ability to note down 38 *Planet Earth and beyond* concepts, and explain them. Tladi listed the following as common misconceptions among learners: Failure to differentiate between steam and vapour; and failure to differentiate between the outer core of the earth and the mantle. Learners may not see any differences between these two layers of the earth (Source: Tladi's Manual Journal). Tladi indicated that she was not confident to teach the following *Planet Earth and beyond* topics: The rock cycle, Extracting mineral resources, and the Birth, life and death of stars. After the intervention workshop, Tladi indicated that she felt that her subject knowledge and skills had improved.

During pre-intervention interviews, when asked if she experienced challenges when teaching *Planet Earth and beyond* topics, Mmapula indicated that knowledge of the content itself was a problem since she did not do *Planet Earth and beyond* at high school, or at tertiary level. She mentioned the following to be the most difficult part of *Planet Earth and beyond*: *The rock cycle,* and *Mining in South Africa*. Tladi declared that teaching *Planet Earth and beyond* to other teachers was challenging, because most of the Natural Sciences teachers had majored in Life Sciences and Physics, so they were able to teach from Term 1 to Term 3. However, they did not do Term 4 Geography - *Planet Earth and beyond* as major subjects at university, so it was challenging to most teachers. Tladi further indicated that she frequently asked her colleague, who teaches Geography, to teach *Planet Earth and beyond* concepts on her behalf. However, when asked the same question after attending the intervention workshop, Tladi stated, "*The challenges that I have encountered is that I have never done Geography in High school or at the University, so it was my first time seeing the topic, so it has been very challenging for me to teach it, because I did not have the knowledge of the content, but ever since I've attended this research, I've gained a lot, and I think now I am confident to go and deliver to learners".* This suggests that Tladi acquired knowledge of student understanding of Science during the intervention workshop.

**Motlatsi**

The entry point in figure 4.6, pictogram 28 was the External Domain. A change sequence was observed with enactment of ED on DP, causing a reflection of ED on PD, and a reflection of DP on PD and DC, further causing a reflection of DC on PD. Breaking it down, it seemed as if Motlatsi had a limited knowledge of learners' understanding of science before participating

in the intervention workshop. She taught *Planet Earth and beyond* for the first time at the intervention workshop. Understanding of students' knowledge of Science started developing from discussions that took place during the intervention workshop, leading to a better understanding of how learners learn *Planet Earth and beyond*. Strategies and instructional material were employed to enhance understanding of *Planet Earth and beyond* topics, as well as identifying possible misconceptions that might impede understanding thereof (enactment of ED on DP).

Motlatsi grouped participants (acting as learners) during a demonstration lesson, having understood that group work is one of the methods that promotes a learner-centred approach (reflection of ED on PD), which allowed active participation by learners. Motlatsi was advised to develop worksheets for hands-on practical tasks, and also made use of a model to help learners understand concepts. Motlatsi managed to use relevant mechanisms to eradicate lack of understanding of concepts. It was indicated that learners found it difficult to understand the interaction between different spheres of the earth. Motlatsi therefore used many examples and pictures to explain this (Source: Motlatsi's portfolio of evidence: Lesson plan number 02). This was observed as reflection of DC on PD, and PD on DC. Motlatsi moved away from using the lecture method after the intervention workshop and opted for the question and answer method, which allowed for active participation by learners. (Source: Motlatsi's Portfolio of evidence: Lesson plan number 02). During the lesson demonstration the following were identified as difficult concepts that might confuse the learners: the asthenosphere, crust, mantle, and the core. All these concepts were explained. An additional 30 concepts were identified and explained as they were likely to cause misconceptions if not properly explained. MOTLATSI identified the following as learners' misconception: differentiating between the lithosphere and the asthenosphere.

During pre-intervention interviews, Motlatsi was asked if she experienced challenges when teaching *Planet Earth and beyond* topics, and she indicated the following as challenges: *Mining, Extracting and refining minerals,* and *the Birth, life and death of stars.* Motlatsi also mentioned the latter as the most difficult part of *Planet earth and beyond.* During post-intervention interviews Motlatsi was asked the same question, and responded as follows, *"Well, the challenges that I have encountered was the topic based on the lifecycle of the star, how it was, during the birth, how it was created, and then the life, and the steps that it takes*

*until the death, where we no longer have that star. I don't have a challenge anymore because during this intervention workshop, I actually learnt all those steps and how to actually deliver the content to learners…."* This suggests that during the intervention workshop, Motlatsi developed knowledge of learner understanding of Science. Motlatsi acquired skills that will help her to articulate *Planet Earth and beyond* concepts easily in future.

Motlatsi was asked the following question during post-intervention interviews, "Many NS teachers say that teaching *Planet Earth and beyond* topics is challenging. What are your views about this?*"* Motlatsi replied, *"Eh … teaching eh … planet earth and beyond is not difficult because I realised after this intervention that, it is actually the problem was the way we deliver content based on this topic. So now I have learnt ways of delivering content to learners, and also I know methods that I can actually follow so that learners can benefit. The method, that I will follow, I will do a demonstration, for example if I am doing extraction of gold we can do a practical based on maybe panning, and I will the procedures that we have to follow to extract gold from eh … from the sand, and eh … eh … I will use the materials, the ones that we have maybe at home like pans, and we will represent the stones as gold and then use sand, sand and water to separate, so it will be much easier, but before they do it, I will show them a video so that they … it will be easier for them to follow the procedures".*

This suggest that Motlatsi learned that for learners to understand *Planet Earth and beyond* concepts, the most relevant teaching method has to be applied, the teacher needs to do demonstrations, and learners need to be engaged in hands-on practical tasks, to ensure understanding. This indicates that Motlatsi acquired knowledge of learner understanding of Science during the intervention workshop. This is supported by what she said when making general comments in her portfolio of evidence, "*When I taught this topic Planet Earth and beyond I made some demonstration on certain topic such as the Rock cycle and afterwards I told my learners go outside in groups to collect different types of rocks. For topic such as the birth, life and death of stars I used video clips so that learners can understand more. I used a Venn diagram to explain how different layers interact with each other and to explain why there is life in our planet Earth. I also made models to explain to learners different layers of the Earth and different layers of the atmosphere. When teaching mining and extraction of mines I used video clips as well. When teaching the topic Planet Earth and Beyond I didn't use the textbook only, I also used Exam fever study guide. I also gave them short test after*

*completing each topic from previous question Paper and Exam Fever workbook. I am still teaching Natural Sciences Grade 9 due to motivation received during my participation in the intervention".*

**Mavis**

Figure 4.6, pictogram 29 showed a change sequence, with enactment of ED on DP, causing a reflection of DP on PD and DC and a reflection of DC on PD. The entry point in pictogram 29 was the ED. It seemed MAVIS showed little knowledge of learners' understanding of Science before participating in the intervention workshop (Source: Mavis's pre-intervention interview). Through the intervention workshop, Mavis started to clearly understand challenging topics for learners on *Planet Earth and beyond*, and misconceptions affecting learners. Mavis indicated that Mining was a challenging topic (Source: Mavis Questionnaire), but managed to mediate this challenge by using a hands-on practical investigation during the demonstration lesson. The practical investigation done was about the physical separation of gold from sand, using rocks to represent gold, to explain and enhance learners' understanding (participants acting as learners).

Understanding how minerals were extracted from ore using physical separation or methods (reflection of DP on DC) led to Mavis developing more confidence in teaching *Planet Earth and beyond* topics. Since all the misconceptions in the class had been cleared, Mavis felt confident to continue teaching Natural Sciences in the year 2020 (Source: Mavis's Portfolio of evidence), which was observed as reflection of DC on PD. Mavis noted the following as misconceptions observed among learners: Learners' inability to differentiate between steam and vapour, and an inability to define the biosphere as opposed to the mesosphere. However, she indicated that all these misconceptions were cleared during the intervention workshop (Source: Mavis post-intervention interview). Mavis noted down and explained a total of 38 terms that could create misconceptions if not properly explained.

When asked during post-intervention interviews if she experienced challenges when teaching *Planet Earth and beyond* topics, Mavis indicated that the challenge that she did meet was

identifying the hottest part of the earth. She indicated that she has been confusing the outer core of the earth with the mantle. When asked the same question after attending the intervention workshop, Mavis said*, "There were some definitions that were giving me a challenge, a few. I was also confusing magma and the inner core, thinking that magma is the hottest layer, and it is in liquid form, only to find those, were the … it was not as I was thinking when I was explaining planet earth and beyond. So, now I know I can teach relevant information"*. Motlatsi further said, "*Challenging topics before attending the intervention workshop I think were the birth of the star, and the … eh … rock cycle. It was a challenging and difficult topic to teach. Maybe it will be difficult to those people who were not exposed to this type of workshop intervention."*

During post-intervention interviews, when Mavis was asked the following question, "Many NS teachers say that teaching *Planet Earth and beyond* topics is challenging. What are your views about this?" Mavis responded, "*They are correct. Teaching this topic, planet earth and Beyond, there is a lot of misconceptions, and you cannot easily identify them, because we've been, like, including myself, we've been just explaining things as they appear in the textbooks only to find that there is different information that you skip unaware. I am no longer having the same view because during the workshop, we have tried to identify the misconceptions, and they were addressed, so I am fine for now."*

**Mabel:**

The entry point in figure 4.6, pictogram 30 is the PD. A growth network was observed with enactment of PD on ED and DP and enactment of ED on DP, causing a reflection of DP on DC and further stimulating a reflection of DC on PD. Breaking it down, MABEL seemed to have knowledge of understanding of Science before participating in the intervention workshop. Challenging topics were the Rock cycle, the Life, birth and death of stars and the earth's spheres. It was also indicated that the use of pictures and the internet assisted dealing with those challenges (Source: Mabel pre-intervention interviews; Mabel's portfolio of evidence and Mabel's Manual Journal). This was observed as enactment of PD on ED. After attending the intervention workshop, Mabel listed the Birth, life and death of stars, The rock

cycle, Global warming and the Greenhouse effect as challenging topics (Source: post-intervention interviews; Mabel's Manual Journal).

Mabel noted down 33 *Planet Earth and beyond* concepts during the intervention workshop and defined them to ensure that they did not create any misconception with the learners. This was observed as enactment of ED on DP. It was indicated that the use of models and posters due to the knowledge gained from the intervention workshop addressed identified challenges to ensure and enhance knowledge and understanding of identified challenges (Source: Mabel's Portfolio of evidence-lesson plans). This was observed as reflection of DP on DC. Mabel indicated that she was now equipped to confront any difficult concept that might confuse learners and impede understood and to deal with all misconceptions, as a result of being equipped during the intervention workshop (Mabel's post-intervention interviews). This was reflected as a change in confidence level, attitude, beliefs and goals, which was observed as reflection of DC on PD.

When Mabel was asked during post-intervention interviews if she experienced challenges when teaching *Planet Earth and beyond*, she replied, "*I think the rock cycle, and the birth, life and death of stars and all those ones. my school is a very small school, under resourced, so some off the things that make it difficult to even explain some topics, is lack of resources whereby you can be able to show learners how ehh, like to explain further and show them physically like NS they will say, what do they call this? Knowing science and doing science, and all those things".* However, when asked the same question during post-intervention interviews, she responded by saying, *"The challenges of explaining in detail, the … specifically the rock cycle, ehh … and the birth, the life and death of star, which have been challenging topics on this strand. Currently I think I would do better than before because of this workshop. I think I know better now what to do*."

Mabel indicated that before the intervention workshop one of the challenges that affected learners' understanding of *Planet Earth and beyond* was the shortage of resources to enhance understanding. However, she had to improvise to acquire more knowledge on the internet, and had to draw charts and develop posters. After attending the intervention workshop, Mabel said the following, *"I have learnt how to present the lessons, and also I have gained*

*more knowledge on some of the concepts that I wasn't really clear about, so I think I am now more equipped to deliver the content or to present the lesson with confidence*". According to how Mabel responded to questions during pre- and post-intervention interviews, it shows that Mabel gained knowledge of learner understanding of science - *Planet Earth and beyond* - during the intervention workshop.

During pre-intervention interviews, Mabel was asked, **"**Many NS teachers say that teaching *Planet Earth and beyond* topics is challenging. What are your views about that?*"* Mabel responded as follows, *"Of course it's challenging, especially if you … for educators who do not really understand the geography part of … the subject, or are not familiar with geography as a subject, it might be very challenging for them, and not be easy to explain some of the content to the learners, in a way that they can understand it"* (Source: Pre-intervention interviews). After attending the intervention workshop, when asked the same question, Mabel responded in the following manner, *"I think that's true, because not every teacher has got the experience or the … or the prior knowledge in terms of Geography and also ja, that part of teaching, it can be a challenge if you do not have the prior knowledge of things like global warming and greenhouse effect. I think for every teacher who is teaching Natural Sciences until they go through this, like eh … the workshop itself, then I think they can be able to deliver the topic even better, so I think training or a workshop is very important for every teacher."*

This suggests that Mabel was assisted by the intervention workshop to gain knowledge of learner understanding of Science. This is supported by her remarks in her portfolio of evidence when she said, "*The topics such as the rock cycle, the birth, life and death of stars were challenging but after the workshop I understood them better and with the help of video clips that were used during the workshop, I was also able to use them in class to help learners understand the topics and concepts better. The templates for lesson preparations are also of great help. It is easy to prepare and present a lesson. The manuals that were prepared for the workshop are user friendly and easy to use. The concepts are explained very well and are easy for learners to remember"* (Source: MABEL Portfolio of evidence).

## 4.4 DISCUSSION OF FINDINGS

### 4.4.1 Orientations towards Science teaching

The study conducted by Boesdorfer (2015) indicate that Magnusson *et al.*'s (1999) model of PCK for Science teachers included teachers' orientation toward Science teaching, which influences their knowledge of the Science curriculum (specific curriculum and general Science goals and objectives), their Science understanding (learners' difficulties and background knowledge), assessment in Science (what to assess and how), and instructional strategies in Science (general Science and topic-specific). Knowledge and beliefs about the purposes of teaching Science was how Magnusson *et al.* (1999:97) define a teacher's orientation toward Science teaching.

According to Mavuru and Ramnarian (2017), teaching is a complex process that requires teachers to transform and apply knowledge from multiple domains. Science teaching orientations have been found to be a critical component within the PCK of Science teachers. Koballa *et al.* present five conceptions about Science teaching held by Science teachers, as follows: (1) presenting Science content to learners; (2) providing learners with a sequence of Science learning experiences; (3) engaging learners in hands-on Science activities; (4) facilitating the development of learners' understanding about Science; and (5) changing learners' Science-related conceptions.

In this study, as indicated earlier, orientations towards Science teaching refers to the understanding of conceptual foundations of teaching *Planet Earth and beyond* topics, teachers' ability to transform and applied knowledge from multiple domains, teachers' beliefs and goals when teaching *Planet Earth and beyond*, as well as teaching methods relevant to be employed when teaching *Planet Earth and beyond* topics.

During interviews, participants were asked to recommend to the Department of Education what the Department should do in its future efforts to improve performance, content

knowledge and pedagogical content knowledge. All six participants (100% of the sampled population) recommended that the Department should organise workshops on *Planet Earth and beyond* topics and train teachers accordingly. Wongsopawiro *et al*. (2017) state that teachers might improve their teaching practice, resulting in better learner outcomes when changing their beliefs and attitudes, as reflected by what Mmapula had to say after attending the intervention workshop, "*My learners' marks are the result of the knowledge and skills gained from the workshop*."

Results of the study revealed that in all six cases, teachers had positive beliefs that influenced classroom practices. Before the intervention, teachers mainly used the lecture method, but after the intervention all six participants opted for the learner-centred approach. All six participants showed improved confidence levels, goals, beliefs and positive attitudes, to such an extent that after intervention, Pule managed to assist other teachers who did not participate in the intervention workshop, hence he said, *"I have also inducted another new educator at my school on how to teach the topic and also how to develop daily lesson plans for Natural Sciences."*

This study supports the study conducted by Boesdorfer (2015), which indicates that representations are effective tools that teachers choose to use in their classes to help their learners understand abstract concepts. In this study, teachers were introduced to the usage of representations to enhance understanding. According to Treagust (2008), representations, including models, graphs, analogies, diagrams, simulations, equations, or any method for representing knowledge, have been shown to enhance learners' understanding of concepts in Science. Representations used during the intervention workshop helped participants to understand definitions of concepts and gain the knowledge to apply them, confirming the Boesdorfer (2015) study. This was confirmed by Motlatsi who stated, "… *the method that worked was actually teaching by using videos because it was easier to explain after looking at the videos, so once the learners look at videos they can capture and even if when you ask a question, it was easy for them to actually imagine what was happening in the videos when they answer they can relate by remembering what they saw because most of learners, they are more visual, than theory… they don't prefer theory that much."*

### 4.4.2 Knowledge of instructional strategies

According to Almekhlafi *et al*., (2020), researchers such as Marzano (2003) and Wiggins and McTighe (2008) define instructional strategies as the classroom techniques and methods teachers use to introduce their learners to learning contents and help them acquire the required knowledge and skills. Knowledge of instructional strategies in this study refer to preparing and planning for a lesson, conducting lessons using appropriate teaching strategies relevant for *Planet Earth and beyond*, and the development and use of appropriate instructional materials.

Results of this study revealed that all six participants managed to use the lesson plan template discussed at the intervention workshop effectively. Participants managed to indicate targeted specific aims, Science process skills, teacher and learner activities and integrated assessment in planning. All features of a good lesson plan were adhered to, as prescribed by CAPS. All participants were requested to use the lesson plan template provided to plan and present a demonstration lesson during the intervention workshop. However, during demonstrations some challenges related to planning were identified, including (1) Lack of evidence of activities that supported the inclusion of targeted specific aims and process skills (for example, Tladi's demonstration lesson indicated that all three specific aims were chosen for the lesson, but based on how the lesson was presented, there were no activities supporting the inclusion of specific aim 1. Only specific aims 2 and 3 were supported by activities); (2) the inability of participants to submit instructions for assessment activities conducted during lessons and the inability of participants to draw worksheets with activities to support both teacher and learner activities done during demonstration lessons.

It was interesting to find that all these challenges were rectified by participants themselves. Participants submitted lesson plans with supporting documents (assessment instructions, worksheets) in their portfolios of evidence, which suggested that the intervention workshop had assisted to sharpen their instructional strategies.

The other important revelation was that during the intervention workshop, participants followed a teacher-centred approach, but after the intervention workshop they changed their teaching approach and opted for a learner-centred approach. When participants were asked which teaching approach worked best for them for the teaching of *Planet Earth and beyond* topics, Mmapula said, "*Mostly before this intervention, it was just ehh … eh … ehh … a lecturer method. But now after this ehh … intervention we can now see that we can use the laptops, we can use the projector, we can design some models, we can also … we have also been taught to be learner-centered, where you ask learners the questions during the presentation of the lesson, where you allow the learners to ask the questions, and also to be involved in the designing of the models. So it makes the lesson interesting and learners can gain a lot."*

It was found in this study that the teachers did not have all the necessary resources needed to teach *Planet Earth and beyond* topics. They conducted hands-on practical investigations, as *Planet Earth and beyond* required more investigations. The use of models to enhance understanding due to its complex nature needed to be adhered to. However, teachers were able to improvise, using even recyclable material to develop a globe that represented the Earth. They used plates as pans to do a practical investigation to separate gold from sand and MMAPULA used a plastic bag to demonstrate global warming and the greenhouse effect in a practical investigation conducted during his demonstration lesson.

This was evidence that teachers' knowledge of instructional strategies and approaches as well as tools to use in teaching were enhanced during the intervention workshop. This is consistent with Hootman (2020) and Hirsch (2000) who believe that instructional strategies play a significant role in the academic success or learning achievements of students of all ages. The performance of learners whose teachers participated in this study showed a remarkable improvement in 2019 as compared to 2018, after participants had participated in the intervention workshop that enhanced their knowledge of instructional strategies. It was noted that, even though it was evident that all six participants had knowledge of instructional strategies, no participant clearly indicated this in lesson plans submitted, or during demonstration lessons conducted. Catering to learners with special needs was highly recommended, which means that learners with special needs might not be excluded from

participating in class. The lesson plan template discussed and shared with participants provided the inclusion of activities for learners with special needs, but all the participants did not indicate how learners with special needs would be catered for.

### 4.4.3 Knowledge of learner assessment

According to Emmanouilidou *et al.* (2012), to educate learners effectively they need to be provided with the opportunity to reach their potential and contribute to society. This can only happen if teachers and others who work with learners obtain data and information on how each learner is progressing, what the students know and could do and what might be done to further develop and encourage their educational development. In other words, teachers must assess students. According to Emmanouilidou *et al.* (2012), student assessment is considered an integral part of the learning process which could be used for learning evaluation, learner motivation and grading, and programme adaptation.

Knowledge of learner assessment refers to teachers' knowledge to use different methods to assess learning when teaching *Planet Earth and beyond* topics. It includes the ability to develop instructional strategies relevant for the assessment of *Planet Earth and beyond*, formal standardised tests and examinations, class work, homework, observation sheets, checklists, hands-on practical tasks, including the development of models.

Results of this study indicated that participants were able to follow the programme of assessment in Term 4, specifically for the assessment of *Planet Earth and beyond* topics. All six participants managed to administer a practical investigation, a research project, including teachers (Tladi and Motlatsi) who had never assessed learners in *Planet Earth and beyond* before. This was made possible by the participation of all six participants in the intervention workshop. This study supports Lephogole (2016) study, which indicates that if teachers are knowledgeable in the usage and interpretation of the assessment guidelines, that might positively affect teaching and assessment, hence a notable improvement in learners' 2019 performances was observed.

The results of CK acquired were improved, teaching approaches used and effective assessment conducted after teachers attended the intervention workshop. Even though all six participants managed to assess *Planet Earth and beyond* effectively, the results of the study also revealed that informal assessment administered did not cater for cognitive levels as prescribed in CAPS, Chapter 4. Most of the informal activities administered covered low-order questions for Pule, Motlatsi and Mabel. All other participants tried to ensure that informal tasks administered covered all cognitive levels (Source: Portfolio of evidence). According to CAPS, whenever assessment is conducted cognitive levels should be balanced, as shown in Table 4.3.

**Table 4.3**: Cognitive levels

| **Setting tests and tasks for different cognitive levels** | **Knowing science** | **Understanding science** | **Applying scientific knowledge** | **Evaluating, analyzing, synthesising scientific knowledge** |
|---|---|---|---|---|
| **Percentages indicating the proportion of low, middle and high order questions in tasks, tests and exams** | **Low order questions 40%** | **Middle order questions 45%** | | **High order questions 15%** |
| **Useful verbs to use when setting questions** | State<br>Name<br>Label<br>List<br>Define<br>Describe<br>and others ... | Explain<br>Compare<br>Rearrange<br>Illustrate<br>Give an example<br>Calculate<br>Make a generalisation<br>and others … | Predict<br>Apply<br>Use knowledge to demonstrate<br>Solve<br>Implement<br>Judge<br>and others … | Select<br>Differentiate<br>Analyse<br>Infer<br>Suggest a reason<br>Interpret<br>Discuss<br>Categorise<br>and others ... |

The study also revealed that no assessment rubrics or memoranda were submitted with instructions for informal tasks and some informal tasks were unstructured. This might help to improve the standard and quality of both formal and informal assessment administered in schools. According to CAPS, assessment should be both *informal* and *formal*. In both cases regular feedback should be provided to learners to enhance the learning experience. This calls

for informal assessment to be well-structured and of good quality, covering all cognitive levels as they are used to enhance the learning experience. This is supported by Lephogole (2016) study that suggests that intensive training of teachers on the use of the assessment tools needs to be done.

### 4.4.4 Knowledge of Science curricula

As indicated in chapter 2, Aydin and Boz (2013) defined CK as knowledge about the actual subject matter to be learned. According to Rollnick and Mavhunga (2014), reasons for poor performance can be attributed inter alia to poor school management, but more prevalently to poor teacher preparation and thus teachers' poor understanding of content concepts. Appleton (2006:42) supports this statement when he says, "Teachers who have little science content knowledge have limited options, especially if they lack confidence to choose activities that work from Science topics about which they know little, or to acquire new Science content knowledge for themselves".

Knowledge of Science curricula in this study refers to teachers' knowledge of goals and objectives for students in *Planet Earth and beyond* topics. It includes knowledge about the topic at hand, variety of instructional tasks, resources and programmes that are relevant to teaching *Planet Earth and beyond* and challenges experienced when teaching *Planet Earth and beyond* topics. During the intervention workshop, misconceptions were identified and dealt with, regarding which Tladi commented, "*At the start of the workshop I had so many misconceptions relating to the topic*". According to Hootman (2020), studies carried out in content courses tend to focus on content knowledge acquisition and misconceptions.

These Science misconceptions have also been found to be persistent and difficult to change, once embedded in a learner's conceptual schemes, are extremely hard to remove (Novak, 1988). Demircioglu, Ayas, and Demircioglu (2005) also contend that misconceptions are resistant to change, persistent, and difficult to extinguish even with instruction designed to address them. This study supports what was stated by Lawrenz (1986) and Trumper (1997), that some research studies recommend that content courses for pre-service teachers should not only be tailored to the type of content the pre-service teachers would be expected to teach, but to also attempt to clarify their content misconceptions.

Results of the study revealed that all six participants knew which *Planet Earth and beyond* topics should be taught in Grade 9, as prescribed by CAPS. However, five out of the six participants did not have a background of *Planet Earth and beyond* topics, these topics not having been done at university or even in Grade 12 (Teacher questionnaire, interviews and portfolio of evidence). Results of the study also revealed that only two participants, Mmapula and Mavis, had previously attended in-service training in which *Planet Earth and beyond* topics were discussed, even though Mavis was not pleased with how and what was done during those in-service training programmes. During interviews participants were asked if they felt that professional development programmes attended before attending the intervention workshop were fruitful and informative, to which Mavis responded, "*Professional Development Programmes I have attended, were not fruitful, due to the fact that they were mixed with monitoring and moderations, and there was just, no time for us to unpack most of the topics and subtopics."*

Before the intervention workshop, all six participants showed a content gap, for example participants indicated that they needed development in the following areas of *Planet Earth and beyond*: Pule, Mmapula and Tladi: The birth, life and death of stars; Motlatsi: Mining in South Africa and the Birth, Life and Death of Stars; Mavis: Mining in South Africa; Mabel: The Rock cycle, and The Birth, life and death of stars (Source: Interviews, Educator questionnaire & Portfolio of evidence). During pre-intervention interviews, participants were asked if they experienced any challenges when teaching *Planet Earth and beyond* topics, to which Tladi replied, "*Jaa, the knowledge of the content itself of the topic I don't know it very well Mr, because I have never done Geography in high school or university. It is my first time to see this topic."*

This study saw all six participants improving their CK through the intervention workshop, which resulted in learners also improving their CK about *Planet Earth and beyond* topics, as shown in figure 4.7. Hootman (2020) indicates that the goal of any teacher is to see the subject-matter knowledge of their students' increase. This was achieved through discussions of *Planet Earth and beyond* topics during the intervention workshop.

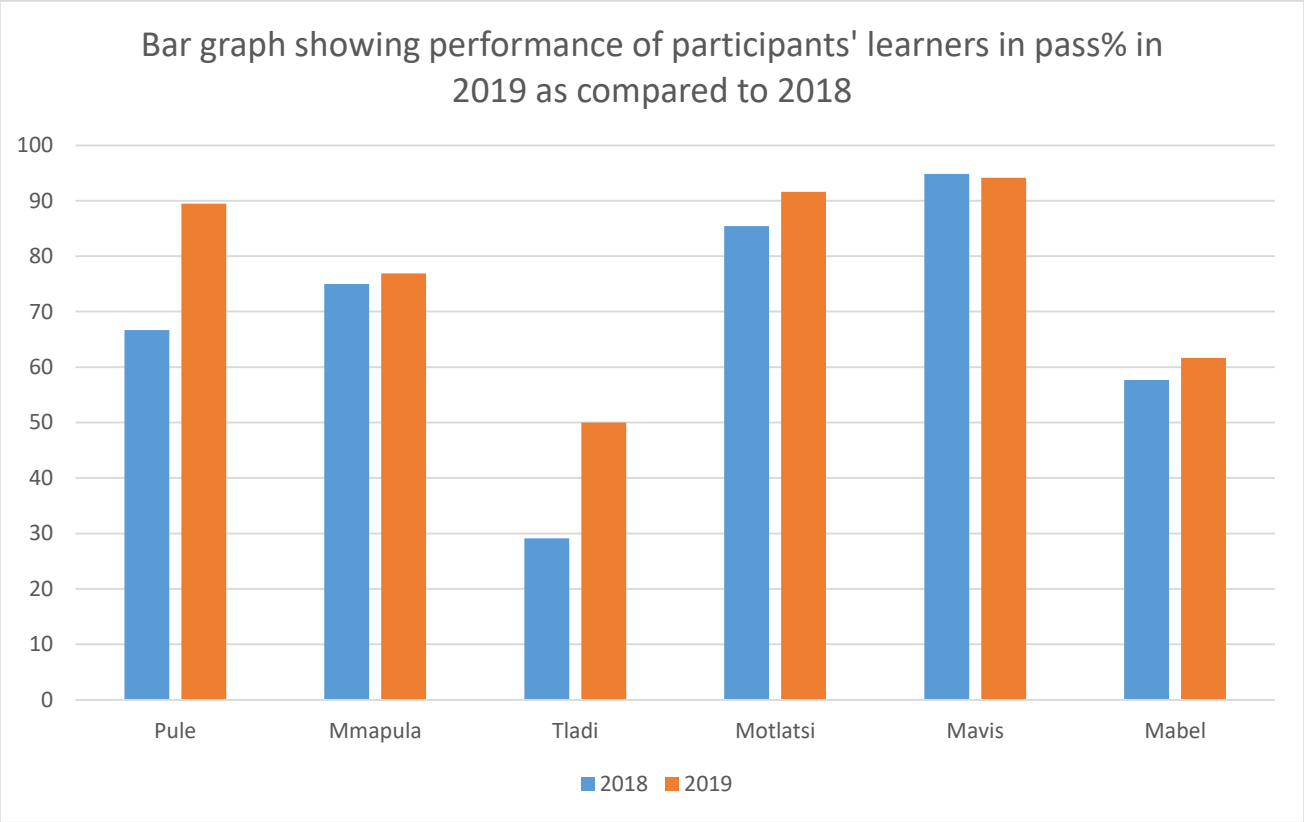



**Figure 4.7**: Improved performance of participants' learners in 2019 as compared to 2018.

Confirmation that CK gained by participants impacted positively on learners, was attested to by Mavis, *"My learners' marks are the result of the knowledge and skills gained from the workshop"* (Source: Mavis's portfolio of evidence). The intervention workshop assisted participants who had a content gap, held misconceptions and showed a lack of confidence to teach *Planet Earth and beyond* topics to clear those misconceptions and close gaps. It also assisted them to gain confidence to teach *Planet Earth and beyond topics* and generally to improve their classroom practices when teaching *Planet Earth and beyond* topics. This was confirmed by what Tladi said after attending the intervention workshop, "*The challenges that I have encountered is that I have never done Geography in high school or at university, so it was my first time seeing the topic, so it has been very challenging for me to teach it, because I did not have the knowledge of the content, but ever since I've attended this research, I've gained a lot, and I think now I am confident to go and deliver to learners."*

This attestation supports Schwarz et al., (2008) who indicate that if beginner teachers do not feel that their own Science CK is adequate enough to rely on when teaching young people,

then not being able to rely on curriculum materials leaves them without options on how to teach these concepts to their learners. This study revealed that participants had no background knowledge of *Planet Earth and beyond topics* and had to contend with the challenge of a shortage of resources. Participants learned how to improvise and discuss content that enabled them to close content gaps they had experienced before the intervention workshop.

### 4.4.5 Knowledge of learner understanding of Science

Knowledge of learner understanding of Science in this study refers to knowledge of *Planet Earth and beyond* content and concepts, and the ability of a teacher to identify areas of *Planet Earth and beyond*. It was found that learners find it difficult to understand and to identify possible misconceptions of *Planet Earth and beyond*. The ability to identify and employ relevant strategies to address areas of difficulty and to deal with misconceptions about understanding of *Planet Earth and beyond* topics were enhanced during the intervention workshop.

Results of this study revealed that teachers had knowledge of areas in *Planet Earth and beyond* topics that seemed to be difficult for learners to understand. This might have led to mushrooming of misconceptions. Concepts that were listed as areas of difficulty included the Rock cycle, the Birth, life and death of stars, the Greenhouse effect, Global warming and Mining in South Africa (Source: Teacher Questionnaire; Portfolio of evidence & interviews). Participants noted down all concepts and explained them in their manual journals to prevent misconceptions from happening. Teachers also managed to deal with misconceptions that were experienced in their classes as they were presenting their lessons after the intervention workshop. Mmapula used a hands-on practical investigation to help learners understand the difference between global warming and the greenhouse effect, as learners confused the greenhouse effect with global warming. After performing a practical investigation, Mmapula's learners started understanding that the greenhouse effect leads to global warming.

It was interesting to learn that participants used a variety of approaches to enhance learners' understanding of *Planet Earth and beyond* content and concepts. It was evident that participants started using representations like video-clips, PowerPoint presentations and posters to enhance understanding of *Planet Earth and beyond* content and concepts. Motlatsi indicated that, as it was reflected in the lesson, it was realised that learners could not differentiate between the inner and the outer core of the earth in the topic Layers of the earth.

In order to enhance understanding, Motlatsi used pictures showing the layers of the earth, which helped learners to be able to differentiate between the inner and the outer core of the earth (Source: Motlatsi's Portfolio of evidence). Motlatsi also said the following in the general comments in the portfolio of evidence, "*For topic such as the birth, life and death of stars I used video clips so that learners can understand more. I used a Venn diagram to explain how different layers interact with each other and to explain why there is life in our planet earth. I also made models to explain to learners different layers of the Earth."*

Results of the study also revealed that participants' knowledge of learners' understanding of Science was sharpened during the intervention workshop. It became evident that participants used some of the skills learnt during the intervention, namely the use of graphs, case studies, models and practical investigations to enhance learners' understanding of *Planet Earth and beyond* topics in their classes. However, results of the study also indicated that all six participants did not introduce learners into the scientific process. No activity included developing an investigative question, developing or evaluating a hypothesis, testing a hypothesis and accepting or rejecting a hypothesis. Scientific process as prescribed in Chapter 2 of CAPS should be used to ensure that learners understand complex Science phenomena. It became clear that teachers need to be developed in that area.

### 4.4.6 Changes in classroom practices when teaching *Planet Earth and beyond* topics

Fullan (2007) explains the term 'teacher change' as pedagogical change implemented by teachers, including alterations in instructional resources, teaching approaches and beliefs about pedagogy. As indicated already in chapter two, Kern *et al*. (2018) argue that teacher change is predominantly more self-initiated than change taking place as a result of the impact of the external stimulus in the form of workshops. Ketelhut *et al.* (2019) contend that they see professional development opportunities inciting change in teacher practices. This study confirms the Ketelhut *et al.* (2019) study. Professional development conducted in the form of the intervention workshop in this study incited change in teacher practices. The Interconnected Model of Teacher Professional Growth (IMTPG) developed by Clarke and Hollingsworth (2002) was used as the basic framework for the establishment of the relationships between the different data gathered in characterising teachers' classroom

practices when teaching *Planet Earth and beyond* topics. Changes established are summarised in table 4.4 below.

Codes - CS: Change Sequence; GN: Growth Network; PULE; Mmapula: Tladi; Motlatsi; Mavis; Mabel:

**Table 4.4**: Identification of the teachers' change for each of the aspects

| **Aspect** | **Pule** | **Mmapula** | **Tladi** | **Motlatsi** | **Mavis** | **Mabel** |
|---|---|---|---|---|---|---|
| Orientation towards science teaching | GN | GN | CS | CS | GN | CS |
| Knowledge of science curricular | CS | GN | CS | CS | GN | GN |
| Knowledge of instructional strategies | GN | GN | CS | CS | GN | GN |
| Knowledge of student understanding of science | GN | GN | CS | CS | CS | GN |
| Knowledge of student assessment | GN | GN | GN | CS | GN | GN |

As shown in Table 4.4 above, the intervention workshop incited teacher change in all five aspects. This suggested that classroom practices of Grade 9 teachers who participated in the study had improved. Participants acquired improved teaching strategies which promoted active learning. They also acquired skills to create a learning environment that sufficiently included aspects of high-quality instructions, and improved their communication skills with learners, as attested to by Ajani (2019). Participants developed content knowledge, pedagogical knowledge, and pedagogical content knowledge, as they participated in professional development. Participants acquired skills to use representations in their class to enhance understanding of *Planet Earth and beyond* topics, as indicated by Rollnick *et al*. (2008).

## 4.5 SUMMARY

In this chapter data were presented, interpreted and analysed for exploring classroom practices of Grade 9 teachers when teaching *Planet Earth and beyond* topics. Clarke and Hollingsworth's IMTPG (2002) model was a useful data analytic tool that offered an excellent opportunity to study different patterns of change leading to teachers' growth. Change in one domain in most instances translated into a change into another domain through mediating processes of enactment and reflection (Clarke & Hollingsworth, 2002). When a single relationship exists between the domains, Clarke and Hollingsworth refer to this as a 'change sequence' and when more than two relationships exist between different domains, they refer to it as a 'growth network'. Eighteen 'growth networks' and twelve 'change sequences' were identified in this study, which marked the impact of the intervention workshop used in this study as a professional development programme.

The next chapter presents a summary of findings, recommendations and conclusion.

# CHAPTER 5

# SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

## 5.1 INTRODUCTION

This chapter presents results and gives a summary of the findings. The main aim of the study was to explore how teachers' Pedagogical Content Knowledge (PCK) of *Planet Earth and beyond* strand concepts influences their teaching. The study employed an interpretive, qualitative, multiple case study to generate data. Data collection instruments used included pre-intervention interviews, an intervention workshop (Lesson planning and presentations, *Planet Earth and beyond* topics content discussion), post-intervention interviews, document analysis (manual journal, portfolio of evidence, lesson plans, lesson observation protocol and educator questionnaire). A summary of findings in relation to the three research sub-questions is presented in this chapter, including highlighting areas for further research regarding classroom practices of Grade 9 teachers when teaching *Planet Earth and beyond* topics, limitations, recommendations, areas of future research and the conclusion.

## 5.2 SUMMARY OF FINDINGS

This section provides a brief summary of each research sub-question investigated. Data generated was used to respond to all three research sub-questions as indicated below:

### 5.2.1 Research sub-question 1

*How does the teachers' orientation to Science teaching influence their pedagogical content knowledge?*

As already mentioned in chapter 4, orientations towards Science teaching in this study refer to the understanding of conceptual foundations of teaching *Planet Earth and beyond* topics, teachers' ability to transform and apply knowledge from multiple domains, teachers' beliefs and goals in teaching *Planet Earth and beyond*, as well as teaching methods relevant to be employed when teaching *Planet Earth and beyond* topics.

The current study shows that four out of six participants' understanding of conceptual foundations of teaching *Planet Earth and beyond* topics was limited before the intervention workshop, as they did not do *Planet Earth and beyond* topics at tertiary level. The other two participants, Pule and Mmapula, gained these conceptual foundations through previous professional development programmes, and through experience accumulated as teachers in the system. Participants had an understanding of teaching methods that were not relevant for the teaching of *Planet Earth and beyond* topics, which were mitigated during the intervention workshop. Results of the investigation revealed that in all six cases of the study, teachers had positive beliefs, which influenced classroom practices. Before intervention, teachers primarily used the lecture method, but after the intervention all six participants opted for a learner-centred approach. All six participants showed improved confidence levels, goals, beliefs and positive attitudes, to such a point that after intervention, Pule managed to assist other teachers who had not participated in the intervention workshop, hence he said, *"I have also inducted another new educator at my school on how to teach the topic and also how to develop daily lesson plans for Natural Sciences".*

Following Magnusson *et al.*'s (1999) model of PCK for Science teachers, participants' instructional strategies were investigated before and after the intervention workshop, to check their knowledge of instructional strategies. Results of this study revealed that all six participants managed to use the lesson plan template discussed at the intervention workshop effectively. They managed to indicate targeted specific aims, Science process skills, teacher and learner activities and integrated assessment in planning. All features of a good lesson plan were adhered to, as prescribed by CAPS. All participants managed to successfully use the lesson plan template provided to plan and present a demonstration lesson during the intervention workshop. During demonstrations, some challenges related to planning were identified, including (1) Lack of evidence of activities that supported the inclusion of targeted specific aims and process skills (Tladi's demonstration lesson indicated that all three specific aims were chosen for the lesson, but based on how the lesson was presented, there were no activities supporting the inclusion of specific aim 1. Only specific aim 2 and 3 were supported by activities); (2) the inability of participants to submit instructions for assessment activities conducted during lessons and to draw worksheets with activities to support both teacher and learner activities done during demonstration lessons. It was interesting to find out that all these challenges were rectified by the participants themselves.

According to Furuhagen *et al*. (2019), Feiman-Nemser (1987) uses the term conceptual orientations. According to her, each orientation depicts a cluster of ideas about the goals of teacher preparation and the means for achieving them. The performance of learners whose teachers participated in this study showed a remarkable improvement in 2019 as compared to 2018, after participants had participated in the intervention workshop that enhanced their orientations to teaching *Planet Earth and beyond* topics. This supports Feiman-Nemser (1987) explanation of conceptual orientations. It also suggests that improved orientations might be as a result of participation in the intervention workshop, and led to improved teachers' pedagogical CK, hence improved knowledge and beliefs about the purposes for teaching Science, as reflected in Magnusson *et al.'s* (1999) explanation of a teacher's orientation toward Science teaching.

This study does not claim that the improvement was as a result of the participation in an intervention programme only, but other factors might also have contributed. Wongsopawiro *et al*. (2017) state that teachers might improve their teaching practice resulting in better student outcomes when changing their beliefs and attitudes, as reflected by what Mmapula said after attending the intervention workshop, "*My learners' marks are the result of the knowledge and skills gained from the workshop*."

### 5.2.2 Research sub-question 2

*How does the Grade 9 teachers' pedagogical content knowledge manifest during the intervention?*

As mentioned in Chapter 3 and Chapter 4, the intervention workshop was used as professional development opportunity in this study. The intervention workshop took place over a period of four days, during which participants were exposed to learning instructional strategies, such as development of lesson plans, and were also given an opportunity to render demonstration lessons, which were later discussed by all participants as a way of assisting each other. This allowed participants to use appropriate and relevant methods to teach *Planet Earth and beyond* topics. Participants were given an opportunity to learn how to use representations in order to enhance understanding of *Planet Earth and* beyond topics. A challenge of a shortage of resources to teach *Planet Earth and beyond* was dealt with, by allowing teachers to learn how to develop models, and to make use of easy but effective resources such as recycled material to teach *Planet Earth and beyond* topics. The workshop also focused on content matter as well as context that provided a conducive environment for

teacher learning, as a way of ensuring mastery of *Planet Earth and beyond* concepts by participants.

The study revealed that pedagogical content knowledge, knowledge of the Science curriculum, knowledge of instructional strategies, and knowledge of learner assessment all improved during intervention, supporting Adjani's (2018) attestation that teachers' knowledge and skills can also be updated on their subject matter through the collaboration of ideas, mentorship opportunities among teachers and skills acquisition. The intervention workshop conducted in the current study seemed to have achieved that. In 2019 an improved performance was observed among learners whose teachers had participated in the intervention workshop. This supports the ideas of Jacuith *et al.* (2010) that participation in professional development helps to improve classroom practices and learners' academic performance.

Amendum and Fitzgerald (2013) also maintain that the greatest growth in student achievement takes place when teachers are provided with high levels of support. This is what the intervention workshop provided to teachers in 2019 that might have led to improved learner performance in 2019 as compared to 2018.

Ajani (2019) further indicates that teachers who participate in professional development learn new knowledge, skills, or values that can improve or change their teaching methods or skills. Findings of the current study confirm Adjani's (2019) attestation. After attending the intervention workshop, Mabel responded as follows*, "I have learnt how to present the lessons, and also I have gained more knowledge on some of the concepts that I wasn't really clear about, so I think I am now more equipped to deliver the content or to present the lesson with confidence*" (Source: Interviews). This confirms that new knowledge, skills and values were learnt during the intervention workshop, which led to participants' improved pedagogical content knowledge.

During post-intervention interviews, Mabel was asked the following question: **"**Many NS teachers say that teaching *Planet Earth and beyond* topics is challenging. What are your views about that? Mabel responded as follows, *"I think that's true, because not every teacher has got the experience or the … or the prior knowledge in terms of Geography and also, that part of teaching, it can be a challenge if you do not have the prior knowledge of things like global warming and greenhouse effect. I think for every teacher who is teaching Natural*

*Sciences until they go through this, like eh … the workshop itself, then I think they can be able to deliver the topic even better, so I think training or a workshop is very important for every teacher".* This suggests that the participants acknowledged the value of the intervention workshop, and that their pedagogical content knowledge improved after participating in the intervention workshop.

### 5.2.3 Research sub-question 3

*In what ways do specific characteristics of the professional development programme contribute to development of the teachers' pedagogical content knowledge of the concepts of the strand of 'Planet Earth and beyond'?*

The professional development programme planned for this study was an intervention workshop. The goals set for the professional development programme were to equip participants with both pedagogy and content knowledge, and to work on their beliefs and attitudes towards the teaching of *Planet Earth and beyond* content and concepts. During the intervention workshop, participants were introduced to a common lesson plan template that was crafted taking into consideration features of a good lesson plan as per CAPS. Participants managed to use this lesson plan template to develop lesson plans that were CAPS aligned, i.e., lesson plans reflecting specific aims targeted, process skills targeted, indicating both teacher and learner activities, resources, showing planned activities that accommodate learners with learning barriers, providing time for an educator to reflect on the previous lesson and reflecting planned assessment (formal and informal). During demonstration lessons, lesson plans supplied did not cover all these features, but after the intervention workshop lesson plans submitted in portfolios of evidence covered all the features of a good lesson plan.

Before the intervention workshop, it was observed that participants preferred the lecture method, but after attending the intervention workshop it was evident that there was a shift from the teacher-centred approach to the learner-centred approach by all six participants. Participants' attitudes, beliefs, values and confidence levels also seemed to have improved after attending the professional development programme. This is supported by remarks made by Mabel in her portfolio of evidence when she said, "*The topics such as the rock cycle, the birth, life and death of stars were challenging but after the workshop I understood them better and with the help of video clips that were used during the workshop, I was also able to*

*use them in class to help learners understand the topics and concepts better. The templates for lesson preparations are also of great help. It is easy to prepare and present a lesson. The manuals that were prepared for the workshop are user friendly and easy to use. The concepts are explained very well and are easy for learners to remember"* (Source: Mabel Portfolio of evidence).

Results of this investigation suggest that there was a gain in subject matter knowledge as well, hence an improved performance was observed in the 2019 results of learners whose teachers had participated in this study, which was far much better than the 2018 performance. Wongsopawiro *et al*. (2017) stated that teachers might improve their teaching practice resulting in better student outcomes when changing their beliefs and attitudes, as reflected by what Mmapula had to say after attending the intervention workshop, "*My learners' marks are the result of the knowledge and skills gained from the workshop*."

During the intervention workshop, teachers were provided with manuals designed to guide their interactions and discussions. From this study it emerged that collaboration is important for teacher development, based on what was observed during the intervention workshop, and the fruits that that particular collaboration of teachers provided. According to Shapiro (1988), CoPs are Communities of Learning for professional growth and development of teachers, which may allow teachers to gain from each other. This study supports and confirms Shapiro's (1988) attestation that teachers learn through collaboration, hence in Mmapula's portfolio of evidence he made the following remarks, "*I managed to use the knowledge gained from the workshop about the following topics: The rock cycle and the types of rocks, Layers of the atmosphere, mining in South Africa, the birth, Life, and death of stars and global warming. I also managed to use the following in term 4 2019, gained from the intervention workshop: Videos used during workshop, materials from the workshop (taken as notes through the Manual Journal), classwork's designed by teachers developed for lesson demonstrations during intervention workshop, models designed by educators at the workshop, lesson plants designed by educators during intervention workshop and tests designed by educators during intervention workshop. I also managed to use the knowledge gained from the workshop for other subjects, i.e. Grade 11 Physical sciences: mining in South Africa; Grade 11 Life Sciences: Global warming; and Grade 12 Life sciences: Human impact on the environment."* This serves as confirmation that collaboration among teachers is

important and that teachers need communities of learning for them to be able to share best practices and to deal with challenging *Planet Earth and beyond* topics.

Results of the investigation show that teachers need professional development, but it should be a well-arranged professional development in which there will be sufficient time for content discussion. The study also revealed that participants were challenged to develop rubrics for informal assessment activities, which were also discussed during lesson demonstrations offered during the four-day intervention workshop. Teachers were also taught how to use representations to enhance *Planet Earth and beyond* concepts, which, according to results of this study, is something that teachers did not do before attending the intervention workshop. The shift from using textbooks to the use of a representations was a huge gain for participants, as it is easier to explain *Planet Earth and beyond* concepts using representations, rather than relying on pictures in textbooks.

According to the findings of this study, participants suggested that more time for content training be scheduled, hence MAVIS, when she was asked if she thought that professional development programmes she attended before were fruitful and informative, said, "*The ones that I attended, they were not fruitful, due to the fact that they were mixed with, you'll find that when we were attending workshops they were mixed with monitoring and moderations, and they were just, no time for us to unpack most of the topics and subtopics. According to me, the intervention workshop we have just attended was very fruitful. We tried to unpack most of the concepts, and we were demonstrating, alternating, and as we were presenting, different individuals presenting, it was giving us a lot of insight, because you would listen to some of your fellow members approaching the topic in a different way that we've been approaching it, and we were advising each other that this is a kind of a teaching method that we must always use may when teaching this kind of a topic"* (Source: Interviews*).*

Another important finding that emerged from this study was that all six participants gained an understanding of *Planet Earth and beyond* content, which was a totally different case before they attended the intervention workshop. Mmapula, for example, had never taught *Planet Earth and beyond* topics before attending the intervention workshop, as she did not have the background, knowledge or skills to teach these topics. She was relying on her Science colleague, who was teaching Geography in grade 10-12, to teach *Planet Earth and beyond*

topics for her for two years before she attended the intervention workshop. When Mmapula was asked about professional development programmes she attended before attending the intervention workshop, during post-intervention interviews, she said, "*I have never attended any workshop about planet earth and beyond before. The intervention workshop is my first professional development programme about planet earth and beyond for me. I found it to be very fruitful, cause when I came here, I only knew 20% of the content from planet earth and beyond, but now I can confidently say 80 … 80% of it, now I can be able to teach it without, some without even referring to the book, so it was very helpful."* Mmapula continued to say, *"More time should be allocated for content training, since most of the teachers are struggling to teach planet earth and beyond topics."*

The study further revealed that some teachers could not follow the 'scientific processes" as one of the Science process skills. For example, they did not expose their learners to the following steps in the scientific process: Designing an investigative question, predicting, hypothesis formulation and hypothesis testing, as none of the participants included the scientific process in their lesson plans and lesson demonstrations, or in their assessment activities. It was found that most of the teachers submitted assessment activities with lesson plans for demonstration lessons and in their portfolios of evidence. This suggested to the researcher that most of the teachers could not develop rubrics for the evaluation of both formal and informal activities, supporting Lephogole (2016) statement that teachers need to be trained to develop assessment rubrics.

Some schools are still without relevant resources that may be used to enhance *Planet Earth and beyond* topics, hence participants were given an opportunity to develop models, and also to use representations to enhance *Planet Earth and beyond* concepts. Generally, all teachers who participated in this study were very cooperative. They participated in both pre- and post-intervention interviews and the intervention workshop. They submitted lesson plans, teacher questionnaires, manual journal, and portfolios of evidence. However, it was not easy to get all these documents for analysis on the agreed time and dates. All the participants were active during the intervention workshop. They shared good practices and demonstrated a positivist constructivist approach. They prepared and participated in lesson demonstrations. Each and every lesson was critiqued by all with the aim of advising each other.

## 5.3 LIMITATIONS OF THE STUDY

Data collection was carried out using a purposive sampling technique. This sampling method was utilized due to the very large population of schools in the Bojanala District, making randomization difficult considering the resource constraints and time limitation of the study, as reflected by Nwafor and Van der Westhuizen (2020). The sample was hence limited to six schools, who participated fully from the beginning to the end of the study. This implies that the results cannot be generalized to all Grade 9 schools in the District, Province and the country at large. Future research should target a much bigger sample. This will ensure a more representative and random selection from this wider sample, which might enhance the generalization of findings.

It was also difficult to measure mastery of CK before and after the intervention workshop, and using interviews as a qualitative approach was followed. It is recommended that in future this study should use a mixed method design, as it will allow for a much bigger population to be sampled, and will also give a researcher the opportunity to utilize pre- and post-tests to measure the extent to which participants know and understand CK before and after the intervention workshop. However, Lesson observations and discussions thereof, allowed for a rigorous discussion of teaching approaches. Participant manual, facilitator guides and PowerPoint presentations shared with participants, proved to be useful resources that participants used to improve both pedagogy and content knowledge, hence we saw improved learner performance in participant's schools in 2019.

Generally, the study results show that professional interventions can help improve teachers PCK. While this is not a new finding, the finding makes some important contribution in so far as research on Planet Earth and Beyond in South Africa is concerned. There is potential that the approach and methodology utilized or this study can be extended to studying teachers PCK in other topics.

## 5.4 RECOMMENDATIONS

Based on the above findings, this study recommends the following:

- The National Department of Education to design a qualification (Two-year certificate) that covers all Natural Sciences strands, including *Planet Earth and beyond*, as there is no qualification offered thus far in South Africa that covers *Planet Earth and beyond*.
- Teachers be taken through interventions for professional development programmes at the end of Term 3 to enhance their pedagogical content knowledge of *Planet Earth and beyond.*
- Professional development programmes to focus on both content and pedagogy; enough time to be availed for content discussion; Content discussion not to be coupled with moderations or any other activity, other than discussing pedagogy.
- Special Professional Development activities to be organised to discuss assessment, covering the development and use of rubrics, and balancing of cognitive levels as per CAPS.
- A manual to orientate teachers on improvisation, to be developed to allow educators to develop some of the resources for themselves due to unavailability of resources. This should include developing models, for example annotated diagrams representing layers of the atmosphere using readily available materials, as was done during the intervention workshop. Teachers to be workshopped on the use of that manual afterwards.
- A strategy to be developed to assist Grade 9 teachers to teach all *Planet Earth and beyond* topics, as these topics are not normally taught in high schools and is only taught in the fourth term. Grade 9 teachers teaching Grade 12 tend not to teach *Planet Earth and beyond* topics as they focus on preparing grade 12 learners for final examinations, and end up not teaching *Planet Earth and beyond* topics completely.
- Relevant *Planet Earth and beyond* teaching and learning resources to be provided to schools, to ensure the practicability of the subject, and to ensure understanding of *Planet Earth and beyond* concepts.

- Misconceptions and difficult concepts of *Planet Earth and beyond* topics to be listed, explained and developed into a booklet and distributed to all schools as a way to deal with difficult and challenging parts of *Planet Earth and beyond* topics.
- Participant and facilitator guides, representations such as PowerPoint presentations and video-clips (URL numbers or websites to be provided for schools to download) to be converted into a booklet and distributed to all schools. These proved to be useful resources during the intervention workshop, and if properly used by Grade 9 schools across the country, they may serve as useful learning and teaching materials.
- Teachers' orientations to Science teaching and CK as well as professional development programmes be taken into consideration when developing the curriculum. Professional development programmes to be continually conducted to ensure continuous discussions on subject matter.

## 5.5 CONTRIBUTION OF THE STUDY

Contributions of this study are as follows:

### 5.5.1 Benefits for the subject area or discipline

The study shed light on the experiences faced by Grade 9 NS teachers in the teaching of *Planet Earth and beyond* topics of CAPS, which in the researcher's opinion may serve as a guideline on how Senior Phase classroom practices might be strengthened. Resources and participant manuals as well as a facilitator guide might be used by schools as a valuable reference for the teaching of topics in *Planet Earth and beyond*. In this study these documents were quality assured before commencement of the workshop. It is hoped that the information from this study in this respect will be useful in the review and development of teacher professional development that may be conducive to effective learning. The intervention employed might improve teacher confidence in the teaching of *Planet Earth and beyond*. The study also might have some positive influence in advising curriculum designers on what can be done to further strengthen Natural Sciences CAPS, especially at provincial level, given that the researcher is a subject specialist and shall share with colleagues' information

emanating from this study in future meetings. The study might also be a source of reference for school managers on how to monitor and manage the teaching of topics in *Planet Earth and beyond*, thus maybe improving performance. In other words, the study may generally improve teacher and learner performance.

### 5.5.2 Research focus area

Based on the recommendations emanating from this research, it is envisaged that the National Department of Education, North West Provincial Department of Education, and the Education district may provide in-service training to the affected NS teacher population to bridge the gaps identified during curriculum implementation, with particular reference to the strand *Planet Earth and beyond*. Independent teacher development bodies and other researchers might also benefit from the findings and recommendations of this study. The information provided might give a picture of what is taking place in Science classrooms that contributes to the level of the present learner attainment, looking at variables such as teachers' PCK, beliefs, teaching instruction, and the classroom learning environment.

## 5.6 AREAS OF FUTURE RESEARCH

In order to improve performance in Natural Sciences, other than looking at classroom practices and PCK, an investigation about the impact of two hours notional time allocated for NS needs to be investigated, to check if effective teaching and learning of NS can really happen in three hours in a week, as allocated as per CAPS document. Furthermore, an investigation into qualifications offered by tertiary institutions in South Africa has to be conducted to find out how a new qualification could be realigned to include all strands as reflected in the ATP. At the current moment, all teacher training qualifications in South Africa for Natural Sciences do not cover the *Planet Earth and beyond* strand. All other strands, for example, Life and living, Matter and materials and Energy and change, are offered when one is acquiring a qualification to teach Natural Sciences. The strand *Planet Earth and beyond* has not been included in any course or any qualification thus far.

The other area of research that could be tapped into is the realignment of schools, where it should be investigated if it is possible for Grade 8 and 9 learners to be removed from secondary schools, and be placed with Grade 7 learners in one building so that they can receive all the much needed attention from their teachers. It would be interesting to find out if the performance of Grade 9 learners will improve or not, should that be done.

## 5.7 CONCLUSION

The main aim of the study was to explore how teachers' PCK of the *Planet Earth and beyond* strand concepts influences their teaching. Lessons have been learnt through this study, which may impact on the PCK of teachers when teaching *Planet Earth and beyond* topics, thus improving their classroom practices. Studies have shown that PCK is the main driving force to effective teaching and effective learning, as it provides a mechanism to teachers to convey subject matter to learners in a manner that allows understanding of concepts under study.

In this study PCK was used as the theoretical framework, which provided an opportunity to scrutinise all aspects related to teacher development. The IMTPG model was used as data analytic tool, which assisted the researcher to categorise aspects of PCK, and to look deeply into all PCK aspects investigated. The IMTPG model further assisted to trace teacher change before and after the intervention workshop. In most of the PCK components investigated, the entry point was the External Domain, which indicated the impact of the intervention workshop in this study. Out of 30 pictograms drawn to show changes in PCK aspects, 18 depicted growth network, and only 12 depicted a change sequence.

Findings of this study revealed that after intervention, participants' orientation to science teaching, knowledge of instructional strategies, knowledge of the Science curriculum, knowledge of learner assessment, and knowledge of learner understanding of Science had improved. Improvement in teachers' PCK, beliefs, attitudes, goals and confidence levels translated to improvement in learner performance, which was observed among learners whose teachers participated in this study. Learners performed better in 2019 as opposed to 2018. This study also revealed that some teachers are still struggling to develop lesson plans that are CAPS compliant, and that some of the teachers are still using the teacher-centred

approach, which does not allow maximum participation of learners. Teachers also still cannot infuse how they deal with inclusivity in their classroom, to accommodate learners with learning barriers.

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## ANNEXURE H: Interview protocol

| INTERVIEW SCHEDULE BEFORE AND AFTER INTERVENTION (WORKSHOPS) | |
|---|---|
| **Questions** | 1. What relevant experience in terms of the number of years do you have in teaching Natural Sciences in grade 9?<br>2. Do you see yourself suitably qualified to teach Natural Sciences? Explain.<br>3. What comes spontaneously to your mind when you hear key words "planet earth" and "beyond"?<br>4. Did you experience challenges when teaching planet earth and beyond topics? Kindly elaborate.<br>5. How do you manage to overcome the challenges that you have indicated?<br>6. What do you find to be the most difficult part of planet earth and beyond?<br>7. Which teaching methodologies work best for you in the teaching of Planet Earth and beyond topics?<br>8. Many NS teachers say that teaching planet earth and beyond topics is challenging. What are your views about that?<br>9. How do you inform yourself about the planet earth and beyond topic?<br>10. Tell me about professional development programmes about planet earth and beyond that you have attended. How many have you attended?<br>11. Do you find professional development programmes about planet earth and beyond that you have attended to be informative and fruitful? Explain.<br>12. What are possible consequences of not adequately teaching the planet earth and beyond topic? Explain in terms of learner point of view and teacher point of view.<br>13. What recommendations do you have for the Department for future efforts to improve performance, content knowledge and pedagogical content knowledge? |
| | 14. Is there anything else you would like to add? |

**ANNEXURE I: Portfolio of Evidence**

## INDEX

| NO | ITEM |
|---|---|
| 1. | Introduction. |
| 2. | Background information of participants |
| 3. | Minutes for Departmental/subject meeting |
| 4. | Subject improvement plan |
| 5. | Planning documents used. |
| 6. | Learner-Teacher support material available. |
| 7. | Reports. |
| 8. | Content workshops attended. |
| 9. | Informal assessment. |
| 10. | Other |

**KEY:**

1. Introduction: Introduction should include the following:

    - Background information about the school.
    - Performance of Grade 9 learners over the past three years.
    - School enrolment for the year 2019.
    - School Management team responsible for NS monitoring and moderations. (Availability)
    - Monitoring and moderation tools. (Availability).
    - Planning documents. (Availability).

2. Background information about participants:
    - Age.
    - Qualifications.
    - Teaching experience.
    - Experience teaching NS.
    - Professional development workshops attended, including content training.
    - Participation in Professional matters. (SAASTE, SAARMSTE, etc.)

3. Minutes for Departmental/subject meeting.

4. Subject Improvement plan.

5. Planning documents available:
    - CAPS
    - Dated ATP
    - NECT Lesson programme (planner & tracker, lesson plans, resource packs)
    - Monitoring and moderation plan.
    - Monitoring and moderation instruments.
    - Evidence of lesson planning.
    - Learner teacher support material.

6. Reports:
    - NWPA (North West Provincial Assessment) diagnostic report.
    - In-school monitoring and moderation reports.
    - External moderation reports.
    - Reports from content training and other developmental workshops.

7. Informal tasks:
    - Instructions for class works.
    - Recording sheets for informal tasks.
    - Suggestions from participants for future improvement.
8. Participant's views about content training workshops attended: Planet Earth and beyond.
9. Include all lesson plans for lessons taught on the section Planet, Earth and Beyond.

10. Each lesson plan should have a reflection section where a teacher reflects on each and every lesson.

## ANNEXURE J: Consent form for participants

### CONSENT TO PARTICIPATE IN A RESEARCH STUDY

### NORTH-WEST UNIVERSITY -MAFIKENG CAMPUS

TO: _____ (The participant) DATE: _____

**Please read this consent agreement carefully before you decide to participate in the study.**

| ACTIVITY | EXPLANATION |
|---|---|
| **Purpose of the research study** | The main aim of the study is to explore how teachers' PCK of Planet earth and beyond strand concepts influence their teaching |
| **What you will do in the study** | You are requested to participate in this study as a participant during a 3-day workshop, to participate in interviews, also to avail your planning documents (Lesson plans, policy documents, textbooks, teacher profile) for scrutiny. |
| **Time required** | You will be expected to avail yourself according to estimated scheduled time reflected below:<br>• 3 Days: Content workshop.<br>• 1 hour: Interviews<br>• 15 Minutes: Complete educator biodata/profile form.<br>• 1 Hour: Submission of planning documents for analysis.<br>• TOTAL: 3 days, 2 hours, and 15 minutes. |
| **Risks** | There are no anticipated risks in this study. |
| **Benefits** | There are no direct benefits to you for participating in this research study. The study may help us to understand and to explore how teachers' pedagogical content knowledge of the planet earth and beyond strand influence their teaching. |
| **Confidentiality** | In this study, the researcher will ensure that what happens during the study will solely be for the sake of the study. Leading statements, during reporting, which may lead to confidentiality, and privacy of participants during reporting, will be avoided during reporting. All participants' information and responses shared during the study will be kept private and the results will be presented in an anonymous manner in order to protect the identities of the participants, thus all data will become anonymous at the conclusion of the study. Audio recordings will be stored safely, and will be destroyed after 7 years. |
| **Voluntary participation** | Your participation in the study is completely voluntary. You may not be coerced to do anything against your will at any given time of the study. |
| **Right to refuse or withdraw from the study** | You have the right to refuse to participate in this study, however, should you agree to participate, you have the right to withdraw from the study at any time without any penalty or any form of intimidation. All audio and video recording used in this study, will be destroyed after seven years and will in the interim be kept under lock and key in a cupboard. |

| | |
|---|---|
| **How to withdraw from the study** | If you decide to withdraw from this study, you may write a letter and direct it to me at any time of the study. |
| **Payment** | You will receive no payment for participating in the study, however you will earn **SACE CPTD** points through a 3-day workshop that you will be attending. |
| **If you have questions about the study, contact:** | Researcher: Mr. D.M. Sentsho.<br>P.O.Box 6130. RUSTENBURG. 0300<br>Email: dsentsho@nwpg.gov.za/davidsentsho@gmail.com.<br>Tel: 0145502000<br>Cell: 0633844472 |
| **If you have additional questions about the study, contact:** | **My supervisor:**<br>Prof. Washington T. Dudu<br>Private Bag X2046, Mmabatho<br>South Africa, 2735<br>Tel: 018 389 2833<br>Fax: 018 392-5775<br>Web: http://www.nwu.ac.za<br>Email: eliza.senne@nwu.ac.za |
| | |

Your signature below will indicate that you have decided to volunteer as a research subject, that you have read and understood the information provided above, and that you are a Grade 9 Natural Sciences teacher.

**Signature: _____ Date: _____**

You will receive a copy of this form for your records.

## ANNEXURE K: Manual Journal Index.

DOCUMENT ANALYSIS: MANUAL JOURNAL

The Manual Journal for participants will be arranged as follows:

| NO | ACTIVITY | YES | NO | COMMENTS |
|---|---|---|---|---|
| 1 | Daily notes | | | |
| 2 | Challenging topics where assistance is required | | | |
| 3 | Glossary of terms | | | |
| 4 | New information learnt | | | |
| 5 | Misconceptions and corrective measures | | | |
| 6 | Suggested activities for future professional development | | | |
| **GENERAL/AOB/ADDITIONAL NOTES** | | | | |
| | | | | |

**NB; Activities reflected above were used as the index for participants' Manual Journal**

## ANNEXURE L: Lesson Plan template

| LESSON PLAN | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Subject: Natural Sciences** | | | | | | | | **Duration :** |
| **Grade** | 7 | 8 | 9 | **Term** | 1 | 2 | 3 | 4 | **Date :** |

| SPECIFIC AIM/S ADRESSED. (TICK) | | | | | |
|---|---|---|---|---|---|
| **Specific Aim 1** | | **Specific Aim 2** | | **Specific Aim 3** | |
| DOING SCIENCE | | KNOWING THE SUBJECT CONTENT AND MAKING CONNECTIONS | | UNDERSTANDING THE USES OF SCIENCE | |

| | NATURAL SCIENCES PROCESS SKILLS (TICK RELEVANT ONE) | | | | |
|---|---|---|---|---|---|
| 1 | Accessing and recalling information | | 10 | Raising questions | |
| 2 | Observing | | 11 | Predicting | |
| 3 | Comparing | | 12 | Hypothesizing | |
| 4 | Measuring | | 13 | Planning investigations | |
| 5 | Sorting and classifying | | 14 | Doing investigations | |
| 6 | Identifying problems and issues | | Other | | |
| 7 | Interpreting information | | | | |
| 8 | Recording information | | | | |
| 9 | Communicating | | | | |

| | |
|---|---|
| **Looking backward:**<br>**Day 1** | **Looking forward:** |
| **Strands / sub strands:** | |
| **Core knowledge and Concepts/ context:** | **Explanation of new words/ terminology:** |

| | | |
|---|---|---|
| | | |
| **Teaching activities:** | **Learning activities:** | |
| **Planned assessment:** | | **Inclusivity (accommodate learners with certain barriers to learning):** |
| **Informal:** | **Formal:** | |

| **Resources:** | **Teacher reflection:** |
| --- | --- |
| **Beginning Knowledge study area in the Intermediate Phase for grade 6/ prior knowledge:** | |

## ANNEXURE M: Lesson demonstration discussion protocol

# Lesson Demonstration Discussion Template

**Teacher No:**_____

**School No:**_____

**Date:**_____ **Subject:**_____ **Grade:**_____

**Topic:** _____ **Duration of lesson:**_____

| No. | Item | | | | Comment |
|---|---|---|---|---|---|
| **1.** | **Topic of the lesson** | | **Yes** | **No** | |
| 1.1 | Clarity and relevance of the topic to the lesson | Is the topic chosen relevant for Grade 9 as per CAPS? | | | |

| | | | | |
|---|---|---|---|---|
| 1.2 | Introduction | Is the introduction interesting and can capture learner's attention?<br><br>Teacher has appropriate instructional materials (worksheets) ready for use at the beginning of the lesson. Motivate. | | |
| **2.** | **Lesson Objectives** | | **Yes** | **No** |
| 2.1 | Specific aims. | Is the lesson developed in line with any CAPS specific Aims? Which specific aims are dressed in the lesson/ Are activities done in the lesson relating to chosen specific aims? | | |
| 2.2 | Science process skills. | Are there any science process skills targeted? Which Science process skills are addressed in this lesson?<br><br>Are activities conducted | | |

| | | | | |
|---|---|---|---|---|
| | | addressing specific aims chosen for this lesson? | | |
| **3.** | **Content** | | **Yes** | **No** |
| 3.1 | Clarity of concepts to be learnt | Which concepts are covered in this lesson? Are concepts clearly addressed by the lesson presented?<br><br>During the lesson, the teacher demonstrated content knowledge and understanding | | |
| 3.2 | White paper 6 | Are activities done catering for the needs of learners with barriers to learning? / Teacher planned for meeting the needs of **diverse** and exceptional learners (Inclusive) through extension and/or modification of instructional tasks. | | |
| **4.** | **Pedagogy** | | **Yes** | **No** |
| 4.1 | Strategies/methodology | Which methodology/strategies were predominantly used in | | |

| | | | | |
|---|---|---|---|---|
| | | the lesson? | | |
| | | Which hands on activities were done? Do you think activities done enhanced learning and teaching? | | |
| 4.2 | Teaching/learning Activities | | | |
| | | Teacher applies content knowledge in ways that enrich and extend learner learning. | | |
| 4.3 | Learner/teacher-Centered approach used. | Was the lesson offered learner-centered or teacher centered? | | |
| 4.4 | Assessment. | Was assessment conducted for activities done in the lesson? Is it formal or informal? | | |
| **5.** | **Language** | | **Yes** | **No** |
| 5.1 | Terminology | Is the language used relevant for grade 9 | | |

| | | |
|---|---|---|
| | | learners? |
| | | Were difficult concepts explained? |
| 5.2 | Code-switching. | Was code switching used during the lesson? Motivate. |

| | |
|---|---|
| **6.** | **General Comments (***including What was done well? What needs to be changed in future? Which challenges were experienced? Did the lesson grow as planned?)* |

## ANNEXURE N: Teacher questionnaire

**TEACHER QUESTIONNAIRE (To be completed by all teachers before participating in the intervention workshop)**

| NO | PERSONAL DETAILS | NOTES |
|---|---|---|
| 1 | Full Names and Surname of teacher | |
| 2 | Name of school | |
| 3 | Age | |
| | **QUESTIONS** | |
| 4 | You have been a teacher for how many years? (No of years) | |
| 5 | For how long have you been teaching Natural Sciences in Grade 9? (No of years teaching Grade 9) | |
| 6 | Which subjects did you do in your matric? (Subjects done at matric) | |
| 7 | Educational qualifications (All) | |
| 8 | Which major subjects did you do at tertiary level? | |
| 9 | Which qualification are you pursuing at this time? Is that qualification related to planet earth and beyond? | |

| | | |
|---|---|---|
| 10 | Which other grades do you teach other than grade 9? | |
| 11 | Does your school have the following planning documents?<br>• CAPS.<br>• NPA<br>• NPPPR<br>• Gazette 36041<br>• Departmental Workbooks.<br>• Textbooks | |
| 12 | What is your employment status? Permanent or temporary? | |
| 13 | Indicate if you have any other resources to be used for teaching and learning (laptops, projectors, interactive board). | |
| 14 | Topics where intervention is needed in the teaching of "***planet earth and beyond*"** strand. | |

| | | |
|---|---|---|
| 15 | Which In-service training/programmes have you attended? Please share your experiences. | |
| 16 | Is there anything else you want to add? General comments? | |

## ANNEXURE O: Evaluation form

**INTERVENTION WORKSHOP FOR RESEARCH PARTICIPANTS**

**NATURAL SCIENCES**

**STRAND: PLANET EARTH AND BEYOND**

**GRADE 9**

**Name of participant (Write participant code only): _____**

**School (Write code provided for the school only): _____**

**Circuit: _____**

**For each item respond by using the space in the response column. In your response, you may reflect on your confidence level, skills acquisition, and content knowledge before attending the workshop, during the workshop and at the end of the workshop.**

| **1.** | **Before the course** | **Response (Yes/NO) and Expansiate** |
|---|---|---|
| 1.1 | I am confident in teaching of 'Planet Earth and Beyond'. | |
| 1.2 | I am confident in using the correct pedagogy in my class. | |
| 1.3 | I am able to prepare lesson plans as per CAPS prescripts infusing specific aims, process skills and relevant assessment. | |
| 1.4 | I am able to prepare worksheet for practicals and can do demonstrations for my learners. | |
| 1.5 | I use video clips and models in my class to enhance learner understanding. | |
| 1.6 | I hate teaching 'Planet Earth and Beyond' | |
| 1.7 | I have a full understanding of the following 'Planet Earth and Beyond topics' and can teach them with | |

| | | |
|---|---|---|
| | confidence: | |
| 1.7.1 | The earth as a system & spheres of the earth | |
| 1.7.2 | Lithosphere | |
| 1.7.3 | The rock cycle | |
| 1.7.4 | Mineral resources (Extracting ores, Refining minerals, Mining in South Africa) | |
| 1.7.5 | The atmosphere | |
| 1.7.6 | Greenhouse effect | |
| 1.7.7 | Birth, life and death of stars. | |
| 1.8 | Confident that I am well orientated to science teaching | |
| 1.9 | Workshops attended before did not assist with understanding of 'Planet Earth and beyond topics' content and concepts, as well as relevant teaching approaches. | |
| **2** | **During the intervention workshop** | |
| 2.1 | The presentations we made are useful to my needs as a teacher | |
| 2.2. | I will use this information for my science learners | |
| 2.3 | The video clips used were enlightening | |
| 2.4 | I will implement these skills in my | |

| | | |
|---|---|---|
| | teaching with immediate effect | |
| 2.5 | I found the intervention workshop easy to follow | |
| 2.6 | The trainer supported me when I needed help | |
| 2.7 | The trainer advised me to find solutions to problems that I experienced | |
| 2.8 | I had sufficient opportunity to work at my own pace | |
| 2.9 | I am able to improvise and do experiments, as well as models to enhance understanding of 'Planet Earth and Beyond topic.' | |
| 2.10 | I found the pair and share session useful | |
| 2.11 | I acquired knowledge and understanding of Planet Earth and Beyond content and concepts. | |
| 2.12 | I felt my lesson planning skills as per CAPS prescripts improving | |
| 2.13 | I started learning different teaching methods and approaches. | |
| 2.14 | Training material (participant guide lesson plan templates, lesson observation templates) were useful and relevant for the intervention workshop | |

| 3 | **After the intervention workshop** | |
|---|---|---|
| 3.1. | I feel that my subject knowledge and skills have improved (Planet Earth and Beyond) | |

| | | |
|---|---|---|
| 3.2 | I have a full understanding of the following Planet Earth and Beyond topics and can teach them with confidence after intervention workshop: | |
| 3.2.1 | The earth as a system & spheres of the earth | |
| 3.2.2 | Lithosphere | |
| 3.2.3 | The rock cycle | |
| 3.2.4 | Mineral resources (Extracting ores, Refining minerals, Mining in South Africa) | |
| 3.2.5 | The atmosphere | |
| 3.2.6 | Greenhouse effect | |
| 3.2.7 | The Birth, Life and Death of stars | |
| 3.3. | I have a better understanding of planning lessons | |
| 3.4 | I will use lesson plan templates used and discussed at intervention workshop. | |
| 3.5 | Comments made by colleagues during lesson demonstrations were helpful, and I will infuse them in my planning even in the future | |
| 3.6 | I feel that my skills for preparing and doing practicals (including developing models) have improved | |
| 3.7 | I feel that I have acquired enough skills that will make me a better | |

| | | |
|---|---|---|
| | teacher | |
| 3.8 | I enjoyed this approach to training | |
| 3.9 | I feel that I am more confident to teach Planet Earth and Beyond | |
| 3.10 | I 'hate' teaching Planet Earth and Beyond after the intervention workshop. | |
| 3.11 | I will use training materials including videos in my class | |
| 3.12 | I feel that I should share what I learnt, as well as training material received from the intervention workshop with my colleagues and anyone who needs assistance. | |
| 3.13 | I will be glad to continue teaching NS and Planet Earth and Beyond in future. | |
| 3.14 | Intervention workshop served as good orientation to science teaching. | |
| 3.15 | Intervention workshop helped with the acquisition of both pedagogy and content and concepts to deal with the teaching of Planet Earth and Beyond topics. | |

| **CATERING and ACCOMMODATION- Comment:** |
|---|
| |

| |
|---|
| **GENERAL COMMENTS:** |
| **RECOMMENDATIONS:** |

**I would like to attend intervention sessions on the following applications/topics:**

| | WORKSHOP PROGRAMME |
|---|---|

1.

2.

| | Planet earth and beyond strand | |
|---|---|---|
| | **DAY 1** | |
| 1 | Opening and Welcome | 08H30-08H40 |
| 2 | Ground rules | 08H40-08H50 |
| 3 | Setting the scene | 08H50 – 09H00 |
| 4 | Spheres of the earth | 09H00 – 10H00 |
| 5 | Lithosphere | 10H00 – 11H00 |
| 6 | **BREAK** | **11H00 – 11H10** |
| 7 | The Lithosphere | 11H10 – 12H00 |
| 8 | The rock cycle | 12H00 – 14H00 |
| 9 | Lunch | 14H00 – 15H00 |
| 10 | Summing up and preparations for Day 2 | 15H00 – 16H00 |
| 11 | **DAY 2** | |
| 12 | Extracting ores | 08H30 -09H30 |
| 13 | Refining minerals | 09H30 – 11H00 |
| 14 | **Break** | **11H00 – 11H 10** |
| 15 | Mining in South Africa | 11H10 – 12H00 |
| 16 | The atmosphere | 12H00 – 13H00 |
| 17 | Greenhouse effect | 13H00 – 14H00 |
| 18 | Lunch | 14H00 – 15H00 |
| 19 | Birth, life and death of stars. | 15H00 – 16H00 |
| 20 | **DAY 3** | |
| 21 | Preparing lessons for presentation | 08H30 -09H30 |
| 22 | Lesson presentation 1 & discussion | 09H30 – 10H50 |
| 23 | **Break** | **10H50 – 11H00** |
| 24 | Lesson presentation 2 & discussion | 11H00 – 12H20 |
| 25 | Lesson presentation 3 & discussion | 12H 20 – 13 H40 |
| 26 | Workshop evaluation | 13H40 – 14H00 |
| 27 | Lunch | 14H00-15H00 |
| 28 | Departure time | |

## ANNEXURE P: Workshop programme

## ANNEXURE Q: Turnitin report

**ANNEXURE R: Letter of language editing**


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**DECLARATION**

12 December 2020

I herewith declare that I was responsible for the language editing of the dissertation:

Classroom Practices of Grade 9 Natural Sciences teachers when teaching the planet Earth and beyond topic: A case study, by Mr DM Sentsho.

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