Faculty of Science

Investigating 4th year Pre-Service Teachers' levels of understanding of the disciplinary nature of Life sciences as a discipline.

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Declaration

I hereby declare that this research report is my own unaided work. It is submitted for the degree of Masters of Science (Science Education) at the University of Witwatersrand, Johannesburg. It has not been submitted for any other degree or examination in any other university, nor has it been prepared under the guidance or with the assistance of any other body or organization or person outside the University of Witwatersrand, Johannesburg.

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Nkosi yami uhlezi umuhle futhi uzibonakalisile empilweni yami, umusa wakho angiwungabazi…

Abstract

Disciplinary knowledge is recognised as teacher professional knowledge base that is central in promoting effective teaching and learning in science education. Although that is the case, in one of the South African University, that this study was conducted in, the 4th year Life sciences Pre-service teachers' were not tested on their understanding of the disciplinary nature of their subject of specialisation. As a result, the type of disciplinary gaze that they acquired by the end of the teacher training remained unknown within the institution. Thus, this study then used a case study methodology to investigate the Pre-service teachers' levels of understanding of the disciplinary nature of Life Sciences as a discipline. The participants of this study consisted of twenty nine 4th year Pre-service teachers' who were enrolled for a Life sciences Bachelor of Education program and one Life sciences lecturer who was involved in teaching the subject. This research took on a qualitative approach, which yielding both qualitative and quantitative data, through the use of questionnaires as well as semi-focused interviews as research instruments. The outcomes of this study showed that, although the Pre-service teachers' were not explicitly taught about the nature of the subject, but they still showed a satisfactory understanding of it. Although that was the case, the Pre-service teachers' still demonstrated a fractured comprehension of the disciplinary knowledge aspects, such as the history, philosophy and the nature of science. On the other hand, the findings of this study also demonstrated that, the Pre-service teachers' acquired an extensive gaze of understanding of Subject Matter Knowledge, which is another component of Disciplinary knowledge, and this was because, this knowledge base was explicitly taught and assessed with the teacher training program.

List of acronyms of this study

B.Ed. : Bachelor of Education

CK : Content Knowledge

DK : Disciplinary Knowledge

NOS : Nature of Science

PCK : Pedagogical Content Knowledge

PGCE : Post Graduate Certificate in Education

PTS : Pre-service teacher

SAX : South African University

SMK : Subject Matter Knowledge

Chapter one: Introduction of the study

1.1 Introduction

Disciplinary knowledge (DK) is recognised as teacher professional knowledge base that is central in promoting effective teaching and learning in science education (Kind, 2009). Thorne (2014, p.1) states that when we think of DK, 'we are most typically referring to the intellectual structures within which the discipline delineates its unique focus of vision and social mandate". In other words, DK refers to the knowledge base that legitimises a field from other fields of specialisation. Furthermore, this knowledge base has to do with how knowledge of a particular discipline is then applied in modern society. Life Sciences as a discipline is framed as having three components which include: **history, philosophy and the nature of the subject** (Lederman, 2000). Moreover, DK is regarded as a broader and encompassing knowledge domain in which SMK is found in. SMK refers to "the amount and organization of knowledge per se in the mind of the teacher" (Shulman, 1986, p. 13). Generally SMK can be said to mean, what teachers need to know about their subject of specialisation. The two knowledge bases explained above are important in a sense that, they enable teachers to be able to choose appropriate concepts as well as **structure**, **sequence** and teach them in ways that will be accessible to their learners (Taylor, 2014).

DK is an important teacher knowledge domain that plays a central role in heightening and 'strengthening' teachers' voices in their practises (Thorne, 2014). This is because; it enables them to holistically understand the nature of the subject that they are teaching (Thorne, 2014). Although this is the case, Van Wyk (2000) points out that, PSTs do not have enough DK for their subject of specialisation and that teacher training programs are to be blamed for this occurrence. My experiences as a former undergraduate Bachelor of Education (B.Ed.) student showed that, PSTs are explicitly taught and tested on SMK, which is just one component of DK and are expected to show competence in this knowledge base (SMK) for them to successfully qualify within the training program. However, the PSTs are implicitly taught about the other components of DK for example, the Nature of Science (NOS) which enables the PSTs to effectively teach their subject of specialisation. Hence, if this problem is not looked into, it means that teacher training programs will continue to qualify PSTs that have limited DK in their teaching subject, which will result in leaners having limited competence in science thus forming an endless cycle. Hence, this study was then concerned with investigating the levels of understanding of the disciplinary nature of Life sciences as a discipline that 4th year PSTs have at the end of their teacher training, as part of figuring out the other possible causes of poor teaching and learning in South African science classrooms.

Norman (2000) suggests that teachers cannot teach what they do not know or understand. That is why Aeuson (2003) sees teaching as some form of art that requires the ‘expert’ which in this regard is the teacher, to have an in depth understanding of the SMK of their subject of specialisation. Following this, it then becomes central that PSTs need to first undergo training, where they are provided with ‘specific preparation for teaching’ and priority is given to a ‘thorough grounding in something to teach’ (Peter, 1977, p.151).This then goes to show that, the main role for teacher training programs is to provide PSTs with adequate knowledge for their subjects of specialisation. According to Hashew (1987) this knowledge is centred on DK which is an important teacher knowledge base that promotes ‘successful teaching’. However, not so much is understood about DK, as there is limited research that has been done on this professional teacher knowledge base up to date. Arising from this, not so much is known about the levels of DK that PSTs have at the end of their teacher training program. Thus, this study then looked at the 4th year Life sciences PSTs to try and examine their levels of understanding of the nature of the Life sciences as a discipline. The PSTs that participated were enrolled for a B.Ed. program where this study was conducted. The B.Ed. program takes upon a concurrent model, which allows PSTs to learn both general and professional components at the same time. According to Nyamupangedengu (2015), the professional component enable PSTs to study the practical skills and theory that is essential for teaching and learning, as well to practice their teaching skills for a certain period of time. While on the other hand, the general components permit PSTs to study one or more academic teaching subjects.

1.2 <u>Background and context of the study</u>

This study was carried out at a school of Education in one of the South African University (SAX). This study largely worked with 4th year Life sciences PSTs and a lecturer involved in the teaching of the subject. This was because at the school, a study such as this one has never been conducted before. As a result, the level of the PSTs understanding of the disciplinary nature of Life sciences after completing the training remains unknown within the school. So, below follows a section about the school’s vision for the 4th year PSTs at SAX.

1.2.1 <u>The Vison for B.Ed. graduates at SAX</u>

At SAX, the vision for B.Ed. graduate seeks to produce an ideal teacher for the South Africa community at large. This vision accounts that an ideal teacher is the one who meets nine characteristics that include major issues of; knowing the subject competence, leadership skills, ethical and moral conduct as set by the school. With that said, the school does take into account that there are certain constraints that may inhibit the B.Ed. graduates in their first two years of being professional teachers; these may include lack of resources in the school and other socio-cultural and/or political issues. However, the school believes that through its four year teacher program, it does lay foundations that enable the graduate to "develop the full range of teaching competence" (Taylor, 2014, p.280). Out of the nine characteristics, this study only focused on one characteristic and its sub-components, this was because, they were more aligned to the DK which was core to this study, since it investigated the 4th year Life sciences PSTs levels of understanding of the disciplinary nature of Life sciences. According this one characteristic stipulated in the vision, it states that:

…Teachers with a high level of subject competence is the one who can

- ✓ *Identify intellectually with a discipline(s) and/or learning area(s) in a particular phase(s) of schooling*
- ✓ *understand and identify with the intellectual practices of their discipline and/or learning areas and can induct learners into these practices*

While the vision explicitly says that the 4th year Life PSTs should identify intellectually with their discipline, there is no evidence to show that indeed the B.Ed. graduates after completing their degree take away these high levels of teacher subject competence (DK) within their subject of specialisation. Thus this study was then concerned with investigating 4th year PSTs' understanding of the disciplinary nature of Life sciences, in order to be in a better position of comprehending whether the school meets its vision or not.

1.3 Disciplinary knowledge Structures

When a subject is regarded as a discipline, it consists of a recognisable form of organisation called DK structures. These DK structures are regarded as the building blocks of knowledge, without which knowledge has no form of organization. An understanding of the form of organisation of a body of knowledge is what Bernstein (2000) refers to as a 'gaze'. According to Bernstein, a 'gaze' refers to a coherent understanding of the underlying principles of knowledge, that a teacher has for a particular subject and this gaze is acquired through teacher training programs. Thus, Bernstein and Bourdieu (2000) state that:

The aim of teacher training is not to produce a complete new person at the end of training, but rather to shift their current ways of knowing into acquiring a new gaze of their subject of specialisation… (p. 256).

This gaze can only be acquired by a PST, if they have developed the necessary DK structures for their teaching subjects. Furthermore, these knowledge structures of a discipline can either be hierarchical or horizontal (Bernstein, 2000), and these concepts will be explained in depth shortly below. Myers (2015) argues that, these structures of knowledge have implications for teaching and learning within a discipline, thus teacher training programs need to ensure that PSTs develop these structures of knowledge by the time they complete their undergraduate program.

1.3.1 Horizontal structures of Knowledge

Horizontal structures of knowledge are made up of "specialised languages with specialised modes of interrogation" (Bernstein, 2000, p.157). These structures of knowledge are concerned with a new language or theory that is added to a discipline. Although, it is important to note that, this new language or theory is not based upon a previous knowledge or language of a discipline. In most cases, this new language or theory develops from past experiences. For instance in Life sciences, the naming of the fossils that were discovered from the Sterkfontein cave such as: Taung child, Mrs Ples and Homo-Naledi; all form part of a new language in Life sciences when teaching about the concept of Human evolution. However, these terms have nothing to do with the existing Life sciences language; rather they were informed by past experiences such as the social settings, language and other cultural ways of living in which these fossils were discovered from.

1.3.2 <u>Hierarchical structures of knowledge</u>

Hierarchical knowledge structures contain "coherent, explicit and systematically principled structures" (Bernstein, 2000, p.157), whereby the knowledge in the discipline is 'theory-integrated" (Muller, 2007, p.72). A systematically principled structure of a discipline delineates that, the knowledge builds on a chain form (Myers, 2015). Within this chain form, each of these individual links or concepts are connected to one other. These concepts or links are best learned when they are thoroughly sequenced and successfully taught under supervision of a more knowledgeable other. This is because, a conceptual hindrance at any particular point in the chain of understanding, may result in the learning process being ceased (Hoadley & Muller, 2009).

A theory-integrated discipline is characterised by students' ability to create new knowledge from past knowledge. Thus, this leads to the concept of 'cumulative learning' (Myers, 2015). Cumulative learning then requires that students first comprehend the fundamental concepts before progressing to the next concepts, as these fundamental concepts will form foundations for future learning. This is because, in hierarchical knowledge structures of a discipline, present knowledge is considered and extended upon in order to build new knowledge. So in Life sciences, the cell theory maybe regarded as an example of such a hierarchal knowledge structure, since it contains basic and unifying ideas that describe the biological living things in Life sciences, as it states that:

- ✓ All living things are made up of cells
- ✓ The cells are basic units of life
- ✓ The cells are the smallest living thing in the body that can perform of functions of life

The cell theory organises the knowledge of living organisms within the subject as shown in the **figure 1** below. So for cumulative learning to occur, it is important that PSTs must first understand the theory of cells, before they could begin to understand other complex knowledge about living organisms. So, deducing from the previous and this current section, we could then say that, Life sciences is a discipline that contains both hierarchal and horizontal structures of knowledge

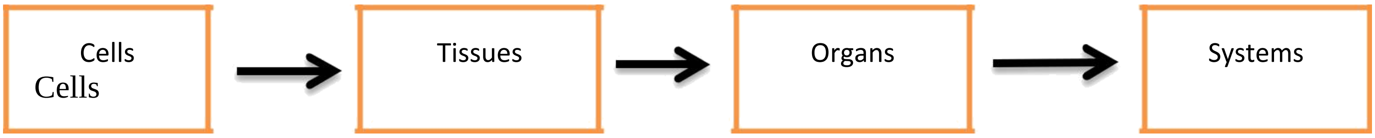

Figure 1: How the cell theory organises the study of living things in Life sciences

1.4 Life sciences as discipline

Life sciences consist of a systematised, empirical and coherent body of knowledge. This Life sciences knowledge has a unique nature that is acknowledged by methods of inquiry such as; scientific investigations, procedures, theories, reasoning in inquiry and producers that are accepted within the science discipline in general. Thus, this study viewed Life sciences as a scientific discipline just as Physics and Chemistry. Furthermore, Life sciences is qualified as discipline because it consists of a defined structure of SMK that is arranged according to specialisms such as Genetics, Zoology, Botany and Physiology to mention a few.

1.5 Motivation for this study

Rollnick et al. (2008) argues that when challenges related to teacher knowledge arise within the science teaching profession, most education researchers often tend to investigate other domains of teacher knowledge, more particularly Pedagogical Content Knowledge (PCK). Regrettably, this occurrence usually 'masks' possible challenges around other teacher knowledge domains such as; SMK and DK. There is therefore, not much research that has been done which has focused more on PSTs DK developments within teacher training programs. Thus, the motivation of this study was to investigate PSTs levels of understanding of the disciplinary nature of Life sciences that they acquire at the end of their training, in an attempt to meaningfully add to this knowledge gap that exists in science education.

1.6 Problem statement

The problem with research on initial science teacher education is that, it usually investigates PSTs conceptions at the end of particular courses (Adler, Pournara, Taylor, Thorne & Moletsane, 2009) and not their levels of understanding of the disciplinary nature of their subject of specialisation that they take away at the end of their teacher training program. Furthermore, some researchers in science education, especially those that have focused more attention on teachers' knowledge base, argue that there is not much extensive research that exists on DK as much as PCK (Thorne, 2014) . Thus, the relationship between the two knowledge domains is usually unknown and so much confusion arises when scholars try to distinguish between the two knowledge domains. Meanwhile, the few researchers who have conducted studies on SMK and DK such as; Rogan (2004), Taylor (2014), Grayson and Kriek (2009) seem to agree that, most South African science teachers do not have sufficient levels of SMK and DK for teaching their subjects of specialisation. As a result, this then jeopardises the quality of their lessons, as they fail to present their subject matter in ways that are easily understandable to their learners. Therefore, this study was guided by the following research questions:

1.5.1. <u>Main research questions</u>

1. What level of understanding of the nature of Life sciences as a discipline is demonstrated by B.Ed. 4th year Life sciences PSTs?
2. To what extent do PSTs develop the required gaze about Life sciences from the B.Ed. program?

1.6 <u>Scope and Limitation of this study</u>

The subsequent scope and limitations are highlighted for the purposes of future research. This study consisted of a relatively small sample of participants (29) from only one institution. Therefore, the results obtained from this study cannot be generalised to all other teacher training institutions. Consequently, more research still needs to be done in other institutions to verify or validate the findings that have been reported in this study.

1.7 <u>Outline of the chapters of the dissertation</u>

1.7.1 <u>Chapter one: Introduction of the study</u>

In this chapter, I outlined the background and context of the study, the motivation, problem statement and research questions. Also, I explained the scope and limitation of the study and the overall structure of the dissertation.

1.7.2 <u>Chapter two: Literature review and Theoretical framework</u>

In this chapter, I discussed the literature that I reviewed in this study. The Literature was concerned with understanding the disciplinary nature of Life sciences. This involved the SMK, CK and nature of Life science as a scientific discipline. Furthermore, in the chapter, I introduced the Legitimation Code Theory (LCT) along with its five dimensions, as the theoretical framework underpinning this study.

1.7.3 Chapter three: Research methodology

In this chapter, I outlined the methodology and research design of this study. Additionally, I explained the sample, procedures, ethical considerations, issues of validity and reliability as well as the research instruments that were used to gather the data. Lastly, I described the data analysis of this study.

1.7.4 Chapter four: Results and discussions

In chapter four, I presented the results of the study alongside with the interpretations of the findings and discussion thereof.

1.7.5 Chapter five: Summary, Recommendations, Implications and Conclusions

In this chapter, I provided a summary of the complete study. Moreover, I also presented the conclusions that were drawn from the results and outlined the recommendations in relation to the study's purpose.

1.8 Summary of chapter one

In this chapter, I provided a brief outline of the crux of the study. I also presented the problem to be investigated by the study, background and context, motivation as well as research questions that guided this study. Moreover, I explained and concisely discussed the main concepts that were core to the study. Furthermore, the next chapter I introduced the theoretical framework and reviewed the relevant literature that was aimed at unpacking all the concepts that I introduced in this chapter.

Chapter two: Literature review

In this chapter, I reviewed the literature related to the concepts of SMK and DK in relation to Life sciences, a problem that I researched in this study. Moreover, in this chapter I placed the study to its relative theoretical framework, which I largely drew from concepts of Maton's LCT dimensions.

Introduction

Researchers in the field of science education continuously argue that teachers' professional knowledge base shapes their overall pedagogy (e.g. Auseon, 1995; Shulman, 1986) .In other words, teachers' professional ways of knowing and representing their subject of specialisation plays a crucial role in every dimension of their instruction, content planning, implementation, assessment and reflection. Thus, research on teaching presented by Elbas (1983); Leinhardt and Smith (1985); Shulman (1986; 1987), Wilson, Shulman and Richert (1987) has placed more emphasis on the knowledge base of teachers, and examined how that knowledge influences teachers ability to plan lessons and provide effective instruction. Resulting from these studies, so much has been understood about teachers PCK. This PCK refers to the professional teacher knowledge that is needed to teach science effectively, and its development requires other knowledge domains such as SMK, Pedagogical Knowledge **(PK)** and knowledge of context (Rollnick et al., 2008). With that said, there is still little that is known about PSTs levels of understanding of DK about their teaching subject after completing their teacher training program. Thus, this study investigated the B. Ed. 4th year levels of understanding of the disciplinary nature of Life science.

2.1 An outline of Disciplinary knowledge

Cunningham, Perry, Stanovich and Stanovich (2004) define DK as a specialised form of teacher knowledge that enables teachers to engage in 'best practices' (p.12), such as thoroughly understanding the central and peripheral concepts of the subject and their application to real life situations. Thus, Kelly, Luke and Green (2008, p.ix) suggest that DK entails "developing identity, affiliation, critical epistemic stance, and dispositions as learners participate in the field of discourse and actions of collective social field". To explain this further, the authors' view **identity** as the qualities that define 'who' or 'what' a person is, while, **affiliation** involves the act of associating or connecting a person to a particular field of study. Also, **critical epistemic stance** is an individual's ability to assess the validity or falsehood of the knowledge from different sources about a discipline. Moreover, **dispositions** of a domain are guided by sets of attitudes and beliefs that are related to values such as: fairness, responsibility and social justice. The assertion by Kelly et al., that I have explained above showed that, DK goes beyond acquisition of basic skills and the possession of learned knowledge within a discipline. Although that is the case, at SAX, the focus in the Life sciences teacher training program, is on SMK. Maybe the assumption is that the PSTs will also develop identity, dispositions and critical epistemic stance in the process. But given that other aspects of DK such as the; history and philosophy of Life Sciences are not tested, so the type of DK PSTs take away at the end of their teacher training program is not known.

DK is a specialized teacher knowledge base which involves more than just knowing about the subject matter and how to represent it, in order to make it accessible for the learners, it entails knowing the subject of specialization in depth. Furthermore, the Life sciences DK legitimates the subject within the broader scientific field. So, Life Sciences DK thus has to do with the comprehension of the history, philosophy and the nature of the subject. Therefore, Life sciences DK includes; knowledge of the history, the philosophy and nature of the subject. It is unfortunate that Life sciences PSTs are not tested on their understanding of the disciplinary nature of Life Sciences. This then limits their understanding of Life sciences as a discipline and as a result, they do not fully develop a thorough gaze of their teaching subject. Hence, this study then placed more emphasis on investigating B.Ed. 4th year PSTs level of understanding of the nature of Life Sciences as a discipline. Reason being that, DK is necessary for teachers to teach effectively and see teaching from a different lens as compared to other professions, as this knowledge base shapes teacher pedagogy and impacts on the overall quality of their teacher knowledge (Taylor, 2014, Kind, 2009; 2011& Shulman 1986; 1987). Moreover, a teacher's DK enables them to have a universal understanding of the development of the Life Sciences knowledge. This knowledge involves: the context that led to the development of the knowledge, what makes the knowledge to be considered valid or invalid, as well as the likely misconceptions, ethical, cultural and religious issues that are held by the learners as well as the general public at large. Also, this knowledge base provides the teachers with ways of how to address these issues. All of the above aspects cover what the study is referring to as the nature of Life sciences as a discipline.

Thorne (2014, p.1) says that DK refers to "the intellectual structures within which the discipline delineates its unique focus of vision and social mandate", as mentioned in the previous chapter. Again, the author contends that DK is outlined as being made up of three elements which include: historical and philosophical basis to the development of teaching knowledge; current and progressive substantive teaching knowledge as well as the methods plus processes of theory or knowledge development. These elements all play an integral role in distinguishing the teaching profession from other disciplines. This type of knowledge base provides science teachers with a variety of approaches for reasoning, conceptualising and interpreting applications that separate 'a science teaching lens' from any other lens (Holt, 2014). So, when attempting to understand the constituents of Life sciences DK, one need to consider the NOS, the philosophy and history of science to be in a better position of fully comprehend this multifaceted and not widely understood teacher knowledge domain within the science education field.

2.1. 1Nature of Science

To understand the nature of Life sciences, we first have to know what we mean by the NOS. Carlson (2000) asserts that there is no clear or universal definition of the NOS. Lederman (2000) however says that, NOS has to do with the different topics associated with philosophy, sociology and history of science. In some cases NOS can be explained using the phrase 'nature of scientific knowledge' which typically refers to characteristics of scientific knowledge that are inherently derived from the manner in which it is produced, that is scientific inquiry and scientific methods (Lederman 1992, Lederman, Antink & Bartos 2014). The National Science Education Standards (NSES, 1996, p. 23) denotes scientific inquiry "as a diverse way in which scientists study the natural world and propose explanations based on evidence derived from their work". While on the other hand, scientific methods can be regarded as the processes which are used by scientists to generate and validate scientific knowledge within a field of study. In addition, the scientific inquiry and methods are at the 'heart' of the scientific enterprise, and as such, demands a valuable position in the teaching and learning of science. The tenet of the NOS inquiry that is relevant to secondary school science education include; "scientific laws, principles and theories are different types of knowledge" (Lederman, 2002).Furthermore, this NOS inquiry demands a comprehensive level of understanding of DK, especially amongst secondary science teachers' to be able to make these distinctions clear to their learners. The Life sciences subject has all the features of the NOS as described above, and that is why in this study it is viewed as a discipline. The nature of Life sciences deals with the sociology, epistemology, ways of knowing, the values and beliefs that are crucial to the subject and its development (Lederman, Abd-El-Khalick, Bell& Schwartz, 2002; Lederman, 1992). The nature of Life sciences is closely tied to its history and philosophy which will be explained shortly in the next sections of this chapter.

2.1.2 Understanding the philosophy and history of Life sciences

One aspect that makes Life sciences a discipline is that, it has a history and it is underpinned by a specific philosophy. The chief objective of the philosophy and history of Life sciences is to create awareness of the subject's mechanisms; developments over time and its main role in contemporary civilization (Lederman, 2002), what Maton (2010) would describe as the temporality dimension of the discipline (see **section 2.6** for more details). Tseitlin and Galili (2006) propose that, the philosophy of Life sciences refers to "its ontology and its epistemology, as well as the logical apparatus and other components which provide science with a structure and framework" (p.5). In other words, the philosophy of Life sciences describes the reasoning, validation, rationale and foundations of Life Sciences teaching. So, the philosophy of Life sciences assists teachers and other educational policy stakeholders in determining the type of science that should be taught and how it should be taught, not who should teach or who should be taught. As a result, this then displays itself in numerous curricular decisions such as; the choice of suitable content, deciding on the balance between experiments and theory, the appropriate number of problems set forward to be resolved, the selection of the suitable scientific methodology, the historical context of science (if any) and the types of laboratory work that could be conducted (Tseitlin and Galili, 2006).

In the South African context, the philosophy of Life sciences is clearly displayed out in the Life sciences CAPS document and this document serves as a 'roadmap' that guides Life sciences teachers use to teach effectively, by knowing how to pace and sequence lessons as well as planning meaningful assessments. Therefore, it becomes crucial that PSTs have adequate levels of understanding of the history and philosophy of Life sciences, so that they can be able to integrate their lessons and enhance their learners' understanding of the Life sciences concepts. By so doing, they will be able to provide their learners with the necessary awareness of the scientific methods, inquiry and the goals of Life sciences. Through this form of learning, science learners will be able to develop critical thinking skills that will enable them to evaluate authentic and non-authentic knowledge, gain better understanding of the subject as well as be able to develop a disposition within the Life sciences discipline. But, given that within the training program, the nature of Life sciences is not explicitly taught and is not assessed in both formal and informal assessments, consequently, SAX does not know the levels of understanding that B.Ed. PSTs have about the history and philosophy of Life sciences, which are key features of DK. Furthermore, the PSTs after completing the training do not know the importance and the purposes of the DK components that I have mentioned above, in relation to the teaching and learning of Life sciences.

When PSTs leave training with inadequate DK knowledge, which involves an understanding of the philosophical and historical components of the Life sciences as a discipline, these PSTs then contribute to the existing argument of science teachers not having 'acceptable' knowledge regarding the nature of science (Lederman, 2002). Subsequently, this lack of knowledge amongst PSTs could also result in them failing to teach other Life sciences concepts from historical points of view, which assist learners in understanding the development of certain concepts through history. For example, in Life sciences, human evolution is one of the topic that is usually taught successfully when a teacher takes on a historical and philosophical approach to the teaching and learning of this concept (Lederman, 2000).

2.2. <u>Subject Matter Knowledge</u>

According to Shulman (1986) **CK** is the teachers' ability of 'knowing what' (p.8) to teach. Shulman defines **SMK** as "the amount and organization of knowledge per se in the mind of the teacher" (p.9),as stated in the previous. While, Ball and MacDiarmid (1989) view **SMK** as a central component of what teachers need to know about their subject. Thus, in education research there is a blurred line between CK and SMK (see, Gudmundsdottir, 1987; Ball, Thames, & Phelps, 2008).This confusion between SMK and CK can be seen in different PCK models that exist in education research. Initially, Shulman's (1986) PCK model proposed that, there are three types of CK which include: CK, curricular knowledge and PCK. However, in Shulman's (1987) PCK model, CK is listed rather as Subject Matter Content Knowledge (SMCK) as one of the teacher knowledge domains together with PCK and curriculum knowledge, which may suggest that SMK is found within CK. Similarly to Shulman's work, Cochran and Jones (1998) PCK model defines SMK rather than CK as an overarching category, which is regarded as substantive knowledge only when combined with syntactic domain and beliefs about subject matter. While on the other hand, Ball et al. (2008) who were mathematical researchers proposed that, CK is an all-encompassing category that entails SMK, as they interpreted it to be the knowledge of the subject and its organising principles. Ball et al.'s view of CK involved Schwab (1978) distinction of substantive and syntactic knowledge structures.

Schwab (1978) proposes that substantive structures can be viewed as the central facts and organising ideas of a particular subject, for example in Life sciences; **genes are basic units of heredity**. These structures also deal with the relationship of these thematic ideas, as well as the order in which the most important principles of a subject are systematised. On the other hand, Xiaoyan (2007) refers to syntactic knowledge as "the canons of evidence and proof that guide inquiry in the field, which involves how a body of knowledge is produced and validated" (p.86). In other words, syntactic knowledge is concerned with the 'rules' that must be followed to create established knowledge within a discipline. These structures are the coherent means that organise the subject, and these speak to the 'methods of verification and justification of conclusions' (Schwab, p. 246). The syntactic structures are usually developed as the Life sciences PSTs practically engage in the subject.

Xiaoyan (2007) argues that teachers' need to have a thorough understanding of substantive and syntactic knowledge structures, in order to be able to understand and prevent possible challenges that learners might encounter when learning a certain Life sciences topic. Unfortunately, in the Life sciences teacher training program when the CK is taught to the PSTs, the substantive or syntactic knowledge structures are not taught explicitly. Thus, there are high chances that although PSTs do learn CK, they may struggle to teach this content to their learners. Hence Kind's (2009) findings revealed that novice teachers usually use transmission mode to teach science in their first year of professional teaching.

The substantive and syntactic knowledge structures are also referred to as Subject Matter Structures (SMS) and are explained as "an understanding that all biology content is interrelated and that a logical order of content presentation exists" (Gess-Newsome, 1995, p.320). Gess-Newsome further argues that the development of these SMS can be linked back to teachers' training background and are gradually improved over the years of teacher practice similar to SMK. Teachers' SMSs develop more when they are engaged in the act of teaching, because this is where they encounter situations that allow them to reflect on the content that they have learned prior or strengthen the beliefs that they have held initially. In this study, I took **SMK** to refer to **CK** as well as the various topics that are taught within a discipline, as well as the teacher's ability to **sequence** and **transform** these concepts in ways that will be accessible to their learners' (Kind, 2009).

2.3. <u>The nature of SMK</u>

There are numerous definitions that have come to existence about SMK; such definitions historically include that of Gudmundsdottir (1987) where he viewed SMK as teachers' thorough comprehension of the subject that they are teaching. His conceptualization of SMK was parallel to Shulman's (1986) view of CK that is, the teacher's ability of knowing what to teach, as stated in the previous chapter. Furthermore, according to Shulman, an understanding of the subject of specialisation involves an in depth and organized system of knowledge. Within the training program, the Life sciences PSTs are taught the subject matter, while how they conceptually organise and integrate the subject matter is often left to the PSTs to figure out on their own. Given that this is not a monitored process, it is often unknown if at the end of their training they have attained a deep and organised system of Life sciences SMK, that would later allow them in their professional teaching to be able to structure and deliver their lessons in meaningful as well as engaging ways that their learners will easily comprehend (Wilson &Winberg, 1988).

In the late 90's more SMK definitions came to be known. Carré (1998) is one of the researchers who offered not only a definition of SMK but also a useful explanation on how we can begin to see the value attributed to SMK in teaching. He stated that:

"The more you know about science, the more you will be able to provide a framework to help children think in scientific ways; in so doing you will also represent the subject with integrity" (p. 103).

It was during this period in which, according to some of the research dealing with SMK came to classify it as either being "weak" or "strong". Deng (2007) saw 'weak' SMK as arising from lack of subject matter mastery. On the other hand, Deng viewed 'strong' SMK as a tool that permits teachers to predict and diagnose pre-instructional misconceptions. This diagnosis of misconceptions is done through sequencing, reformulating and breaking down content that re-organises learners understanding. Thus, responsiveness of possible misconceptions can help teachers in choosing suitable teaching and learning strategies. Thus, in this study SMK was seen as an important aspect that contributes to the development of the DK of Life sciences that PSTs ought to have at the end of their training.

2.4 Life science disciplinary knowledge

Life sciences as a discipline is made up of SMK and NOS. The SMK of the discipline consists of a body of knowledge that is identifiable in the form of topics. The facts of each of these topics is what makes up the Life sciences substantive structures of knowledge, and is what is described in the subject's school textbooks. As described earlier, the NOS encompass the history and philosophy of the subject. The history includes how the knowledge of the subject was generated and validated. The history and the philosophy form the Life sciences syntactic structures of knowledge. The teaching of the syntactic structures of knowledge is meant to develop students' identity, affiliation, critical epistemic stance and dispositions of a domain. Nevertheless, the structures of Life science programs at tertiary institutions and many school science syllabi as well as textbooks include both substantive and syntactic knowledge structures, the purpose of including these knowledge structures are not made clear to teachers of the subject. Therefore, these teachers often teach this knowledge implicitly, leaving the development of the appropriate disciplinary gaze to develop by chance. For example, for every topic that is taught in Life sciences such as; genetics, cell theory and human evolution, they all have a history that is described in textbooks and taught to students, but, the purpose of learning this history is never made clear. Scientific investigations are also part of every science syllabus, students are constantly exposed to these investigations, but the purposes are never explained. Therefore, while the DK is taught, the disciplinary understanding of its nature and purpose is left to develop by chance.

Life sciences as a discipline has a substantive body of knowledge. The history of this body of knowledge shows that it is old. However, the old knowledge is used in a progressive manner. For instance, the knowledge about cells and genes was discovered a long time ago, though scientists even today still use these knowledge developments to try and understand their structure as well as how they work in different environments. The Life sciences body of knowledge is also independent of context. The concepts of DNA, cells and chromosomes mean the same thing anywhere in the world. In addition to that, the knowledge of the subject is highly condensed into words and symbols that are understood universally by all affiliated to the discipline (such words like; photosynthesis, cellular respiration and DNA).

2.5 Problems related to teacher training courses in developing SMK and DK

Van Wyk (2002) argues that, it is important to invest more time and resources in the cultivation and development of teacher DK and SMK especially in initial teacher education programs. This is because, DK and SMK supports teachers to fully comprehend their subject in terms of what makes their subject important and distinguishable. Also, these two knowledge bases allow teachers to identify central and peripheral ideas in their subject of specialization. Yet, the learning and acquiring of this SMK and DK for PSTs is not an easy process (Taylor, 2014).One problem is that, Life sciences PSTs are not clearly taught the distinctions between SMK and DK. Also, the other problem which was affirmed by Niess (2005) is that even in the 21st century, Life sciences knowledge is taught as bits and pieces of information. Moreover, it is still unknown if the bits and pieces of knowledge that PSTs learn in their training courses do eventually become interconnected after their training, in a way that supports them in understanding the knowledge structures as well as being able to translate this knowledge in forms that are accessible to their prospective learners. Furthermore, Niess argues that one of the problems with PSTs development of SMK and DK in training courses emanate from the ways in which they are taught. In most cases, the knowledge presented to them in an integrative manner, hence even after they graduate from their training; they still fail to teach their subject of specialisation successfully.

Taylor (2014) also indicated that, there are a number of challenges that pre-service teachers encounter during their teacher training. These challenges show the fact that Life sciences consists of a body of knowledge, which needs to be understood at microscopic, macroscopic and symbolic levels. It then becomes important that, when Life sciences PSTs are taught this knowledge, the concepts are scaffolded and thoroughly unpacked in order for the PSTs teachers to gain a deeper gaze of the subject. But, due to the high number of learners as compared to lecturers' ratio in different universities across the globe, students end up not acquiring the sufficient levels of understanding of the disciplinary nature of their subject (Smeby, 1996).

Kind (2009) argues that, teacher training courses usually offer a variety of knowledge systems without often specifying how PSTs should incorporate this knowledge presented to them into an organised as well as systematic knowledge base, leaving this to occur during their professional teaching years, which is also the case at SAX. This scenario then leads to majority of novice science teachers struggling to teach science, including Life sciences during their first few years of professional teaching. Some researchers such as Green and Rollnick (2006) suggest that, 'good' PCK is a product of SMK; but this study believes that DK is the building blocks of teacher knowledge, from which other teacher knowledge domains result and develop from. Thus, more time should be invested in the development of this knowledge base amongst teacher training institutions.

2.6 Theoretical Framework: Legitimation Code Theory (LCT)

In the above literature review, I discussed the aspects that Legitimises Life sciences as a discipline. In this section, I introduced the theoretical framework that supported this study. According to Maton (2010), the LCT framework can be used as a tool to identify and to gain understanding about the structuring principles that are core to a particular discipline. Thus, in this study, LCT was used as a theoretical framework in investigating PSTs levels of understanding of the disciplinary nature of Life Sciences. The LCT framework consists of five key dimensions namely **specialisation, semantics, density, temporality and autonomy.** However, this study only made use of the first four dimensions as the autonomy dimension was beyond the scope of this study. These dimensions were expanded on below, to ensure thorough understanding of LCT and for better comprehension of the data analysis that is presented in the next chapter of this study.

2.6.1 The specialisation dimension

The first dimension of LCT to be developed was the specialisation dimension. According to Maton (2010), this dimension was concerned with demonstrating clarity as to "what makes someone or something different, special and worthy of distinction" (p.196). In other words, this dimension was focused on what is considered important in a discipline, between the **knowledge,** which Maton refers to the epistemic relation of a field and the **knower**, which he denotes as the social relation of a domain. In Life sciences, it does not matter 'who you are' but what matters is the knowledge of the discipline. Although that is the case, the knowers are usually recognised for their contributions within the field. Arising from this, it is then possible to separate between: social relations **(SR)** amongst practices and their subjects, from epistemic relations **(ER)** between practices and their focus or object. To explain this briefly, each relation may be either weakly or strongly stressed in practices, and both these comparative strengths combined is what makes up the specialisation code. Furthermore, these relative strengths can be demonstrated as x and y axes of a Cartesian plane, whereby four major modalities are identifiable as shown in figure **2.1 below**

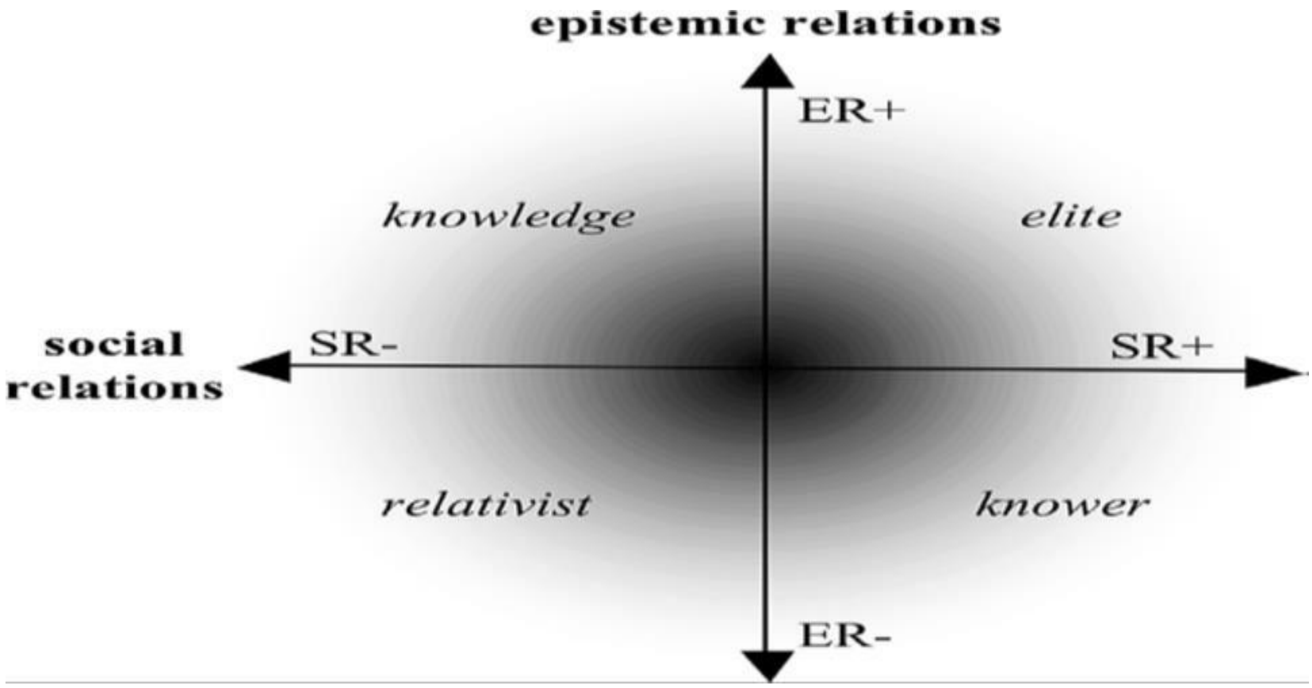

Figure 2.1: The Specialization codes of Legitimation (adapted from: Maton, 2007, p. 97)

<u>Summary of the four codes of specialisation</u>

- **<u>A knowledge code</u>**: Describes a view that a discipline is made legitimate by the body of knowledge that makes it up, and the symbol that explains this view is the epistemic relation **(ER+)** and the social relation **(SR-).**

- **<u>A knower code</u>** :Describes a position in which specialist knowledge is less important **(ER-),** rather the characteristics of the subject as a knower are stressed more **(SR+)** as the measure of success of a discipline (Howard & Maton, 2011). In this case, the knower is more important than the knowledge of the discipline.

- **<u>An elite code</u>:** Describes a view of a discipline which legitimacy is centred upon both having specialist knowledge and being the right type of knower. Howard and Maton (2011) strongly emphasises that the word "elite" is this context is not intended to show social discrimination, but to signify the importance of having legitimate dispositions and legitimate knowledge. So, generally in this instance, both the Knower **(SR+)** and the Knowledge **(ER+)** are important.

- **A relativist code:** Describes a view that, the legitimacy of a discipline is not tied to the characteristics of the knower or the specialist knowledge. Meaning that, neither the knowledge nor the knower is important in this in case and this is signified by the code **(ER-; SR-)**.

In summary, the specialisation dimension revealed that, Life sciences as discipline has a known or identifiable body of knowledge, and it is this knowledge that legitimises it as a discipline and not the knower of the knowledge.

2.6.2 Semantics dimension

Maton (2010) argues that the semantic dimension was developed in the late 2000s as a result of empirical research that focused in both classroom practices and intellectual fields. The idea of semantic gravity and semantic density can be used to analyse primary dimensions that appear through Bernstein's research in sociology. Furthermore, Maton (2013) proposed that, the Semantics dimension of LCT is thus largely based on concepts of social disciplines, whose structuring principles are theorised as semantic codes that are made up of semantic gravity **(SG)** and semantic density **(SD). SG** refers to the extent to which meaning is tied to its context. Semantic gravity is said to be relatively weaker **(SG-)** if the meaning is less-dependent on context. While on the other hand, semantic gravity maybe said to be stronger **(SG+)** if the meaning is mostly dependent on the context (Arbee, Hugo & Thompson, 2014).In addition, where meaning is strongly dependent to the context, segmented knowledge-building results while cumulative knowledge-building is dependent on weaker semantic gravity **(SG-)** (Maton, 2014).When looking at Life sciences, it is a subject that is not context dependent, meaning that, the discipline is characterised by a weaker semantic gravity. This is because; the Life sciences knowledge that is taught here in South Africa, is the same throughout the world. For example, taking the concept of **cellular respiration**, it will be the same concept in India, USA or anywhere else in the world. However, when teaching these scientific concepts, some teachers often use localised examples to enhance learners understanding. In most cases, these localised examples are expressed in the form of everyday examples that are familiar to learners and they could either be abstract or concrete.

Arbee et al. (2014) suggest that Semantic density **(SD)** refers to the extent to which meaning is reduced to concepts, terms, symbols, expression, phrases, gestures and clothing within socio-cultural practices. With stronger semantic density **(SD+)** it would mean that, there is a strong reduction of meaning within a social practice. Whereas, a weaker semantic density **(SD-)** signifies that, there is a lesser reduction of meaning within a social practice, as shown in **Figure 2.2** below. The Life sciences discipline is characterised by a strong semantic density. For example, when taking the same concept of cellular respiration again, one can write a whole book about the concept. This then suggests that, the meaning of the domain is highly condensed within the sociocultural practises of the discipline. This high condensation of the subject's meaning is further demonstrated by the governing laws, principles, subject matter and theories that organise the body of knowledge of Life sciences.

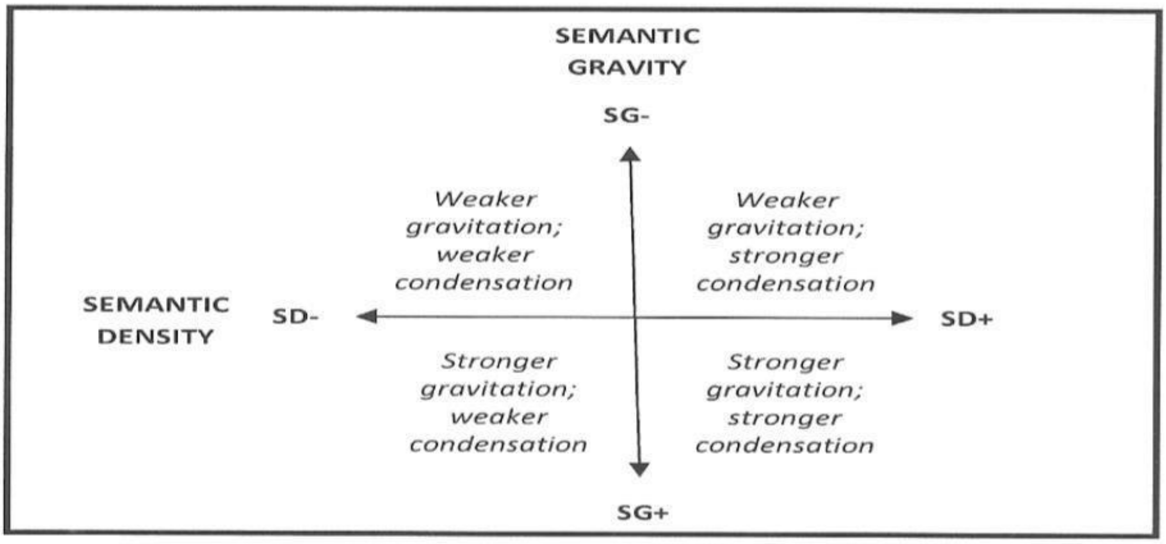

Figure 2.2: The semantic plane (adapted from: Maton, 2011, p. 66)

<u>Summary of the four codes of semantic dimension</u>

- **<u>Weaker gravitation and weaker condensation code</u>**: Describes a view that, the knowledge of the domain is not context independent **(SG-).** Also, that the meaning of the subject is weakly condensed into words or symbols **(SD-).**

- **<u>Weaker gravitation and stronger condensation code:</u>** Describes a view that, the knowledge of the domain is not context independent **(SG-).** Also, that the meaning of the subject is strongly condensed into words or symbols **(SD+).**

- **<u>Stronger gravitation and stronger condensation code:</u>** Describes a view that, the knowledge of the domain is context dependent **(SG+).** Also, that the meaning of the subject is strongly condensed into words or symbols **(SD+).**

- **<u>Stronger gravitation and weaker condensation code:</u>** Describes a view that, the knowledge of the domain is context dependent **(SG+).** Also, that the meaning of the subject is weakly condensed into words or symbols **(SD-).**

In summation, the semantic dimension indicated that, Life sciences as discipline consists of a body of knowledge that is context independent and this knowledge can be applied in real world situations to alleviate certain social ills. Additionally, the meaning of the subject is strongly tied to the socio-cultural practices of the discipline, such as expressions, words and symbols.

2.6.3 <u>Density dimension</u>

The density dimension of LCT refers to field's internal associations and also addresses the extent of range within a field, in terms of its subject matter. This aspect of the field is what Maton (2005) termed as material density **(MaD).** Maton also referred to the beliefs systems that govern a particular discipline as moral density **(MoD).** Arbee et al. (2014) contends that, these notions can be viewed as "members of units and the member of structuring principles respectively within a context" (p.48). In a scholarly perspective, **MaD** can be said to be the magnitude of the disciplinary community, while **MoD** refers to the magnitude or rather, the diversity of the belief systems that characterises a field. In scenarios where there is a stronger material density **(MaD+)**, this will indicate that there is quite a high variety of content within a particular domain. While a weaker material density (**MaD-)** will signify a low variety of content within a particular field of knowledge. Arbee et al. (2014) claim that in a discipline, moral and material density combinations have an impact on differentiation of subject matter and, thus the relationship between these unit structures. As mentioned earlier, Life sciences as a discipline is made up of many specialisms such as Microbiology, Biotechnology, Genetics, Zoology and Botany. This then shows that there is a variety of concepts that make up the discipline, thus it is denoted by a strong material density **(MaD+)**. These specialisms constitutes many other disciplines such as medicine, therefore the disciplinary community of Life sciences content is also high. The subject is also governed by different sets of beliefs systems (**MoD+)** that legitimises the discipline and they are different from the ones that govern the Chemistry or Physical sciences fields. This results from the different topics of the subjects and how they are taught. So, **Figure2.3** below shows the possible density codes.

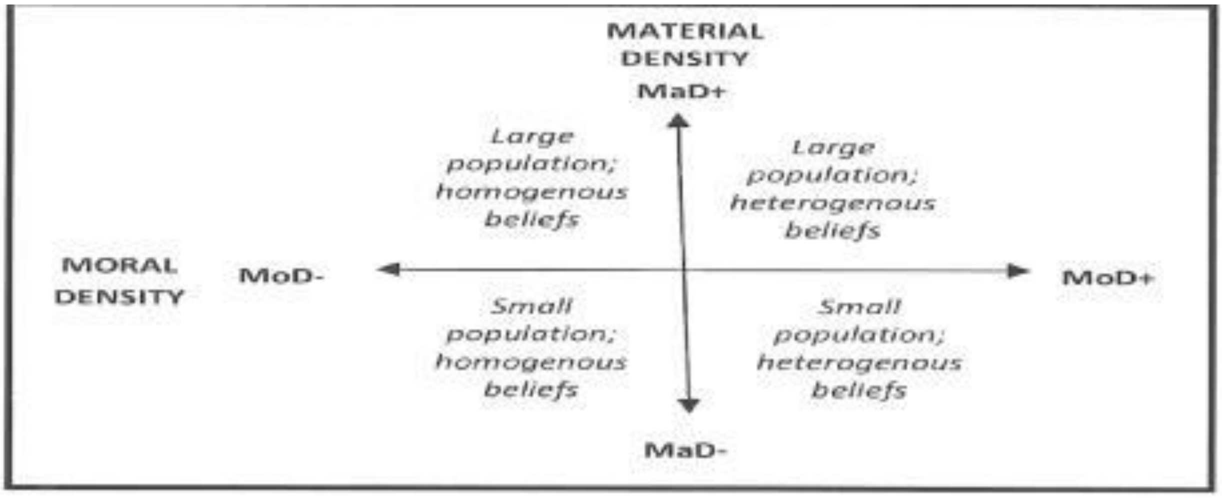

Figure 2.3: The density plane (adapted from: Maton, 2005a, p.90)

Summary of the four codes of density dimension

- **Large population and homogeneous beliefs code**: Describes a view that, the discipline is made up of a large disciplinary community **(MaD+)** and it is governed by the same belief systems **(MoD-)**.

- **Large population and heterogeneous beliefs code**: Describes a view that, the discipline is made up of a large disciplinary community **(MaD+)** and it is governed by different belief systems **(MoD+)**.

- **Small population and heterogeneous beliefs code**: Describes a view that, the discipline is made up of a small disciplinary community **(MaD-)** and it is governed by different belief systems **(MoD+)**.

- **Small population and homogeneous beliefs code**: Describes a view that, the discipline is made up of a small disciplinary community **(MaD-)** and it is governed by the same belief systems **(MoD-)**.

To summarise the above density codes, they showed that, Life sciences as discipline consists of a large disciplinary community with different belief systems.

2.6.4 <u>Temporality dimension</u>

Arbee et al. (2014) say that, temporality was the last dimension of LCT that Maton developed for his framework. Maton (2010) says that, the temporality dimension expands further on the conception of differentiation amongst fields and how they relate to their temporal profiles. A discipline is considered in relation to whether it is long-developed or recently established which talks about its temporal position **(TP)** or its age. This dimension also deals with whether a knowledge domain is forward-looking or backward- looking, which refers to its temporal orientation **(TO).** Some of the well-developed fields are strongly predisposed by historical disciplinary traditions, which perpetuates to the likely features that strongly determines the legitimacy of that particular discipline. In contrast, other disciplines emphasise more on 'keeping up with the times' (Arbee et al., 2014, p.49) and adjusting to the modern ways of knowledge development. Again in such scenarios, there are implications as to how legitimacy is comprehended in such fields. There are four likely temporal codes as shown in **figure 2.4** below that include: ***archeo-prospective*** **(old and forward-looking, TP+, TO-),** ***archeo-retrospective*** **(old and backward-looking TP+, TO+), neo-*****prospective*** **(young and forward- looking, TP-, TO-) and neo –*****retrospective*** **(young and backward-looking, TP-, TO+).** The temporal orientation and positioning combined show the rate of change of a discipline. Life sciences is not a recently established field as it was developed in the 18 centuries. Thus, Lederman (2002) argues that we cannot begin to understand the nature of a science without understanding its history and philosophy. Adding to this, studies (e.g. Aikenhead, 2000) that looked at Society, technology and science (STS) teaching and learning approach, similarly to those that looked at the history and philosophy of science (Bybee, 1987; Hodson, 1988) assert that, Life sciences is a progressive knowledge domain. Furthermore, it is a subject that draws from historical knowledge to alleviate social ills that arise due to scientific and technological advancements. So, it could be said that Life sciences is an old knowledge field that has forward looking temporal orientation, which is denoted by an archeo-prospective code.

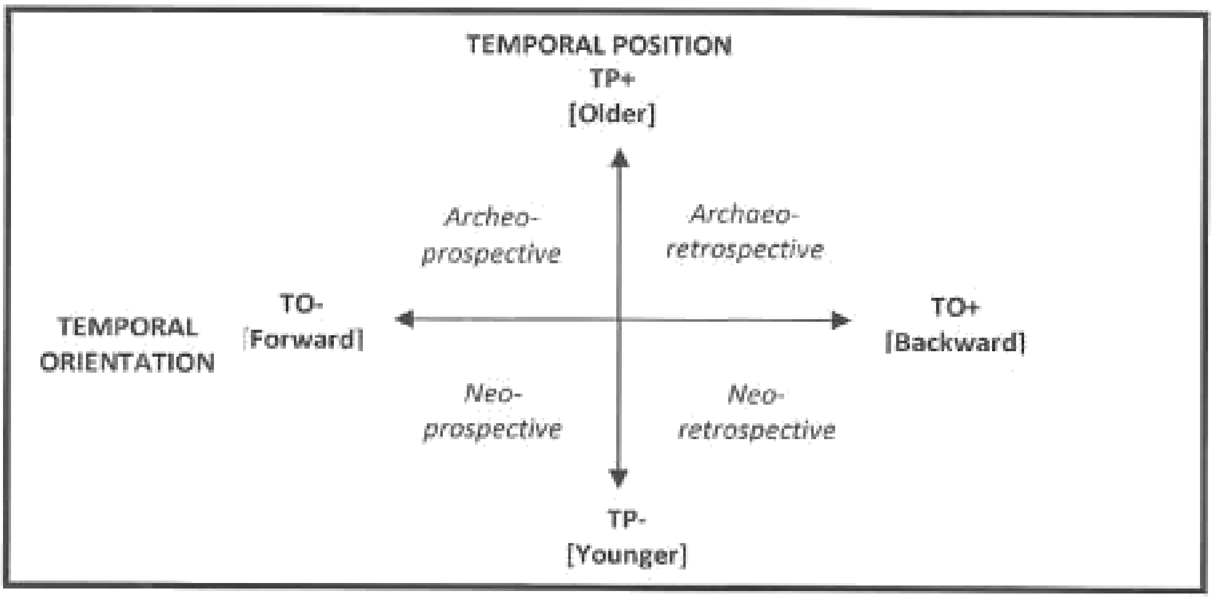

Figure 2.4: The temporality dimension (adapted from: Maton, 2005a, p.94)

Summary of the four codes of temporality dimension

- **Archeo-prospective code:** Describes a view that, the discipline is an old knowledge domain **(TP+)**, that has a forward looking orientation **(TO-).**

- **Archaeo-retrospective code:** Describes a view that, the discipline is an old knowledge domain **(TP+)** and it has a backward looking orientation **(TO+).**

- **Neo-retrospective code:** Describes a view that, the discipline is a young knowledge domain **(TP-)** and it has a backward looking orientation **(TO+).**

- **Neo-prospective:** Describes a view that, the discipline is a young knowledge domain **(TP-)** and it has a forward looking orientation **(TO-).**

To summarise the above temporality codes, they showed that, Life sciences as discipline is an old knowledge domain with a forward looking orientation.

2.7. Summary of the four LCT dimensions

In summary, using these four LCT dimensions, they presented Life sciences as a discipline in which; knowledge is what matters and not the knower. In addition to that, the knowledge of the subject is context independent while its meaning is strongly condensed with sociocultural practices. Moreover, the Life sciences discipline is characterised by a large disciplinary community and extensive content, additionally the knowledge domain is governed by different belief systems. Lastly, Life sciences is an old knowledge field that is legitimised by a forward looking temporal orientation. The above description of the nature of Life sciences is the understanding that 4th year PSTs should demonstrate at the end of their teacher training program, which is what this study was investigating.

2.8. Conclusion

In this chapter, I reviewed the literature related to the problem that was researched by this study. Additionally, I placed the study to its relative theoretical framework, on which I drew from Maton's LCT. Furthermore, I introduced as well as explained the four dimensions of LCT namely: **specialisation, semantics, density and temporality**. In the next chapter, I presented the methodology, research instruments that were used and also expounded on their suitability for this research.

Chapter three: Research methods, methodology, instruments and data analysis

3.1. **Introduction**

In chapter two, I reviewed literature that is related to the problem that was investigated in this study. Also in the previous chapter, the theoretical framework underpinning this study was introduced and thoroughly elaborated on. In this chapter, I outlined the research methodology and design of this study. Additionally, I explained the sample, procedures, ethical considerations, issues of validity and reliability of the research instruments that were used to gather the data as well as the analysis of data.

3.2. **Re-stating the research questions**

Since this study was concerned with investigating 4^{th} year PSTs levels of understanding of the disciplinary nature of Life science, the main aim of this study was then to provide answers to the following questions:

1. What level of understanding of the nature of Life sciences as a discipline is demonstrated by B.Ed. 4th year Life science PSTs?

2. To what extent do PSTs develop the required gaze about Life sciences from the B.Ed. program?

3.3. **Methodology of the study**

Methodology does not only refer to the "methods of data collection and analysis that are used", instead, it is a "theoretical justification for the use of the methods and the kind of knowledge that they are able to generate" (Case & Light, 2011, p.205). Methodology is concerned with the framework within which the research methods are located in. This study took on a qualitative approach that, however, yielded both quantitative and qualitative results. This is because, the study analysed the data sets both in words and numbers. The quantitative data set was made up of the raw and average scores that were obtained from the questionnaires. These quantitative findings were then interpreted qualitatively in words, so to explain what they meant in relation to the study's purpose.

A qualitative study refers to research that does not make use of any statistical or numerical procedures to generate its findings (Cousin, 2009), and this could be regarded as a disadvantage to some extent.

Haverkamp, Morrow and Ponterotto (2005) points out that, qualitative research has the ability to yield not only rich data set, but provides responses from participants that are detailed in their nature. Additionally, Moss (2012) suggests that, a qualitative study is usually more concerned with providing numerous answers. While on the other hand, quantitative research makes use of numerical measures to generate findings. Thus, one of the advantages associated with a quantitative approach involves the accuracy of results (Moss, 2012). Though that is the case, Viruel-Fuentes (2007) contends that one of the main constraint of using quantitative approach is that, the numerical measurements usually separates the information from its natural context, and this phenomena is referred to as de-contextualization. Furthermore unlike the qualitative approach, the quantitative approach is naturally concerned with looking for one answer. Thus, this qualitative study then implemented both quantitative and qualitative aspects, because the two approaches both have advantageous and disadvantageous contributions in research. So, this study then applied the features of both approaches to balance out the limitations associated with the two methodological approaches.

3.4 Research method

Cousin (2009) suggests that methods are the procedures and tools that scholars use for inquiries in research. So, since this study was only concerned with one problem in one institution, it then adopted a case study research method. There are multiple definitions that exist about case study research methods. One is offered by Yin (1994) who defines it as a research approach that, allows a researcher to explore a phenomenon within its particular natural setting, through the use of various data sources. This ensures that, the case is not viewed only through one lens; but rather multiple lenses are applied so that numerous facets of events can be discovered and understood. Similarly, Cohen, Manion and Morrison (2000) also view a case study research method in science education research, as being characterized by a detailed and in-depth analysis of participants in their natural environments. Also, this case study method, generally includes observing what happens to a single participant or rebuilding the ‘case’ to study about a group of individuals in a specific social group or in a learning institution. In this study, the ‘case’ involved investigating the 4^{th} year PSTs levels of understanding of the disciplinary nature of Life science at SAX.

Like any other research method, a case study has both limitation and benefits. Yin (1999) suggests that there are a number of benefits that are associated with a qualitative case study method and the examples include:

- The ability to capture reality of phenomenon in their natural context
- It offers descriptive narratives of the results that are rich and holistic in their nature
- It provides insights and integrates meaning to enhance the readers understanding of the findings or experiences.
- Plays a central role in the progression of a field's knowledge base

While on the other hand, the limitations of the case study research approach involves:

- Issues of validity, reliability and generalisability arising from focusing on a single group or a single instance
- Case studies are usually conducted by a single person and this person is normally the one analysing the data collected. This can contribute to the issues of biasness in a data collection and results.

Yin (1999) says that, although there may be disadvantages that may be linked with using a case study research method, they do however, have many advantages when used in properly in a qualitative research. This is because; they are useful and important methods of data collection, especially in cases of rare phenomena. Given that this study has never been conducted before within the South African context, the case study research method was thus deemed suitable for this study.

3.5 <u>Participants of the study</u>

Coyne (2009) argues that in qualitative research, the choice of participants has an important impact on the overall quality of the study. Since, the study was concerned with understanding the levels of understanding of the disciplinary nature of Life science that the 4^{th} year PSTs takes away at the end of their teacher training program, the participants of this study then consisted of 29 4^{th} year Life science PSTs who were enrolled for a B.Ed. degree and 1 Life sciences lecturer at SAX. The Life sciences lecturer that participated in this study, was the only lecturer that gave consent to participate in this study amongst other three lecturers that were also invited to participate but did not give their consent , hence being the only lecturer partaking in this research.

3.6 <u>Data collection instruments</u>

Data collection instruments generally refer to the tools that are used to gather data for a study (Opie, 2014). The data set for this study was collected through the use of two research instruments which were; questionnaires and semi-structured focus group interviews. These research instruments were particularly chosen for this study, because they had unique characteristics, such as, their ability to provide rich data set and this was in alignment with the methodology as well as the research method of this investigation, thus their suitability in this study.

3.6.1 <u>Questionnaires</u>

The questionnaires for this study were adopted from a running project that was conducted at SAX, thus it was an already piloted instrument. However, before the questionnaire was administered to the participants, the Likert items were revisited to establish the sort of data that they would yield. This process involved, revisiting the items individually and categorising them using the four LCT dimensions. After the items were classified into the various dimensions, they were then analysed in terms of the Likert levels, as to what it would mean if a respondent agreed, disagreed and neutral. After this was done, I started to get understanding of whether the data set had the potential of answering the research questions for this study.

Del Grego, Walop and McCarthy (1987) define a questionnaire as a set of questions for gathering information from individuals. The authors' further point out that, a questionnaire can be made up of either closed ended, open ended questions or a combination of both. Close ended questions are those that require respondents for check- mark or short answers, such as yes or no (Best & Kahn, 1993).In addition to that, they are useful for easily categorizing the data set. While on other hand, open ended questions are those that call for a free response and the respondents are encouraged to use their own words when answering such questions (Michael, 1995). So for this study, the questionnaire that was used was made up of a total of 24 questions, out of which 22 items were closed ended Likert items, while 2 were open ended items (see **Appendix1** for the questionnaire).

3.6.1.1 <u>The structure of the questionnaire</u>

The questionnaire that was used in this study consisted of 22 Likert- scale items and 2 open-ended questions. Rensis (1932) defines a Likert scale as a summation of responses of numerous Likert items. Likert items are commonly statements, which the participants are required to assess using any type of objective or subjective criterion, usually the level of disagreement or agreement is measured. This study used a Likert scale questionnaire that consisted of five levels as shown below (see attached **Appendix 1**). However, these levels were later combined to three levels being agree, disagree and neutral because the sample of this study was relatively small and the results became more significant, after combining the different Likert scale levels.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly disagree

These Likert scale items focused on PSTs understanding of Life science in terms of the LCT theory (**see a later section for more details**). While, the open-ended items of the questions were aimed at eliciting the PSTs understanding of Life sciences as a discipline, in relation to SMK and the aspects related to NOS.

3.6.1.2 <u>Semi-structured focus group interviews</u>

According to Drever (1995) a semi-structured focus group interview, is usually used in qualitative research as an approach of inquiry. This type of focus group interview uses a combination of a set of open ended and pre-determined questions that are usually aimed at prompting the discussions, with the prospect for the interviewer to discover certain responses or themes in more details. Furthermore, these semi-structured interviews usually do not restrain the respondents to only a set of pre-planned answers. Hence, they are used to comprehend how certain interventions work and how they could be enriched. Moreover, it permits respondents to raise and discuss concerns that the researcher may not have considered initially, thus yielding more critical and detailed responses. Therefore, this study particularly made use of semi-structured focus interviews, because already the literature reviewed in this study had revealed that, not much is understood about DK within science education. Also, given that Opie (2014) points out that, questionnaires could sometimes be biased and when analysed they could present gaps in the data set, which arise from incomplete responses from the respondents. So in this study, the semi-structured focus group interviews were used in triangulation with the data set that was produced by the questionnaires to strengthen the credibility and quality of this research study (Patton, 2002). In this study, I conducted two focus group interviews sessions with the PSTs and only one interview session with lecturer, given that he was the only lecturer who gave consent to participate in this study. The semi-structured interview items shown in **Table 3.1** below were aimed at provoking the participants' understanding of the disciplinary nature of Life sciences that they demonstrated in their responses to the Likert scale items. This is because; semi-structured focus interviews may allow the researcher the chance to assess preliminary understanding demonstrated by participants at the beginning of the study, yet still providing enough opportunity for different ways of seeing and understanding amongst participants that may reveal other insights relating to their initial ideas.

Table 3.1: List of the semi-structured items that were asked during the different interviews sessions

Semi-structured focus group interview questions for interview 1 with two 4th year PSTs	**Semi-structured focus group interview questions for interview 2 with three 4th year PSTs**	**Semi-structured questions for interview 3 with the 4th year lecturer**
1. As L.S4 students what type of knowledge do you think you have gained after completing the whole teaching course? 2. Do you know anything about Subject Matter Knowledge and Disciplinary Knowledge? 3. Do you think you that you are taught this knowledge? 4. Which one of these two knowledge bases do you think is taught more? 5. In terms of assessment, do you think still SMK is assessed than DK? Is DK ever assessed? 6. To what extent do you think	1. Do you know anything about subject matter Knowledge and Disciplinary Knowledge? 2. How much of these two knowledge bases (DK and SMK) do think you are taking away at the end of your teacher training course? 3. Do you think if they taught these two knowledge bases explicitly you would understand them better? 4. Do you think it takes a special person to study Life science or anybody can? 5. What sort of knowledge have you gained throughout your training?	1. Do you as a Life science lecturer have a clear structure of the type of Subject matter knowledge (SMK) disciplinary knowledge that is taken away by 4th year PSTs after they complete the Life science course? 2. When you structuring your own course, do you think about structuring the knowledge in terms of SMK and DK? -Do you know the difference between SMK and DK? 3. Is the assessment of SMK and DK the same or different? 4. So can you say that DK is a knowledge domain that is not recognised in Life science?

you have gained these two teacher knowledge base since from first year to now? 7. Do you think if you were taught these two knowledge bases explicitly you could have had a better understanding of them?		5. Do you think that the PSTs leave the training with sufficient levels of SMK and DK that allows them to teach the subject well? 6. With regards to the content and methodology classes, what is their role in the development of PSTs SMK and DK?

3.7 <u>Procedure</u>

About 29 Life Sciences PSTs and 3 Lecturers' were asked to participate in this study at a time and venue agreed upon. Unfortunately, only 1 out of the 3 lecturers' participated in this study. The participants were then given information sheets (see **Appendix2**) that gave the general overview of what the study was about. After it was certified that the participants knew what the study was about, they were then asked to fill consent forms (see **Appendix 3**) before continuing further partaking in this study. This was done to ensure t, the participants were aware that their participation was completely voluntarily and are aware that they could withdraw from the study at any given point without any adversities. Also, the participants were given the consent forms, so I could get permission to utilise their responses as part of the data set(s), while making them understand that their responses will be used with confidentiality and anonymity. From there on, the 29 PSTs were given questionnaires to fill and returned following their completion. From the same participants they were asked to again participate in a focus group interview. Unfortunately, only 5 PSTs and 1lecturer consented to partake in the interview sessions and further arrangements were made in terms of time and venue for these interviews.

Initially, it was intended that each focus group interview will involve a maximum number of four participants to allow enough interaction amongst the participants. Also, these groups were intended to be structured in a way that there would diversity amongst the participants in terms of race, gender, age and educational background. Additionally, that these focus group interviews will be conducted several times with different participants, in order to detect trends and patterns in their insights. However, due to other unforeseen academic events, a total of three focus group interviews with unevenly distributed group members were conducted.

The first semi-structured focus group interview consisted of two black male PSTs, while, the second semi-structured focus group interview comprised of three black female PSTs and lastly the last interview was conducted with the lecturer that was involved in teaching the subject within the Life sciences department.

3.8 Data analysis

As stated by Hatch (2002):

Data analysis is a systematic search for meaning. It is a way to process qualitative data so that what has been learned can be communicated to others. Analysis means organizing and interrogating data in ways that allow researchers to see patterns, identify themes, discover relationships, develop explanations, make interpretations, mount critiques, or generate theories. It often involves synthesis, evaluation, interpretation, categorization, hypothesizing, comparison, and pattern finding. It always involves what Wolcott calls "mind work" . . . Researchers always engage their own intellectual capacities to make sense of qualitative data. (p. 148).

The above quote indicates that, data analysis is the most crucial aspect in research. This is because, data analysis provides feedback on the types of insights that the collected data reveals concerning the problem(s) investigated by the study.

3.8.1 Deductive analysis of the data sets

A deductive analysis is one that involves a qualitative researcher using a particular theory or framework that is in alignment with the purpose of their study (Hatch, 2002). In other words, a deductive qualitative analysis refers to a theory guided research and in this study; the LCT dimensions were used as a conceptual framework guiding the analysis of this study. What is important to note is that, all the data analysis of this study was guided the different aspects of the LCT dimensions that legitimatised the Life sciences discipline.

3.8.1.1 Deductive analysis of the Likert items

The 22 Likert scale items of the questionnaire were analysed deductively using the four dimensions of the LCT that were discussed in the literature review chapter (**section 2.6**). **Table 3.2** below, showed examples of explanations that guided the analysis of Likert items; however, a detailed and complete conceptual framework can be viewed in **Appendix 5**. The explanations in the table below, described what it meant when the PSTs agreed with each of the Likert scale items with regards to the four LCT dimensions and their respective codes. Whereas for all instances, disagree meant that the PSTs had a different view, while neutral showed that the PSTs were not sure whether they agree or disagree.

Table 3.2: The sample of how the Likert scale items were deductively analysed using the LCT dimensions

LCT dimension	**Likert scale Item**	**Explanation of how responses to the item were analysed**	**Likert Scale level**
Specialisation	1.It takes someone with special kind of personality to be an expert in this subject	This item meant that it takes an individual with certain personal attributes or characteristics to be a specialist in Life sciences.	If PSTs agree it meant they their view was that, being a specialist in the subject involved certain personal attributes or traits. Implying that the knower mattered and knowledge does not matter thus the code **(ER-, SR+).**
Semantics	5. The learning of this subject develops a particular gaze through which one can understand aspects of the world.	There is a certain understanding or way of thinking that is expected to develop in someone who is learning Life Sciences such as the nature of knowledge that makes up the Life Science subject e.g. is it context dependent or context independent, is it highly condensed or not.	Agree in this case meant that the PST view was that the subject content is highly condensed to symbols and expressions. Also they thought that the subject knowledge is context independent and this is signified by the code **(SD+, SG-).**
Temporality	6.This subject makes connection across time	The item puts forward that, Life sciences makes links between historic knowledge and the existing knowledge to expand its knowledge base in the contemporary modern world. These connections within the subject show the progression of knowledge of the subject, as well as it's backward and	Agree meant that the PSTs believed that the subject does make links between its past and present knowledge bases to show the knowledge advancement of the subject. This then meant that the subject is an old domain of knowledge with a backward and forward looking orientation and this is showed by the code of **(TP+, TO+).**

		forward looking temporal orientation.	
Density	16. There is a wide agreement amongst subject experts about the nature of the subject	This item alluded that the nature of the subject in terms of density has a large amount of content and that there are many beliefs that exists about the content of the subject.	Agree indicated certainty amongst PSTs that there is mutual consensus between the specialists about the nature of Life sciences. Meaning that, there's a large population with homogeneous beliefs (MaD+; MoD-) Whereas, disagree meant the inverse. Neutral demonstrated that the PSTs were no sure about the item.

The complete data analysis of the Likert scale items (**Appendix 5**) showed that six out of the twenty two items focused on the **specialisation dimension,** which was concerned with the epistemic and social relations of a discipline. The epistemic relations dealt with the body of knowledge that characterises a discipline. Whereas, the social relations was concerned with the personal attributes and talents that specialists possess within a particular field. Within the Life sciences discipline, it is the knowledge that matters more than the knower. So, the purpose of the six Likert scale items within the specialisation dimension was to find out PSTs understanding of the subject in terms of its knowledge and knower relations.

With regards to the **semantics dimension**, there was only one item out of the twenty two that was categorised under this dimension. This dimension was concerned with the semantic gravity and density of a field. Maton (2010) says that, semantic gravity refers to the degree to which meaning is linked to its context of attainment. Whereas, the semantic density deals with the extent to which the meaning is condensed within expressions, symbols and phrases. The Life sciences discipline is legitimised by a systematic body of knowledge that is context independent, and its meaning is highly condensed within the sociocultural practices of the field. So, the chief objective of this item was to elicit PSTs comprehension about meaning, as well as the context of use or acquisition of the subject's knowledge.

Five items of the Likert scale were concerned with the **temporality dimension,** which deals with the temporal positioning as well as the temporal orientation of a field. This dimension was concerned with understanding if whether a domain was a young or old, also, if it had a forward looking or backward looking direction. Life sciences is a discipline that is old in its temporal positioning, but has a forward looking direction. These items were asked in order to gain an understanding of the PSTs comprehension of the subject's temporal positioning and its orientation.

Out of the twenty two Likert scale items, eleven focused on the **density dimension**. This dimension was concerned with a field's internal coherence and consensus in relation to what makes up the disciplinary knowledge domain, its methods and focuses also whether if it is governed by a common culture. Within a discipline, material density discusses the size or population of the disciplinary community and the magnitude of its knowledge base .Whereas, moral density explains the amount of belief systems or what Maton (2005,p.2005a) refers to a "school of thought" within a field. The Life sciences knowledge domain is legitimised by a large population that is characterised by different beliefs. The aim of these items was to probe PSTs understanding about their understanding of the variety of content that makes up the discipline, as well as the different belief systems that govern the knowledge domain. After all the Likert scales were analysed and fitted into their respective LCT dimensions, the responses were then calculated and the raw scores were recorded as shown in the attached **Appendix 6**. The data findings yielded by this analysis was further discussed and interpreted in the next chapter.

3.8.1.2 Deductive analysis of the open-ended items

Similarly to the Likert scale items, the open-ended items were also analysed deductively using the four dimensions of LCT. Each of the items was coded as shown in Table **3.3** below. According to Opie (2004) coding is a reasoned and diagnostic process in which data is classified into different categories to simplify the analysis of the data. Again, the following analysis of the open-ended items provided a synopsis of how the items were coded and analysed (**Appendix 7** shows the complete analysis of the open- ended items). The open-ended items consisted of two items. The first item was phrased as *"when someone studies this subject, they learn…"* this item was aimed at gaining comprehension of the type of knowledge that PSTs acquire when learning this knowledge. Again, this knowledge (SMK) was interpreted in terms of the aspects of the four LCT dimensions. The second item was expressed as "*when someone studies this subject, they learn how to…"*, this item was intended at eliciting the type of NOS understanding that PSTS have with regards to the disciplinary nature of Life sciences. Also, the analysis of this item was largely guided by the features of the four LCT dimensions as represented in the **Table 3.3** below. Generally, these two open-ended items were intended to gain a rich insight in terms of the PSTs understanding of the disciplinary legitimacy of Life sciences, in relation to the respective LCT dimensions that have been mentioned in this study.

Table 3.3: A sample of how the open-ended items were analysed

Statement	LCT dimension	Explanation
1 .It teaches us about things that happen, or are to happen in the future	**Temporality**	This statement contained aspects that had to do with the temporal orientation of the subject.
2.Human evolution, Human reproduction, Biodiversity, Life processes in plants and animals, plant reproduction	**Specialisation**	The participants listed the SMK of Life sciences. This SMK organises the knowledge of the subject. This then was viewed as showing the epistemic relation aspect of the specialisation dimension.
3. Content is so varied and can be applied to everyday life. The content is very interrelated to each other	**Density**	The statement showed how Life sciences is differentiated within which is a key aspect of the density dimension.

3.8.1.3 Data analysis of the semi- focused group interviews

The semi-focused group interviews made use of semi-structured questions, so the responses were read through more than once and transcribed. After the transcription process was completed they were then partially analysed using the four LCT dimensions as shown in the two excerpts below (see **Appendix 8** for completed transcripts of the interviews). This LCT guided analysis was implemented to check the consistency of PSTs understanding of the disciplinary nature of Life sciences.

Actual interview Question: How much of these two knowledge bases are you taking away at the end of your teacher training course?

Statement 1: I think quite a lot, even if I am a primary school teacher. The children that you find in class they challenge you because they want to know more. So the knowledge that I have gained helps me, because for example if you are teaching about photosynthesis **specialisation**, in primary it's not as in-depth as in high school. But a child may want to know if it does happen at night, so the knowledge I have gained about the subject will help in such cases, I could be able to explain even if it's not in the curriculum.

Actual interview Question: What sort of knowledge have you gained throughout your training?

Statement 2: …that were important and we actually saw that there was a link between the physical science knowledge and the Life science knowledge **density**. This is because over the years you realized that you now need to draw back from the Physical science knowledge and implement it in the Life science. You further realize that ohhh you can't separate them as much as they categorize them as Life science and physical science.

The semi-focused group interviews excerpts were used in triangulation with the results obtained from the open and closed ended items of the questionnaire. They were used as supporting statements that were aimed at strengthening the validity and credibility of findings that yielded from the PSTs responses to the questionnaire that investigated their levels of understanding of the disciplinary nature of Life sciences.

3.9. Validity and reliability of the research instrument

The concepts of validity and reliability are significant in education research reason being that, almost all the measurements attempted in this field are acquired indirectly. Thus, it becomes important to evaluate the reliability and validity of the instruments that are used in research. So, a researcher in education then needs to provide in their research report, an explanation of reliability and validity of their research instrument. In this study two research instruments were used, that is one, a questionnaire that was administered to the 4th year Life science PSTs (**Appendix 1**) and two, semi-structured focused group interviews with PSTs and a lecturer.

Validity and reliability are criterions that are used in both qualitative and quantitative research to assess credibility of a study. Meaning that, validity and reliability in research are aimed at ensuring that the researcher's findings are "worth paying attention to" (Lincoln & Guba, 1985). Although that is the case, Hatch (2002) argues that while reliability is necessary, but it alone is not sufficient in qualitative research. So, for an instrument to be reliable, it also needs to be valid. Mchunu (2009) says that in most cases, the use of questionnaires in education research needs to be handled with a high degree of sensitivity in relation to the issues of validity and reliability. This is because; questionnaires play a limited role in research, as they are usually a 'one-time' (p.162) data collection instrument that has a very short life cycle, which can only be administered to a small number of participants. Although that is the case, there are numerous strategies that could be employed in a study to improve both reliability and validity of research instruments, especially questionnaires. For a questionnaire to be valid, it is essential to check whether the right questions are being asked and if these questions are phrased in a non-confusing way. Furthermore, validity of an instrument requires that, the researcher ensures that the items represent the important features that are aligned to the purpose of the study. To ensure this, Cohen and Marion (1989) argues that it then becomes crucial that the researcher defines and breakdown all the complex terminology so they have the same meaning to all the participants.

3.10 Conclusion

In this chapter, I outlined the research methodology and design of this study. Additionally, I explained the sample, procedures, and ethical considerations. Furthermore, I also outlined the issues of validity and reliability of the research instruments that were used to gather the data as well as the analysis data. In the following chapter, I explained the research findings as well as provide a summary thereof.

Chapter four: Findings and discussion of the results

4.1 Introduction

In the previous chapter, I delineated the methodology and design of this study. Moreover, I explained the sample, procedures, ethical considerations, issues of validity and reliability, research instruments that were used to gather the data and further described the analysis of the data. So in this chapter, I presented the findings and discussed the results of the study.

4.2. Re-stating the research questions

This study was aimed at investigating 4th year PSTs levels of understanding of the disciplinary nature of Life sciences. Thus, the purpose of this study was then to provide answers to the following research questions:

1. What level of understanding of the nature of Life sciences as a discipline is demonstrated by B.Ed. 4th year Life science PSTs?

2. To what extent do PSTs develop the required gaze about Life sciences from the B.Ed. program?

4.3 Data analysis and results

The Likert items were formulated in such a way that , when a PST agreed to what the item was saying , it was then possible to deduce their view about the nature of Life sciences. While, disagree meant that the PST had a different view from the one depicted in the Likert scale item. The data analysis framework of this study, therefore meant formulating categories of what **agree** meant and then counting the number of PSTs who had said agree, those who were neutral and those that disagreed. **Section 3.8.1.1** in the previous chapter, clearly showed how the analysis was carried out for all the four dimensions of LCT and a complete analysis framework was attached as **Appendix 5**. So, **Table 4.1** below showed an example of how one Likert item within the specialisation dimension was analysed, and this was meant to serve as a reminder to the reader as to how the Likert scale items were analysed for this study. The results obtained from this analysis were explained in the next sections of this chapter.

Table 4.1: An example of how one specialisation dimension item was analysed

LCT dimension	Likert scale Item	Explanation of how responses to the item were analysed	Likert Scale level
Specialisation	1.It takes someone with special kind of personality to be an expert in this subject	This item meant that it takes an individual with certain personal attributes or characteristics to be a specialist in Life science.	If PSTs **agree** it meant they thought that, being a specialist in the subject involved certain personal attributes or traits. Implying that the knower mattered and knowledge does not matter. **Disagree** meant that the PSTs had a different view. While, **neutral** suggested that the respondents were uncertain.

4.3.1 Specialisation dimension

The specialisation dimension was concerned with the epistemic and the social relations of a discipline. So, **Table 4.2** below presented the results that yielded from the PSTs responses to the Likert items that were classified under the specialisation dimension.

Table 4.2: Results of the six specialisation dimension items

Items	PSTs responses			Explanation of the Agree response.
	A	D	N	By agreeing:
1. It takes someone with special kind of personality to be an expert in this subject	**9**	**12**	**8**	Nine out of twenty nine PSTs showed a view that in the Life sciences discipline, the knower matters more than the knowledge.
2. Anyone can learn this subject given sufficient time or training	**20**	**4**	**5**	Twenty out of the twenty nine PSTs were of the view that knowledge matters more than knower.
3. There is a special kind of knowledge that a subject specialist needs	**29**	**0**	**0**	All The PSTs were of the view that it is knowledge that is more important within the Life sciences discipline.
4. There are special skills that one develops when learning this subject	**26**	**3**	**0**	Twenty six out of twenty nine PSTS were of the idea that Knowledge is more important than the knower within the Life sciences domain.
10. It is vital for teachers to understand what the subject is, and what it is not	**28**	**1**	**0**	Twenty eight out of twenty nine PSTS were of the idea that Knowledge is more important than the knower within the Life sciences

				domain.
20. Certain kinds of people understand this subject better than others	**5**	**20**	**4**	Five out of twenty nine PSTs were of the opinion that the knower matters more than the knowledge within the Life sciences discipline.
Total number	20	6	3	

Key: Agree (A), Neutral (N) and Disagree (D)

From the above **Table 4.2**, it is important to note that, the agree response demonstrated that, majority of the PSTs were of the view that within the Life sciences discipline, the knowledge matters more than the knower of the subject. These results showed that twenty out of twenty nine PSTs at 4th year level of the B.Ed. degree, understood that in Life sciences, the knowledge is what legitimises the discipline and not the knower as well as that, there are no special qualities or personality traits required to learn the subject.

The issue of knowledge being important in teaching is also emphasised by Howard (1992, p.2) who argues that "teachers' can't teach what they don't know". In other words, this then alludes that teachers' knowledge is instrumental in promoting effective teaching and learning. Thus, most studies in science education have focused more on teacher knowledge than teachers' personal attributes. However, it is not so long ago that research has started to pay more attention in teachers' beliefs and identity, and such a study was conducted by Luehmann (2016) which revealed that teachers' identity shapes their overall pedagogy. Bryan and Atwater (2002) define teacher identity as being closely linked to teachers' beliefs. Furthermore, these beliefs are referred to as a collection of ideas, that describe the content and structure of a teacher's thinking which guides their actions. So, these beliefs and identity could be viewed in relation to the personal attributes that were highlighted within the specialisation dimension. This could be possibly the reason why seven out of twenty nine PSTs thought that the knower was more important that knowledge.

4.3.2. Semantics dimension

The next item in the questionnaire focused on the semantic dimension. Within this dimension, the semantic code of density was concerned with the condensation of meaning within socio-cultural practices of a subject. Whereas the semantic code of gravity, talks about the context dependence or independency of knowledge within a discipline. Life sciences is characterized by a sematic code of **(SG-, SD+)** which signifies that the knowledge is context dependent, and the meaning of the subject is strongly condensed within the sociocultural practices of the discipline.

Table 4.3: Results of the semantic dimension items

Items	PSTs responses			Interpretation of the Agree response. By agreeing:
	A	**D**	**N**	
The learning of this subject develops a particular gaze through which one can understand aspects of the world.	**24**	**4**	**1**	Twenty four out of twenty nine PSTs were of the idea that learning this subject equips one with knowledge that can be applied in real life situations. In other words, the PSTs viewed the knowledge of the subject as being context dependent and the meaning being therefore strongly condensed into words and symbols.

Key: Agree (A), Disagree (D) and Neutral (N)

The results in **Table 4.3** indicated that, twenty four out of twenty nine PSTs, erroneously believed that the Life sciences discipline comprises of a stronger semantic gravity **(SG+)**, which meant that the knowledge of the subject was context dependent. This finding was inconsistent with the legitimation of Life sciences semantic gravity code. The reason for this error could be because; in most cases, the Life sciences knowledge like any other scientific body of knowledge is contextualised when it is taught to students. The contextualisation of the Life sciences topics includes; teachers incorporating students' every day or local examples to enhance students' understanding of the concept that is taught. For example, when Life sciences lecturers' teach about biomes, a concept of plant biodiversity, they usually focus on the biomes that are found within the South Africa context and they do not emphasise that biomes across the world are affected by climate change and temperature. So, PSTs complete this module with an incorrect idea that the knowledge about biomes is dependent within the South African context, because the notion of Life sciences knowledge is not made explicit to the PSTs when these localized examples are used within their training. In support of this claim, a respondent in one of the open-ended items stated that:

Actual open-ended item statement: When someone studies this subject, they learn about…

Statement PST3: *We learn Life science concepts better when the lecturer uses everyday examples and we then know how to relate it to our everyday life. We understand more about our bodies and how they work. We learn about the world around us and how it has evolved from what it once were to what it is now and how it is adapted to have life.*

The lecturer also confirmed this notion of using contextual examples within the training during an interview (**Appendix 8**), by mentioning that they model the Life science subject matter using everyday examples and other practical real life examples, to enrich their understanding of concepts, as shown in the excerpt below;

Actual open-ended item statement: When someone studies this subject, they learn how to…

Statement (L4): *Umm….. Well I would say that content classes that I have already mention it, they cover content that we think is important for student to know which is obviously beyond matric level in the particular topics and also in those classes we try to model the content using the students' everyday examples on how they can teach that knowledge* ***Density*** *and other ,examples that are relevant for the classroom, so we do talk about how to teach it, then in methodology that's where we are having problems, I must admit we were talking together recently our structure for the whole of Life sciences including LS4 we haven't yet got as good structure for the methodology courses, as we have with the content course we think we got the complete content course right. But we haven't had that discussion to say right where is the sequence all the way through from the Natural sciences to Life sciences all the way through to LS3 into LS4 for methods ,we haven't got that nailed down yet.*

The idea of using localized examples is supported by many authors in science education such as, Holbrook and Rannikmae (2010). The authors argue that using contextual examples to teach science has benefits in the teaching and learning of the subject. These benefits include the development of: relevance, interest and motivation amongst students about science knowledge.

The results in **Table 4.3** also revealed that in terms of semantic density, the PSTs were of the view that, the meaning of Life sciences concepts are strongly condensed and this was denoted by the code **(SD+).** This view was indeed correct, because Life sciences learning is not perceived as a spontaneous practice, hence teachers then need to make use of cultural tools such as; scientific theories, laws, symbols, principles key vocabulary and visual aids of the discipline to ensure that learning is taking place (Lave, 1996). These cultural tools are aimed at supporting, extending and recognizing learners' knowledge and mental schemes. The PSTs open-ended responses asserted that the Life sciences knowledge is strongly condensed, as they were able to say that when learning the subject, they learn about scientific drawings, lab reports and the different topics and concepts which all form part of the socio-cultural practices of the subject. So, the correct semantic code for Life sciences is denoted by **(SG-; SD+)** and it showed that within the subject , applied knowledge is more acknowledged as compared to theoretical knowledge of the discipline. Also, more stress is put on the development of knowledge that addresses real world problems in social contexts. This then suggested that PSTs need to gain more understanding about different socio-cultural problems that are there in their communities that function as site of application in order to apply the knowledge learned in alleviating these socio-cultural ills.

4.3.3. Temporality Dimension

The other group of the Likert scale items in the questionnaire were classified under the temporal dimension. This dimension was concerned with a temporal positioning of a domain, and this specifically deals with either how young or old a particular discipline is in relation to other fields. Also, the dimension focuses on the temporal orientation of a field, and this was concerned with whether the knowledge domain has a forward or backward looking temporal direction.

Table 4.4: Results of the four Likert item results for the temporality dimension

Items	**PSTs responses**			**Interpretation of the Agree response. By agreeing:**
	A	**D**	**N**	
6.This subject makes connection across time	**26**	**1**	**2**	Twenty six out of twenty nine PSTs were of the idea that, Life sciences has a forward looking temporal orientation.
7. This subject tries to understand how things were in the past	**23**	**1**	**5**	Twenty three PSTs were of the view that, the Life sciences discipline has a backward looking orientation. This also alludes that the discipline is an old knowledge domain.
8. This subject tries to understand how things are in the present	**25**	**1**	**3**	Twenty five out of twenty nine PSTs were of the idea that, Life sciences has a current and forward looking temporal orientation.
9. This subject makes predictions for the future, or informs planning for the future.	**21**	**4**	**4**	Twenty one out of twenty nine PSTs were of the idea that, Life sciences has a forward looking temporal orientation.
Total Number	24	2	3	

Key: Agree (A), Disagree (D) and Neutral (N)

The majority of Life sciences PSTs agree response revealed that they were of the idea that, the discipline reflected an archeo-prospective code that was denoted by the code (**TP+, TO-),** meaning that the subject is old, but has a forward looking orientation as shown in **Table 4.4** above. These results by the twenty four out of twenty nine PSTs, demonstrated that most of the PSTs saw the subject as an old domain that has a forward looking orientation.

These results are in accordance with Magner (2002) idea, that the Life science knowledge domain emerged centuries ago, but underwent important changes during the late 20th century. Also, even today modern knowledge still draws on and develops from the historical ideas proposed by scientists of those times. In addition, Magner asserts that we should start viewing Life sciences knowledge as a human product and as an evolving concept that incorporates a body of knowledge, a methodology of developing new knowledge and a way of predicting future knowledge. The archeo-prospective code was further evident in the 4th year Life sciences PSTs open-ended responses to both the statements of: *'when someone studies this subject, they learn about…'* and '*when someone learns this subject they learn how to…'* as shown below:

Statement PST 7*: how things change overtime and how they influence each other*

Statement PST 8: *It teaches us about things that happen, or are to happen in the future*

Statement PST 9*: The subject teaches us about animals and human anatomy also about evolution and the future*

In addition to the above examples, the PSTs also mentioned learning about the nature of Life sciences a number of times in their open-ended responses (**Appendix 7).** This component of knowledge provides the PSTs with a platform to learn and acquire a gaze of the development of the Life sciences knowledge, as well as the changes that it has undergone overtime to meet modern society's high demands of technological and scientific advances (Lederman, 2002). Thus, the PSTs responses showed an archeo-prospective code within the temporality dimension.

4.3.4 Density Dimension

The last group of items of the questionnaire concentrated on the density dimension. Density is a dimension that consists of two codes namely: material density **(MaD)** and moral density **(MoD)**. Material density is a code that determines the size of a discipline (is it big or small) and the length as well as the breadth of a discipline's knowledge base. Whereas moral density was a code, that looked at the beliefs systems that govern a particular knowledge field. These beliefs could either be the same **(homogeneous, MoD-)** or different **(heterogeneous, MoD+).** The Life sciences discipline is legitimized by a density of code of **(MoD+, MaD+).** This density code signified that, the subject is made up of a large community and it has a diversified range of content that organizes the discipline. Furthermore, it showed that the Life sciences subject is underpinned by different belief systems such as; some teachers using the creationist approach when teaching the concept of Human evolution, while others will not even use the creationist approach when teaching the topic.

Table 4.5: Eleven Likert item results for the density dimension

Items	PSTs responses			Interpretation of the Agree response. By agreeing:
	A	**D**	**N**	
11. People can use knowledge from this subject for purposes that exist outside the discipline.	**27**	**1**	**1**	Life sciences has a variety of content, it has a large disciplinary community and is made up of different belief systems.
12. When teaching this subject, teachers draw on knowledge that is outside the subject	**19**	**2**	**8**	Life sciences has a variety of content, it has a large disciplinary community and is made up of different belief systems.
13.This subject makes links between theoretical concepts and real world examples or problems	**25**	**2**	**2**	Life sciences has a variety of content, it has a large disciplinary community and is made up of different belief systems.
14. A course of this subject would be made up of a collection of different (often independent) modules.	**17**	**5**	**7**	Life sciences has a variety of content, it has a large disciplinary community and is made up of different belief systems.
15. The sequencing of modules in this subject is essential for students understanding of the subject	**24**	**1**	**4**	Life sciences has a variety of content, it has a large disciplinary community and is made up of different belief systems.
16. There is a wide agreement amongst subject experts about the nature of the subject	**9**	**6**	**14**	Life sciences has a variety of content and are made up of same belief systems.
17. There are strong theories that hold this subject together as networked body of knowledge	**21**	**1**	**7**	Life sciences has a variety of content, it has a large disciplinary community.
18. It is very clear where the boundaries of the subject are	**11**	**5**	**13**	Life sciences has a variety of content, it has a large disciplinary community and is made up of different belief systems.
19. This subject is connected to other subjects	**18**	**4**	**7**	Life sciences has a variety of content, it has a large disciplinary community and is made up of different belief systems.
21. To be an expert in this subject requires one to holds certain beliefs.	**8**	**13**	**8**	Life sciences is made up of different belief systems.

22. This subject gives one a special way of understanding real life problems, and addressing them.	**1**	**2**	**26**	Life sciences has a variety of content, it has a small disciplinary community and is made up of the same belief systems.
Total number	16	4	9	

Key: Agree (A), Neutral (N) and Disagree (D)

From the above **Table 4.5,** the results showed that sixteen out of twenty nine PSTs responses correctly highlighted the same code. This code demonstrated by the PSTs responses for the Likert items, was also supported by their responses that they provided in their open ended responses as shown in the statements below:

Statement PST10: *...Content is so varied and can be applied to everyday life. The content is very interrelated to each other...*
***Statement PST11*: …** *learn about different topics…*
Statement PST12*: Various concepts in biology*

The above statements verified how diversified the Life sciences content is. This view was also shared by Medawar (1977) who says that, Life sciences is a subject that consists of different branches of scientific studies, which largely involves the examination of numerous aspects of life processes. The Life sciences body of knowledge includes concepts such as; physiology, anatomy, biochemistry, cell biology, human evolution and it includes all organisms that range from microorganisms, plants and to animals. Medawar further says that, when a subject consists of a diversified content, it also goes to suggest that the size of the community of the discipline is also stretched out. This is because; these different specialisms require more specialists to constantly refine and develop the knowledge for social application purposes, thus, the code **(MaD+)** as indicated by the PSTs results from the Likert scale items.

As mentioned earlier, the findings also revealed a code of **(MoD+)** which meant that, there are different beliefs systems that govern the subject. These heterogeneous beliefs arise from debates and contestations regarding the different topics that are taught within the subject. The PSTs open-ended responses frequently pointed out topics such as human evolution and genetics as concepts that are covered during their Life sciences teacher training. Ngxola and Sanders (2008) argue that, human evolution is one of the most controversial topics to teach and learn in Life sciences, similar to the topics of genetics and biotechnology (stem cells).

The following statements below made by a PST clearly exemplified and showed that other PSTs are aware of the controversial nature of some of the Life sciences topics:

***Statement PST13**: Deal with the controversial matters such as sexual reproduction education.*

Ngxola and Sanders suggest that, the controversies around the above mentioned topics stem from moral and ethical debates as well as contestations amongst the general public, education stakeholders, religious and faith groups, science teachers and their learners. These deliberations amongst these topics usually lead to the lack of agreement of 'what' and 'how' these topics should be taught within the Life sciences discipline. Arbee et al. (2014) argues that, usually in discourses where there is inadequate consensus amongst topics to be taught to students, this leads to the lack of accord amongst lecturers themselves, in relation to what makes up the "disciplinary discourse, how this discourse is best taken on and who should be responsible for facilitating the students that are taking on the discourse" (p.65). Arbee et al. also say that, this lack of consensus in Life sciences may have repercussions on the type of disciplinary gaze that students acquire at the end of their training. In sum, the findings revealed that the Life sciences discipline is characterized by high material density, which shows that the subject is made up of differentiated content. Also, the subject is legitimized by high moral density due to the heterogeneous beliefs that strengthen the discipline.

4.3.5 analysis of open-ended responses

As mentioned in the previous chapter, the two open-ended items were also deductively analysed using the four LCT dimensions. SMK and NOS aspects were also identified within the PSTs utterances. The open-ended items were revisited again, because the two items were aimed at eliciting PSTs understanding of the disciplinary nature of Life sciences, in relation to SMK and DK. The PSTs responses to the open-ended items were deductively analysed and categorised using major components of DK and SMK as shown in **Table 4.6** below (see the attached **Appendix 7** for complete analysis). From this deductive analysis that was guided by the LCT codes, SMK and NOS aspects, it was then possible to gain an insight on the type of knowledge that PSTs legitimised as the Life sciences discipline.

Table 4.6: Transcribed and coded data of PSTs open-ended items of the questionnaire

Code of respondent	When someone studies this subject, they learn about…	When someone studies this subject, they learn how to	NOS knowledge identified	SMK identified
LSPST1	Life science teaches things about life, our bodies (from a macro level to a cellular or molecular level). It teaches us about things that happen, or are to happen in the future Temporality. For example in genetics specialisation and density you learn that there are possibilities on everything that looks at the health of a person.	N/A	-(teaches about life) philosophy of Life science	-Genetics Human philology Cells
LSPST2	We learn about the content and how it relates to our everyday lives semantics, we also get to understand how the world functions and how things change overtime and how they influence each other temporality such as humans who due to their ignorance or hunger for power caused global warming which as a result is affecting human again. We also learn about how all organisms correlate with one another and how they are interdependent to each	We learn to draw scientific diagrams and how to perform experiments properly with proper caution. We also learn how to apply our content knowledge to real life or everyday lives. We also learn how to teach the subject at the level of the learners and how to build from one topic to the other in a coherent manner. Specialisation, temporality and semantics	-Relationship between content and everyday Life -Change of Life science knowledge over time and its influences -Scientific diagram and laboratory skills	- The relationship between of organisms -Sequencing of topics -Ways of transforming the subject into accessible ways that learners can understand

	other Density.			

4.3.5.1 Results of the PSTs understanding in relation to SMK

SMK refers to the teachers' ability to transform their knowledge about the subject in ways that are easily accessible to their leaners (kind, 2009). This knowledge is made accessible to learners through teachers' ability to use appropriate teaching and learning strategies, incorporating learners' prior knowledge as well as everyday real world examples to enhance their understanding. The open-ended item that was focused on SMK was a statement that was posed as '***when someone learns this subject, they learn...***'.This item was interested in gaining understanding of the type of knowledge that PSTs think teachers should have about their teaching subject and **Table 4.7** showed their responses.

Table 4.7: Major categories that emerged from PSTs responses of what they learn from studying Life sciences (SMK)

Aspects of SMK	Total number of respondent
The important topics (e.g. biodiversity, genetics, etc.)	**22**
Transformation of content to become accessible to learners and (linking to learners prior knowledge).	**12**
Sequencing	**1**

The results from the above table indicated that twenty two out of twenty eight PSTs believed that within the Life sciences discipline, the most important SMK aspects were the topics or concepts that are taught in the subject. Moreover, twelve of the PSTs were of the idea that a teachers SMK is also demonstrated by their ability to make the subject easily understandable to their learners, through suitable teaching and learning strategies as well as being able to connect the subject to learners' everyday lives. According to Kind (2009) SMK is demonstrated by teachers' aptitude to not only know the content of the subject, but to also know how to sequence these topics. Although that is the case, the results revealed that just one PST pointed out the importance of sequencing the concepts that are taught within the Life sciences discipline as a crucial component of SMK. This then alluded that, even though the PSTS are explicitly taught the SMK at SAX, but the sequencing part of this knowledge is not thoroughly taught to the PSTs.

4.3.5.2 <u>Results of the students understanding of Life sciences in relation to NOS</u>

As mentioned earlier, DK is an encompassing teacher knowledge base in which SMK is found in, and NOS is an important aspect of DK. NOS incorporates teachers understanding of the sets of skills, history, philosophy and the nature of a subject. This knowledge base provides science teachers' with the necessary science teacher 'lenses' that they need when to teach the subject effectively to their students. The next open ended item was concerned with the aspects of the NOS of the subject and the statement stated that 'when *someone studies this subject, they learn how to…*' This item was aimed at eliciting PSTs ideas of the sort of NOS comprehension that a Life sciences teacher should have about their subject. **Table 4.8** below demonstrated the PSTs responses.

Table 4.8: 4th year Life Sciences PSTs categorised responses of what they perceive a person who studies this subject learns how to do (NOS)

Aspects of NOS	Total number of respondents
Inquiry	15
philosophy	3
History	8

The results indicated that, fifteen out of twenty eight Life sciences PSTs were of the idea that the inquiry of the subject was an important feature of NOS. While, eight out the twenty eight PSTs believed that, the most vital aspect of NOS was the history of the subject and only three PSTS were of the view that the philosophy was a crucial component of NOS. These results indicated that the PSTs had a fractured understanding of NOS, especially in relation to the history and philosophy aspects. In their open-ended responses, they mentioned bits and pieces of NOS knowledge. However, they failed to go beyond those bits and pieces, in terms of activities that they do, as they could not mention the purposes, for instance, how the knowledge of the subject is generated, how the knowledge is validated, the reasoning and the approaches that are acceptable in the generation of that knowledge.

4.5 <u>Summary of the results</u>

From the above results, the PSTs demonstrated a satisfactory understanding of the disciplinary nature of Life sciences. This is because, the PSTs understood that the subject is characterised by specialist disciplinary skills and knowledge, rather than personal dispositions or attributes that may be possessed by an individual participating within the discipline.

However, the Likert items did not demonstrate as to which knowledge legitimized the discipline. This was taken care of by the results from open-ended items, which revealed the type of knowledge that the PSTs have come to understand as the knowledge that is learnt within the Life sciences B.Ed. program. From these findings, it was then clear that the PSTs understanding incorporated the components of DK, such as SMK and NOS. The results however revealed that most PSTs understood more about SMK as compared to DK.

In terms of density dimension, the PSTs results showed that within Life sciences, there is differentiation of content. Also, that the community of the domain is characterised by a large population that is governed by different belief systems, for example, within the subject there is a group Life scientists who believe that stem cell research is ethically wrong, because it promotes the termination of unborn babies and therefore it should not be taught. On the other hand, there is an opposing group which also believes that stem cell research should be taught because the knowledge has potential to cure chronic diseases such as cancer. These heterogeneous beliefs lead to disagreement over the content that should be taught and how this content is taught within the field.

The results further indicated that the PSTs were aware that, the discipline is an old and forward looking knowledge domain that has a forward looking direction. Furthermore, the PSTs erroneously thought that, Life sciences knowledge is context dependent and this was as a result of how they were taught the subject within the training. However, PSTs correctly understood that the meaning of the subject is highly condensed within sociocultural practices. Thus, this study suggested that the PSTs demonstrated a satisfactory gaze of disciplinary nature of Life sciences, in terms of LCT dimensions.

4.6 Conclusion

In this chapter, I analysed and discussed the data that was collected from 4th year Life Sciences PSTs. Their responses indicated an incorrect view regarding the semantic nature of Life sciences, as they were of the view that Life sciences knowledge is context dependent. On the one hand, there were correct views that were expressed by the PSTs in relation to what legitimatises the disciplinary nature of the Life sciences according to other various LCT dimensions. In the next chapter I discussed the findings and answered the research questions that guided this study.

Chapter five: Answering the research questions, implications of this study, recommendation and Conclusion

5.1. Introduction

In the previous chapter, I explained the analysis of the data and discussed the results of the study. In this chapter, I provided a brief summary of the findings, and answered the two research questions that guided this study. Moreover, I discussed the implications of this study and suggested recommendations for future studies. Lastly, I then outlined some conclusions that I deduced from the findings of this study.

5.2. Summary of the findings and discussion

The application of the LCT to students' responses demonstrated that 4^{th} year B.Ed. PSTs have satisfactory Life sciences disciplinary understanding, as they knew that the subject is legitimised by the possession of specialist disciplinary skills and knowledge, rather than personal dispositions or attributes that may be possessed by an individual participating within the discipline. The 4^{th} year PSTs also demonstrated this level of understanding through their responses to the Likert items. Their responses indicated that, in terms of the semantic dimension, Life Sciences is context independent and the meaning of the subject is rooted within sociocultural practices. The results from this study also revealed that, the PSTs were of the same idea that the Life sciences meaning is strongly condensed within sociocultural practices. So, it is therefore crucial that the lecturers involved in the subject should enculturate PSTs within the discourse. This enculturation process demands that, the PSTs are constantly exposed to all the sociocultural tools within the training which include the terminology, theories, symbols and other expressions, so that they can be able to use them in meaningful ways in their own professional teaching practices, thus effectively teaching the subject. Looking at the second aspect of the semantic dimension, the findings from this study pointed out that, the PSTs erroneously thought that, Life sciences knowledge is context dependent. The analysis of PSTs' responses to open-ended questions further revealed that, this erroneous thinking emanated from the teachers and lecturers use of contextualized examples when teaching Life Sciences concepts. To address this misconception, it then requires that teachers and lecturers make it clear and explicit to their students that the Life sciences concepts are context independent when teaching, although they are using localized examples. It is important that the PSTs understand that the knowledge of the discipline itself is context independent, so that, they do not pass the same incorrect view to their future learners.

In terms of the temporality dimension, the PSTs results accurately showed that Life Sciences is an old field of knowledge and that it has forward looking temporal orientation. This then means that, the subject knowledge is rapidly progressing. Therefore, PSTs also need to be constantly exposed to the current knowledge developments of the discipline, in order for them to be in a better position of applying the knowledge in their own societies and also contribute towards advancing future knowledge of the discipline.

Life Sciences as a discipline has high material density in terms of amount of content and size of the community. In addition, the community that is found within the discipline has heterogeneous beliefs. The findings from the PSTS responses in relation to the density dimension indicated that, the PSTs in this sample understood that within Life Sciences subject, there is a large amount of content and a large population that legitimises the discipline. Also, that the discipline is characterised by people with heterogeneous beliefs. These different beliefs have serious implications for the teaching and learning of the subject, as they contribute to the lack of agreement over the content that should be taught within the discipline and how this knowledge is then taught. Thus, it is crucial for PSTs to have this kind of understanding about their knowledge, so that they can be able to find meaningful ways of managing this lack of consensus within the field, as they would know which knowledge to teach and how best to teach it to their learners.

5.3. Answering the research questions

This study was centrally guided by two research questions. So, in the next two sub-sections of this chapter, the main aim was to provide comprehensive answers for these questions based on the findings that were obtained in this study, through the use of questionnaires and the semi-structured focus group interviews.

5.3.1. Research question 1: What level of understanding of the nature of Life sciences as a discipline is demonstrated by B.Ed. 4th year Life science PSTs?

Deducing from the results obtained in this study, the 4th year B.Ed. PSTs demonstrated satisfactory levels of understanding of the disciplinary nature of Life sciences. This was a very interesting result to get, because the nature of Life Sciences as discussed in chapter 2 through the lens of the LCT is not explicitly taught at SAX. In addition, the Life Sciences program from year 1 to year 4 does not clearly spell out in its curriculum documents and assessment regime, the key attributes of the discipline that PSTs must acquire from the program, except for SMK, thus, making it difficult to make claims about their levels of understanding of the nature of Life Sciences as a discipline. The results of this study are therefore important, as they show that despite the implicit nature of the institution's approach to teaching students about NOS, they still acquire the knowledge that constitutes the knowledge of Life sciences as a discipline, although it is not integrated and coherent. Furthermore, the findings start informing the Life sciences department, of the need to explicitly structuring the B.Ed. program in such a way that clearly develops the PSTs understanding of the disciplinary nature of Life sciences, so that by the time they graduate they already have acquired the sufficient disciplinary gaze about their subject of specialisation. Furthermore, so that the department could have an idea about the levels of disciplinary nature of understanding that PSTs have at the end of their teacher training as similarly to SMK.

5.3.2. To what extent do PSTs develop the required gaze about Life sciences from the B.Ed. program?

The findings of this study revealed that, the Life sciences PSTs develop an extensive gaze of SMK than NOS. Therefore, their disciplinary gaze is skewed towards SMK and this is because, the program structures and teaches this SMK in ways that support the PSTs to be able to teach this knowledge in their own professional pedagogical practises, as suggested by the excerpts from the lecturer below. Moreover, the modelling of this knowledge is done in both content and methodology classes. This knowledge base was comprehensively acquired by the PSTs at the end of their B.Ed. teacher training program, reason being that, it was further both formally and informally assessed to ensure that the PSTs leave the training with adequate levels of SMK in their subject of speciality. These assessment also continue to inform the department of the type of SMK that the PSTs acquire at the end of their training, thus they have successful structures in place that play a vital role in the thorough grounding of PSTs SMK of Life sciences. Unlike the NOS, the PSTS acquire a fractured understanding, reason being that, within the teacher training at SAX, this knowledge is presented in the form of activities, without specifying the logic behind those activities.

Statement (L3): *... Also we have rearranged the content classes to emphasize more on teaching the students how to teach this content rather than just leaving it to the methodology classes. Although we have been doing this, we haven't reached the point of discussing the disciplinary knowledge of Life science.*

Statement (L4): *Umm..... Well I would say that content classes that I have already mention it, they cover content that we think is important for student to know which is obviously beyond matric level in the particular topics and also in those classes we try to model the content using the students' everyday examples on how they can teach that knowledge* ***Density*** *and other ,examples that are relevant for the classroom, so we do talk about how to teach it, then in methodology that's where we are having problems, I must admit we were talking together recently our structure for the whole of Life sciences including LS4 we haven't yet got as good structure for the methodology courses, as we have with the content course we think we got the complete content course right. But we haven't had that discussion to say right where is the sequence all the way through from the Natural sciences to Life sciences all the way through to LS3 into LS4 for methods ,we haven't got that nailed down yet.*

As revealed by the lecture's statement **(LS3)** in the above excerpt, the Life sciences B.Ed. training program does not have the necessary structures in place, that are aimed at specifically and explicitly helping the PSTs to acquire appropriate levels of NOS. This occurrence could be traced back to the earlier finding in this chapter that exposed the lack of NOS understanding that the lecturer that participated in this study demonstrated. So, it could be said that the B.Ed. program has only been successful in helping the PSTs to explicitly understand and develop appropriate levels SMK, which is just one component of the disciplinary nature of Life sciences. This goes to support what was argued by Kelly et al. (2008) that most institutions do not know much about DK and often confuse it with SMK, which may be the case at SAX.

The results also showed that, although the PSTs had limited understanding of NOS, they did however, show signs that other basic components of the knowledge base are indirectly taught within the Life sciences B.Ed. program. These basics components largely included scientific drawing and the writing of laboratory reports' (scientific inquiry). Also, the results from the open-ended items as shown in **Table 4.7** in the previous chapter revealed that the PSTs do not have an extensive comprehension about the philosophy and history of their subject of specialisation. These components of NOS are only understood elementary by some PSTs, because of the implicit nature in which they are taught within the B.Ed. training program. This then means that, as suggested by the Life sciences lecturer that participated in this study, the department needs to restructure and re-arrange its methodology syllabus and to also start thinking about effective ways of explicitly teaching, as well as testing the PSTs understanding of NOS. This is because; NOS plays an important role in helping PSTs understand Life sciences knowledge as more than just a sets of accumulated knowledge, but rather provides them with an in-depth understanding of how this knowledge was generated. Also, DK enables PSTs to view the knowledge of the subject as interrelated sets of ideas and also provides them with effective ways of how to teach these connected ideas in ways that would prepare their learners to be future responsible citizens (Lederman, 2000). Schwab (1978) argues that, it is this sort of understanding about a subject that leads to the overall development of a teacher's substantive and syntactic structures. Hence, it is important that the Life sciences department starts to explicitly teach the NOS and also test this knowledge base as much as SMK if not more, so PSTs can develop the necessary understanding of the disciplinary aspects of Life sciences after completing the training program.

5.4. Implication of this study

One of the results of this study was that, there is lack of understanding about one component of DK, which is NOS from both PSTs and lecturers within the Life sciences teacher training course. Resulting from this, the lecturers end up not having a clear structure about the disciplinary gaze that they would like their PSTs to acquire at the end of their training program. While on the other hand, the PSTs end up not knowing what DK is, and the role it serves in their overall pedagogy. Evidence presented by this study pointed out that, some of the components of DK are taught within the training, such as the scientific inquiry part. But, given that most of the NOS components are not explicitly taught to them and they are not even formally assessed on them, this then results in the PSTs not acquiring a fully rounded gaze about their teaching subject. Also, this may result in PSTs leaving the training with some undetected and undiagnosed misconceptions about the disciplinary nature of Life sciences, such that, the knowledge of the subject is context dependent. Consequently, these misconceptions are likely to be passed on to their learners in the future. So, this lack of DK comprehension within the Life sciences B.Ed. program has potentially serious implications for the teaching and learning of the subject, which I believe provide no solution to the already manifesting problems reported by scholars; such as, Rollnick et al. (2008) about the lack of knowledge that teachers have about their subject of specialization, especially secondary science teachers in South African schools. Thus, the development of understanding of the disciplinary nature of Life sciences needs to be carefully taken into consideration by all the different major stakeholders involved in science education. This is because, the PSTs responses revealed that there is a crucial role that DK plays in their training, as it contributes to their overall knowledge acquisition of their teaching subject. As alluded by Thorne (2004), DK serves as the building blocks for the development of the necessary 'gaze' that PSTs need to have at the end of their training.

5.5. <u>Recommendations</u>

The issue of DK being a neglected teacher knowledge base was pointed out earlier in this study during the literature review chapter, and it highlighted that this occurrence has led to not so much being known about this teacher knowledge base. In support of this, the results from this study also demonstrated that indeed there is lack of DK understanding amongst Life sciences PSTs and their lecturers as well. Given that the lecturer also had inadequate knowledge about DK, it is therefore not easy to teach the knowledge domain explicitly to the PSTs during their teacher training. This study then recommends that lecturers' within the Life sciences training program should undergo development workshops that are aimed at cultivating their DK, so that they could be able to openly teach and expose the PSTs to the necessary disciplinary nature of Life sciences understanding that they would need to teach the subject effectively . Furthermore, I also suggest that, more research that explores DK should be done in the future, so that more will be known about this knowledge base and as a result be taught as explicitly within training institutions. This is because, as suggested prior, DK is an encompassing knowledge domain from which other knowledge domains branch from. In addition to that, DK is a type of specialized teacher knowledge base that involves more than the knowledge of a field, as it comprises of other crucial components that science teachers need to promote effective teaching and learning, such as the skills, the expertise, the people, community, inquiry and methodological approaches, challenges and the nature of a discipline Thorne (2014). Thus, Thorne regards this knowledge base as having the ability to 'strengthen and heighten' science teachers' voices within their classrooms.

The results from this study also showed that the Life sciences PSTs incorrectly though that the Life sciences knowledge is context dependent and probably there were many other misconceptions that they had that this study was not able to bring out, which resulted from their lack of DK understanding. I then recommend that, the Life sciences teacher training program should invest more time and resources towards developing and measuring the PSTs disciplinary gaze as much as their SMK, so that the training could also have an idea of the type of disciplinary understanding that the PSTs take away after completing the program.

5.6. Direction for future research

Results of this study indicated that there is a need for PSTs to understand the disciplinary nature of Life sciences at SAX, thus it is taught implicitly. Also, there is inadequate knowledge amongst PSTs about DK, given that this knowledge base is not stressed as much as SMK within the training course. These results showed that DK assist PSTs in the development of the necessary knowledge structures (hierarchal and horizontal) that are needed in order for them to fully understand the disciplinary nature of the subject. Furthermore, the results revealed that DK is taught within the training but given the implicit nature that is used to teach it, still not so much is understood about this knowledge base by both lecturers and PSTs. So, future research could look at the following areas regarding the development and understanding of disciplinary nature of Life science:

- How can Life sciences lecturer(s) and PSTs levels of their understanding of the disciplinary nature of their subject of specialisation be improved?
- What factors affect the Life sciences PSTs acquisition of DK?
- Which teaching and learning strategies need to be implemented to promote the successful learning of the disciplinary nature of Life sciences amongst PSTs?
- How can formal assessment of DK be effectively implemented in teacher training programs so that PSTs can develop a better understanding about the disciplinary nature of their subject and be able to effectively apply the knowledge in their future classrooms?
- How can DK play a role in the diagnosis of misconceptions that are held by PSTs instead of 'masking' them?

The above mentioned are all areas of concern and with enough insight they could help address the lack of understanding about the disciplinary nature of Life sciences that is facing many educational systems.

5.7 Conclusion

This study has examined the levels of understanding of the disciplinary nature of Life sciences that 4th year PSTs demonstrated at the end of their teacher training program. The Literature that I reviewed showed that, Life sciences is a discipline with a distinct body of knowledge. Also, this body of knowledge is composed of SMK and NOS. SMK as a component of DK, covers what the PSTs need to know about their subject of specialisation, in order to teach it successfully to their future learners. While, NOS covers the history and philosophy behind the knowledge of the subject that the PSTS need to teach. Furthermore, the literature revealed that, although Life sciences is a discipline with a defined body of knowledge, the nature of that body of knowledge is not taught explicitly within the teacher training at SAX and the results of this study affirmed this assertion. Furthermore, the findings demonstrated that failure to explicitly teach the nature of the subject can negatively impact how the PSTs teach their subject of specialisation after qualifying, as they do not develop an extensive comprehension about the disciplinary nature of Life sciences as a discipline. Even though, the nature of Life sciences as a discipline is not explicitly taught, it does not necessarily mean that, the PSTs do not acquire an understanding of the disciplinary nature of the subject, as shown by the results of this study. What the findings also revealed about this understanding of the discipline that PSTS learned implicitly was that, the knowledge is learned in bits and pieces, thus, leading to the PSTs having a fractured understanding of the disciplinary nature of their subject of specialisation.

The outcomes of this study further showed that, the PSTs take away satisfactory levels of understanding of the disciplinary nature of their teaching subject and a large part of this understanding being that of SMK, which in this study was viewed as a component of DK. Moreover, the PSTs demonstrated limited understanding of DK in general. This lack of DK comprehension resulted from the implicit nature in which this knowledge base is taught to the PSTs. Furthermore, what this study also discovered was that, DK within the Life sciences teacher training was taught implicitly because even the lecturer involved had inadequate understanding of the knowledge domain. So, if this problem continues unresolved within the training at SAX, it would mean that more PSTs will continue to be qualified without having developed the necessary DK understanding that they require for their teaching subject, thus contributing to the escalating problem that exists about science teachers' having limited knowledge about their subject of specialty.

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List of Appendices

Appendix 1: The questionnaire

<table>
<tr><td>Name</td><td colspan="2"></td></tr>
<tr><td>Email address</td><td colspan="2"></td></tr>
<tr><td>Tel number</td><td colspan="2"></td></tr>
<tr><td>Programme</td><td colspan="2">B Ed PGCE</td></tr>
<tr><td rowspan="10">Which is your subject/ discipline specialisation?</td><td>Psychology</td><td></td></tr>
<tr><td>Sociology</td><td></td></tr>
<tr><td>Philosophy</td><td></td></tr>
<tr><td>Mathematics</td><td></td></tr>
<tr><td>Physical Science</td><td></td></tr>
<tr><td>Life Science</td><td></td></tr>
<tr><td>History</td><td></td></tr>
<tr><td>Geography</td><td></td></tr>
<tr><td>Accounting</td><td></td></tr>
<tr><td>Economics</td><td></td></tr>
<tr><td>Did you take this subject (Grade 12) level as a National Senior Certificate subject?</td><td colspan="2">YES

NO</td></tr>
<tr><td>For how many years have you studied this subject at University?</td><td colspan="2">0: I'm in my first year of study
1 year
2 years
3 years
4 years</td></tr>
</table>

Please read through all the following statements and then indicate the extent to which you agree or disagree with each one by placing an X in the chosen block.

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	It takes someone with a natural talent to learn this subject.					
2	Anyone can learn this subject given sufficient time or training.					
3	There is a special kind of knowledge that a subject specialist needs.					
4	There are special skills that one develops when learning this subject.					
5	To learn this subject, one needs to 'get a feel' for it through experience.					
6	This subject makes connections across time.					
7	This subject tries to understand how things were in the past.					
8	This subject tries to understand how things are in the present.					
9	This subject makes predictions for the future, or informs planning for the future.					
10	It is vital for teachers to understand what this subject is, and what it's *not.*					
11	People can use knowledge from this subject for purposes that exist outside the discipline.					
12	When teaching this subject, teachers draw on knowledge that is located outside the subject.					
13	This subject makes links between theoretical concepts and real world examples/ problems.					

14	A course in this subject would be made up of a collection of different (often independent) modules.					
15	The sequencing of modules in this subject is essential for students' understanding of the subject.					
16	There is wide agreement amongst subject experts about the nature of the subject.					
17	There are strong theories that hold this subject together as a networked body of knowledge.					
18	It is very clear where this subject boundary are					
19	This subject is connected to many other subjects.					
20	Certain *kinds of people* understand this subject better than others.					
21	To be an expert in this subject requires that one holds certain beliefs.					
22	This subject gives one a special way of understanding real life problems, and addressing them.					

The following two questions are open-ended and require more detail in answering them:

22. When someone studies this subject, they learn about…

23. When someone studies this subject, they learn how to…

Focus Group Interview

DATE:

TIME:

VENUE:

Thank you for your participation!

Appendix 2: Information sheets for the participants of the study

Title of the study: Investigating 4th year Pre-Service Teachers' levels of understanding of the disciplinary nature of Life sciences as a discipline.

university of the Witwatersrand Private Bag 3 Wits 2050 Johannesburg +27 11 7173414 f+27 11 7173259

Masters Student: Xaba Nomzamo
Student No.: 588607
588607@students.wits.ac.za
Cell phone number: 0617947792

Dear Lecturer

Re: Invitation to participate in a research study on disciplinary and subject matter knowledge for Life science PSTs

My name is Nomzamo Xaba and I am a fulltime Masters in Science Education student in the School of Education at the University of the Witwatersrand. I am currently conducting a study aimed at investigating the levels of understanding of the disciplinary nature of Life sciences that 4^{th} year B.Ed. students demonstrate at the end of their training. My study is under a bigger study that is being conducted at the Wits School of Education (WSoE).

Recent research points to the importance of understanding of disciplinary and subject matter knowledge structures regarding their ability to teach effectively and make sound judgments. For this reason, the Teaching and Learning Committee based at the Wits School of Education is conducting a research entitled "Teaching the teachers: Disciplinary Knowledge in Education and Teaching Subjects". The research team seeks to do a comparative analysis of the disciplinary knowledge that prospective teachers learn when they take the Bachelor of Education (B.Ed.) route and the Post Graduate Certificate of Education (PGCE) route to qualifying. The study seeks to find out, how student teachers' understand the nature of the subjects they have learnt during the course of their studies.

So, I would like to invite you to participate in this study. Your participation would involve providing me consent to analyse the questionnaire and to also to participate in a 45 minute focus group interview, convened at a date, time and venue convenient to you.

Participation in this research is entirely voluntary. There will be no negative consequences should you not participate. If you do choose to participate, all information about you will be kept confidential, and no-one would be able to recognise you in any publication or presentation arising from the research. You may at any time withdraw from the study with no negative consequences. All data (electronic and material) will be kept securely in locked offices and would be destroyed within five years of the completion of the project. It is envisaged that the results of the research will be used for academic purposes (including books, journals and conference proceedings). Please let me know if you require any further information.

Thank you very much for your help.
Yours sincerely,
Nomzamo Xaba (588607)

Appendix3: Consent form for the participants of the study

Lecturer's Consent Form

Please fill in and return the reply slip below indicating your willingness to be a participant in my voluntary research project called: **Investigating 4th year Pre-Service Teachers' levels of understanding of the disciplinary nature of Life sciences as a discipline.**

I, __________________________ give my consent for the following:

	Circle one
Permission to be interviewed	
I agree to be interviewed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to Answer all the questions asked.	YES/NO
Permission for questionnaire	
I agree to fill in a questionnaire for this study.	YES/NO
Permission to be audiotaped	
I agree to be audiotaped.	YES/NO
I know that the audiotape will be used for this project only.	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped
- All the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign______________________________ Date____________________________

Appendix 4: Ethics letter

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11
717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

15 September 2016

Student Number: 588607

Protocol Number: 2016ECE053M

Dear Nomzamo Xaba

Application for Ethics Clearance: Master of Science

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate, has considered your application for ethics Clearance for your proposal entitled: **Investigating 4th year Pre-Service Teachers' levels of understanding of the disciplinary nature of Life sciences as a discipline.**

The committee recently met and I am pleased to inform you that clearance was granted. Please use the above protocol number in all correspondence to the relevant research parties (Schools, parents, learners etc.) and include it in your research report or project on the title page. The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report. All the best with your research project.

Yours sincerely,

Wits School of Education

011 717-3416

cc Supervisor - Dr Eunice Nyamupangedengu

Appendix 5: Frame-work for analysing the Likert scale items

Table 7.1: Analysis of the Likert scale items in relation to the LCT dimensions

LCT Dimension	**Likert scale Item**	**Explanation of how responses to the item were analysed**	**Likert Scale level**
Specialisation	1.It takes someone with special kind of personality to be an expert in this subject	This item meant that it takes an individual with certain personal attributes or characteristics to be a specialist in Life science.	If PSTs **agree** it meant they thought that, being a specialist in the subject involved certain personal attributes or traits. Implying that the knower mattered and knowledge does not matter thus the code **(ER-, SR+)**.
	2.Anyone can learn this subject given sufficient time or training	This item suggested that a person's characteristic or knowledge background about Life science does not matter. However, any person can learn the subject if they undergo proper training or are given a chance to learn the subject over a period of	**Agree** revealed that the PSTs believed that personal traits are not important, but anyone can learn the subject through time and training. Given that training involves knowledge, it then meant that the knowledge mattered more than the knower, thus the code **(ER+, SR-).**

		time.	
	3.There is a special kind of knowledge that a subject specialist needs	This item pointed out that for one to be regarded as a life science expert; they need to possess a detailed understanding of what makes up the body of knowledge of their subject of specialisation.	When PSTs **agree** it showed that the special kind of knowledge mattered more than the specialist and this was signified by the code **(ER+, SR**).
	4.There are special skills that one develops when learning this subject	Life Science as a discipline of science has known or defined skills that are expected to be acquired by someone learning the subject.	**Agree** meant that the PSTs believed that the learning of this subject, results in a person acquiring expertise or skills within the subject. In other words, knowledge mattered more than the knower and this was signified by the code of **(ER+, SR-).**
	10. It is vital for teachers to understand what the subject is, and what it is not	Life Science is a discipline and as such, has a certain nature in terms of how knowledge is generated and a defined body of SMK.	When PSTs **agree** it meant, the knowledge mattered more than the knower and this was revealed by the code of **(ER+, SR-).**

	20. Certain kinds of people understand this subject better than others	This item suggested that it takes people with particular personal qualities than others, to have a better comprehension of the Life science knowledge.	**Agree** in this instance showed that the PST thought that it took people with certain personal abilities or talents to understand the subject better. Meaning that, the knower mattered more than knowledge and this was demonstrated by the code of (**ER-, SR+).**
Semantics	5. The learning of this subject develops a particular gaze through which one can understand aspects of the world.	There is a certain understanding or way of thinking that is expected to develop in someone who is learning Life Sciences such as the nature of knowledge that makes up the Life Science subject e.g. is it context dependent or context independent, is it highly condensed or not.	**Agree** in this case meant that the PST thought that the subject content is highly condensed to symbols and expressions. Also they thought that the subject knowledge is context dependent.
Temporality	6.This subject makes connection across time	The item puts forward that, Life sciences makes links between historic knowledge and the existing knowledge to expand its knowledge base in the contemporary modern world. These connections within the subject show the progression of	**Agree** meant that the PSTs believed that the subject does make links between its past and present knowledge bases to show the knowledge advancement of the subject. This then meant that the subject is an old domain of knowledge with a backward and forward looking orientation and this is showed by the code of **(TP+, TO+)**.

		knowledge of the subject, as well as it's backward and forward looking temporal orientation.	
	7. This subject tries to understand how things were in the past	The item revealed that the subject is not only concerned about improving modern day life. But, the subject is also inquisitive about understanding the origins of the human life and that of the world that we live in generally.	When PSTs **agree** it meant they are aware that Life sciences temporality is backward looking and is an old domain body of knowledge and this was signified by the code of **(TP+, TO+).**
	8. This subject tries to understand how things are in the present	The item revealed that the subject is not only concerned about understanding historical events. But, the subject is also inquisitive about understanding the how things are in the modern world. Thus it is successful in contributing towards civilisation, as the subject has its application in modern day agriculture, industries, health and medicine.	**Agree** meant that, the PST was aware that the subject has a forward looking orientation even though it's an old knowledge domain and this was denoted by the code of **(TP+, TO+).**

	9. This subject makes predictions for the future, or informs planning for the future.	This item showed that Life sciences is not only concerned with past or present events. But, the subject is makes extrapolations that inform upcoming happenings.	**Agree** meant that PSTs, though that the subject makes future predictions and it uses existing knowledge to inform plans concerning the future. This meant that the subject has a forward looking orientation though is an old knowledge domain and this was showed by the code of (**TP+, TO+).**
	11. People can use knowledge from this subject for purposes that exist outside the discipline.	This item meant that the Life sciences knowledge can be applied in real life situations or in any other disciplines. For example, a PST who was worried about not looking like any of their sibling or parent may understand why this is the case, after learning about DNA recombination in a genetics lesson. The very same concept of genetics may also be used in medicine, forensics and may other for different fields of specialisations for diverse purposes.	When PSTs **agree** it meant that, they see the Life sciences being characterised by a temporal profile that is old yet both forward and backward looking **(TP+, TO+).** **Disagree** highlighted the PSTs have an inverse opinion. While, **Neutral** was an indication of the PSTs being unsure.

	12. When teaching this subject, teachers draw on knowledge that is outside the subject	The item explained that, when Life sciences teachers teach the subject, they draw from other sources knowledge such as; knowledge from other disciplines, learners' prior knowledge or their own past experiences to enhance their learners understanding.	In this case **Agree** suggested that the PSTs are saying that the subject has strong material density, as it can link to other sources of knowledge that are outside the discipline. **Disagree** meant that the PSTs had a different view. While **Neutral** demonstrated uncertainty.
Density	13.This subject makes links between theoretical concepts and real world examples or problems	This item meant that, the subject does not only teach the Life sciences concepts in isolation. Rather, the subject makes connections between these concepts to everyday and real life occurrences.	When PSTs **agree,** it showed that they know that Life sciences topics or concepts relate to real world problems and examples. Thus, viewing Life science as being characterised as having large population with heterogeneous beliefs **(MaD+, MoD+).**
	14. A course of this subject would be made up of a collection of	The item suggested that, the Life sciences program consists of a collection of independent components that do not link in anyway.	If PSTs **agree** were of the view that the Life sciences material density is weak and course comprises of an internally segregated collection of content. **Disagree** meant that the PSTs had a different view. Whereas, **Neutra**l indicated that the PSTs were not sure about this item.

different (often independent) modules.		
15. The sequencing of modules in this subject is essential for students understanding of the subject	The item meant that the ordering of the concepts of Life sciences play an important role in improving PSTs comprehension of the overall subject.	If PSTs **agree** the responses expressed that Life sciences they see the importance of ordering the Life sciences module in a particular way, as having a positive impact on their general understanding of the subject. So, the units of the subjects are differentiated but internally related. Thus, the code **(MaD+, MoD+).** While, **disagree** meant that these PSTs had an opposing view. **Neutral** responses revealed uncertainty.
16. There is a wide agreement amongst subject experts about the nature of the subject	This item alluded that within the Life sciences discipline, there is consensus amongst the specialist of the subject about the history, philosophy and overall knowledge development of the subject. This agreement also involves, the 'kind of knowledge' that needs to be taught, 'who' should teach this knowledge and 'how' this knowledge should be	**Agree** indicated certainty amongst PSTs that there is mutual consensus between the specialists about the nature of Life sciences. Meaning that, there's a large population with homogeneous beliefs **(MaD+; MoD-)** Whereas, **disagree** meant that the PSTs had an alternative response. **Neutral** demonstrated that the PSTs were no sure about the item.

	taught.	
17. There are strong theories that hold this subject together as networked body of knowledge	The item explained that there are factual principles that unify and present the subject as an integrated knowledge system. In life sciences an example of such a theory will be The Cell Theory, reason being that the cell is viewed as a basic unit of life. So, the cell theory is thus a unifying theme in Life sciences, because one cannot begin to know the complex forms of life without first understanding the cell structure and its functions given that the basic characteristic of life will be found in a cell such as reproduction, growth and motility. It is only after grasping this fundamental understanding that one might be able to comprehend Life sciences from unicellular organisms to the more complicated	In this case**, Agree** showed that there is diversity in terms of Life science concepts thus the code **(MaD+, MoD+).** On the other hand, **Disagree** indicated that these PSTs held a contrasting view. **Neutral** signified a degree of indecisiveness.

	multicellular organisms.	
18. It is very clear where the boundaries of the subject are	The item meant that, the subject's constraints or limits are explicit. In other words, one knows that Life sciences knowledge can only be used to study living things and non-living thing with regards to their interaction within an environment. Anything that is outside that scope, Life sciences knowledge cannot be successfully applied.	**Agree** showed that the PSTs are aware of large population in terms of the structuring units of the subject but because of the heterogeneous beliefs with regards to other related fields , the Life sciences boundaries are clear hence the code **(MaD+; MoD-)**. **Disagree** demonstrated a contradicting views. While. **Neutral** revealed indefiniteness.
19. This subject is connected to other subjects	The item suggested that the Life sciences subject is related to other subjects such as chemistry, physical sciences and geography to mention a few. For instance, Geography is a subject that deals with various concepts such as the rain fall, temperature, suitable soil types for sowing crops and everything existing on earth. These concepts are also	When PSTs **agree** it alluded that they are certain that the Life sciences subject is related to other subjects, which again shows science is a big community although the scientist themselves hold diverse beliefs about the subject thus the code **(MaD+, MoD+).** While, **Disagree** indicted an opposing stances. **Neutral** showed that the PSTs are not sure.

		some of the main topics covered in Life sciences major topics of Diversity, Change and Continuity as well as environmental studies.	
	21. To be an expert in this subject requires one to holds certain beliefs.	This item explained that for one to be regarded as a specialist in Life sciences, they need to have certain sets of principles that they hold or are committed too. These beliefs could either be religious or scientifically based about certain ideas of the world. So, for example a Life science expert can believe that God created the earth and mankind. Yet, still believe in the Human evolution theories that attempts to explain the origins of earth and mankind.	When PSTs **Agree** it indicated they do acknowledge that for one to be a specialist in Life science, they must hold certain beliefs that vary from one specialist to the other hence the code **(MaD+, MoD+).** While, **disagree** showed contrasting perspectives. Neutral revealed a level of doubt about the item.
	22. This subject gives one a special way of	This item meant that the Life sciences subject can provide one with a sort of knowledge that can be	**Agree** meant that the PSTs saw life science knowledge as having solutions to real world problems. Whereas, **disagree** indicated refuting views**. Neutral** showed a degree of uncertainty.

	understanding real life problems, and addressing them.	applied to solve their real life challenges that they encounter in their everyday lives.	

Appendix 6: The raw score results of the Likert scale items

Table 7.2: The raw scores of each of the different LCT dimensions with respect to their codes that were obtained from the PSTs responses of the Likert scale items

LCT dimension	**Total number of respondents per Code**												
Specialisation Codes and their meaning	**(ER+, SR-) : knowledge matter s more than knower**				**(ER-,SR+): knower matters more than the knowledge**			**(ER+, SR+) : both knowledge and knower matter**			**(ER-; SR-):both knowledge and knower don't matter**		
Choice of response	**Item number (s)**	**A**	**D**	**N**	**A**	**D**	**N**	**A**	**D**	**N**	**A**	**D**	**N**
	1	9	12	8	12	9	8	0	0	0	0	0	0
	2.	20	4	5	4	20	5	0	0	0	0	0	0
	3	29	0	0	0	29	0	0	0	0	0	0	0
	4	26	3	0	3	26	0	0	0	0	0	0	0
	10	28	1	0	1	28	0	0	0	0	0	0	0
	20	5	20	4	20	5	0	0	0	0	0	0	0
Semantics Codes and their meaning	**(SG-; SD-): The meaning of the subject is weakly condensed within socio-cultural practices (e.g.: symbols, terms, concepts, expressions, etc.). Also the knowledge of the subject is not context dependent**				**(SG-; SD+): The knowledge of the subject is not context dependent but the meaning is strongly condensed within socio-cultural practices of the subject.**			**(SG+; SD-): The knowledge of the subject is strongly context dependent. But the meaning is weakly condensed within the socio-cultural practices.**			**(SG+; SD+): The knowledge of the subject is context dependent and the meaning is strongly condensed within the socio-cultural practices.**		
	5	0	0	0	0	0	0	24	4	0	0	0	0
Temporality Codes and their meaning	**(TP+; TO-): The discipline is an old knowledge domain with a forward looking orientation**				**(TP+; TO+): The discipline is an old knowledge domain**			**(TP-, TO+): The discipline is a young or new**			**(TP-; TO-): The discipline is a young or new knowledge**		

	(concerned with present and future knowledge).				**with a backward looking positioning (concerned with knowledge of the past).**			**knowledge domain with a backward looking orientation**			**domain and it has forward looking orientation (concerned about contributing to existing knowledge and informing future knowledge)**		
	6	26	1	2	0	0	0	0	0	0	0	0	0
	7	23	1	5	0	0	0	0	0	0	0	0	0
	8	25	1	3	0	0	0	0	0	0	0	0	0
	9	21	4	4	0	0	0	0	0	: 0	0	0	0
Density Codes and their meaning	**(MaD+, MoD-): The Life sciences community is large and it has a diversity of content. Also, the subject is underpinned by the same beliefs systems**				**(MaD+: MoD+): The Life sciences community is large and it has a diversity of content. However the subject is not underpinned by the same belief systems.**			**(MaD-; MoD+): The life sciences community is small and does not have a diversified content. Also, is not underpinned by the same belief systems**			**(MaD-; MoD-): The Life sciences community is small and does not have a diversified content. But, the subject is governed by the same beliefs systems.**		
	11	0	0	0	27	1	1	0	0	0	0	0	0
	12	0	0	0	19	2	8	0	0	0	0	0	0
	13	0	0	0	25	2	2	0	0	0	0	0	0
	14	0	0	0	17	5	7	0	0	0	0	0	0
	15	0	0	0	24	1	4	0	0	0	0	0	0
	16	0	0	0	9	6	14	0	0	0	0	0	0
	17	0	0	0	21	1	7	0	0	0	0		

												0	0
	18	0	0	0	11	5	13	0	0	0	0	0	0
	19	0	0	0	18	4	4	0	0	0	0	0	0
	21	0	0	0	8	13	8	0	0	0	0	0	0
	22	0	0	0	1	2	26	0	0	0	0	0	0

Keys: Agree (A), Disagree (D) and Neutral (N)

Appendix7: showing the transcribed open-ended item results

Table 7.3: Transcribed and coded data of PSTs open-ended items of the questionnaire

Code of respondent	When someone studies this subject, they learn about…	When someone studies this subject, they learn how to	DK codes	SMK Codes
LSPST1	Life science teaches things about life, our bodies (from a macro level to a cellular or molecular level). It teaches us about things that happen, or are to happen in the future Temporality. For example in genetics specialisation and density you learn that there are possibilities on everything that looks at the health of a person.	N/A	-(teaches about life) philosophy of Life science	Genetics Human philology Cells
LSPST2	We learn about the content and how it relates to our everyday lives semantics, we also get to understand how the world functions and how things change overtime and how they influence each other temporality	We learn to draw scientific diagrams and how to perform experiments properly with proper caution. We also learn how to apply our content knowledge to real life or everyday lives. We also learn how to teach the	-relationship between content and everyday Life -change of Life science knowledge over time and its influences	- The relationship between of organisms -sequencing of topics -ways of transforming the

	such as humans who due to their ignorance or hunger for power caused global warming which as a result is affecting human again. We also learn about how all organisms correlate with one another and how they are interdependent to each other Density.	subject at the level of the learners and how to build from one topic to the other in a coherent manner. Specialisation, temporality and semantics	-scientific diagram and laboratory skills	subject into accessible ways that learners can understand
LSPST3	Life / Human evolution, Human reproduction, Biodiversity, Life processes in plants and animals, plant reproduction , scientific way of drawingS MK-specialisation	Content scientific research , scientific drawing , interpret and write down a lab report Temporality and specialisation	- Scientific way of drawing - Scientific research skills - Interpretation skills - Laboratory report writing skills	-Human evolution, Human reproduction, Biodiversity, Life processes in plants and animals, plant reproduction
LSPST4	The living organisms and what life is made of and how they are classified as part of life. The subject teaches us about animals and human anatomy also about evolution and the future Density and temporality. The subject also requires one to know about life processes that are complex.	Have skills of observation. Analyzing and explaining complex knowledge, Research skills, interpretation and problem solving skills. Temporality and specialisation	-Observational skills -Analyzing and explaining skills -Investigative skills -Interpretative skills -Problem solving skills	-Living organisms -What life is made up of (cells the basic units of life) -Animal and human anatomy (physiology) -Life processes
LSPST5	Biological processes leading to environment and adaptation and	Perform experiments and learn how life processes occur. Temporality	-Nature of life science -Research skills	-Biological processes

	survival, the nature of life science or biology. Temporality			
LSPST6	The different life processes and how living and non-living things interact with the environment. Specialisation How the unseen life processes keep the earth moving processes such as the movement of the earth plates, the evolving of living organisms. Temporality	Teach the different aspect of life sciences, analyse life process in a way that only a person who did life sciences can e.g. if one is sick and that person will know that they have bacterial infection. Specialization and semantics	-Develop a Life science disciplinary gaze	-Biological processes -Living and non-living things interact with the environment (Biodiversity) -Evolving of organisms (Evolution)
LSPST7	Life sciences and processes specialization	Solve scientific processes , use instruments and conduct scientific experiments related to the discipline. Semantics and specialisation	-Problem solving skills -Investigative skills	-Biological processes
LSPST9	They learn about processes of life and its connection to the real life. Semantics	Link the processes of life. semantics	-Application of Life science knowledge in real life situations	-Biological processes -Using everyday examples to teach Life science concepts
LSPST10	Life processes of humans and the plant evolution and their connection. Specialisation and temporality	The knowledge for life science to the outside world. semantics	-Application of Life science knowledge in real life situations	-Biological processes
LSPST11	Processes of life and its connection to the external world. how it began, temporality and semantics animal	To make connections about what they have learned about the human body and the various functions that	-Application of Life science knowledge in real life situations	-Biological processes -Animal anatomy

	anatomy and basic processes of the living organisms specialisation	occur and furthermore link to their external environment and their everyday lives. semantics		
LSPST13	Life sciences and their everyday life. They understand more on their bodies and how they work specialisation. The world around us and how it has evolved from what it once were to what it is now and how it is adapted to have life. Temporality	Value and change their attitude towards evolution, life and how the world works in general. Temporality You learn about disease and what causes them, how they can be cured and if they can be cured and why they can't be cured if they can't. Semantics	Critical epistemic stance	-Human physiology -Evolution -Diseases
LSPST14	Relevance of life science in society semantics	N/A	-Application of Life science knowledge in real life situations	-N/A
LSPST15	Life science concepts that relate to biological origins, history of the earth, Human an animal anatomy, sexual and asexual reproduction specialisation etc. scientific knowledge of the earth origins and also making people aware of the health education. How Scientific theories and knowledge was generated. Temporality and	N/A	- The generation of scientific knowledge(nature of science)	-Human evolution -Human and animal anatomy -Human reproduction

	semantics			
LSPST16	The content and how best to teach it in order to transform the knowledge in a way that diverse learners can get knowledge. Specialisation and semantics	Perform and carry out scientific experiments temporality which can help with understanding the content. Specialisation	-Investigative skills	-Content knowledge -Ways of transforming the subject into accessible ways that learners can understand
LSPST18	The different aspects of life science specialisation the human body and how to improve the environment for the future generations temporality to make the connections between everyday knowledge and school knowledge. semantics	Perform practicals correctly. Draw biological drawing correctly. Perform certain skill required to complete the subject. Think abstractly about issues facing the society and the environment. Temporality and semantics	-Investigative skills or laboratory skills -Biological drawing skills -Application of Life science knowledge in real life situations	-Human body -Environmental studies
LSPST19	Biological systems, the environment, the effects of evolutions , the anatomy. specialisation	Conduct experiments Appreciate their surroundings. Temporality and semantics	-Investigative or laboratory skills -Development of disposition with the subject	-Biological processes -Environmental studies -Evolution -Human anatomy
LSPST20	What is awesome about life sciences is that the content is so varied and can be applied to everyday life. The content is very interrelated to each other density (the molecules link). You learn about animals, plants and	Conceptualise, to analyse and to apply. Life science is also stemmed through observation so learning to observe is extremely important. Specialisation and temporality	-Conceptualisation skills -Analysing skills -Observation skills - Diversification of Life science concepts and the relationships of the concepts	-Molecules -Structure of living organisms

	humans both externally and internally. specialisation			
LSPST21	Human anatomy and physiology along with environment studies. Specialisation	They learn how to apply theory and semantics biological phenomena as well as produce scientific reports. Specialisation	-Application of life science knowledge in real life situations -Writing scientific reports skills	-Human anatomy -Human physiology -Environmental studies
LSPST22	They learn about environment aspects interrelated with human aspects and they make (anatomy up) at various components in plants, animals and humans. Specialisatio n	They learn application of skills for semantics what they have learned to naturally occurring phenomena. They also learn to generate hypothesis and undergo testing and experimentation. specialisation	-Application of life science knowledge in real life situations -Scientific inquiry -Investigative and laboratory skills	-Environmental studies -Human anatomy and physiology -Biodiversity
LSPST23	When someone studies this subject, they learn about the nature of the subject temporality as to how to teach the subject, what theories semantics are involved in the subject as well as the content knowledge specialisation and what resources are relevant and appropriate to the content knowledge.	They learn how to teach the subject, they also learn about different topics and their content knowledge density as well as the current researches related to the topics that provide us with correct information. specialisation	-Nature of Life science	-Content knowledge -Theories -Appropriate teaching resources

LSPST24	The natureoflifescience temporality	Deal with the controversial matters such as sexual reproduction education. Density	-Nature of Life science -Dealing with controversies of the topics off the subject	-Human reproduction
LSPST25	Various concepts in biology density as well as how to teach them effectively.	Make connections between everyday knowledge and school related concepts Semantics Address difficult topics such as contraception, human reproduction and evolution in a way that is skillful, and not vulgar and respectful to everyone. Density	-Using skills to deal with controversies of the topics off the subject	-Teaching various Life science effectively -Using everyday examples to teach Life science concepts -Human reproduction -Evolution
LSPST27	Things that occur in a daily basis for instance in terms of scientific discoveries. Learn about past and present life forms Temporality	Learn how to take better care for themselves for instance when we got taught about human reproduction and use of contraceptives. Semantics	-Scientific discoveries	-Evolution -Human reproduction
LSPST28	They learn about nature and how humans function. Specialisation	Take care of their environment and their body systems. Semantics	-Development of disposition within the subject	-Environmental studies -Human anatomy and physiology

Keys: Agree (A), Neutral (N) and Disagree (D)

Appendix 8: showing the transcribed semi-structured focused group interview excerpts

8.1 Transcribed excerpt for semi-structured focus group session 1

Interview one with two LS 4 PSTs

Interviewer : Uhmmm so…. as L.S4 students what type of knowledge do you think you gain after completing the whole teaching course?

Respondent 1: Like the whole set of skills including of how to conduct experiments you know and just research analysis. Being able to choose the right information, apparently that's not easy. We have gained a lot of knowledge regarding the whole Life science teaching process it wasn't just about grasping the content knowledge but the whole packing including pedagogical…

Interviewer: Okay! Okay!

Respondent 2: Adding more on that…like, I feel that we get enough Life science content for us to pass here (meaning at the education campus) but with us going to the work place (I know it's not about that) but with us going further I don't think we get enough…enough as needed ko **skolong** (meaning at the schools) because as compared being here studying to pass mo skolong (here at the campus) it is enough. I feel like ***re thola*** (we get) content that is aimed at assessing us.

Interviewer: Do you know anything about Subject Matter Knowledge and Disciplinary Knowledge? Have you ever heard of anything like that before?

Respondents: No…No….No

Respondent 1: Can you distinguish between the two, please?

Interviewer: Well with regards to SMK, it is actually the type of knowledge that you have as a teacher regarding your subject of specialization and being able to transform that knowledge into accessible that learners could easily understand, that is SMK . Other researchers view SMK as simply meaning CK. But with disciplinary knowledge it is very complex, it deals with a set of skills that you as a life science teacher must have. It also includes the knowledge of understanding the nature of life science holistically. Like how your understanding of concepts such as genetics and evolution can be applied across the scientific field, whereby any person who is not even a teacher maybe doing BSc would understand it…. and how this knowledge comes to be what we know it today and how it is validated…do you think you that you are taught this knowledge???

Respondent 1: Ohhh… like so the seven…the seven…the seven things…I know like the tentative knowledge, there's bias aspect and stuff like that

Interviewer: Something likes that…and yes those are the aspects of the NOS and you can link it to DK…So how much of this knowledge do you think you learn till 4th year level?

Respondents: I think…… (Not giving a response)

Interviewer: or rather which one do you think is taught more between the two knowledge bases I have told you about?

Respondent 1: I think the content knowledge is taught more, but when you start doing things like Methodology then you start understanding the NOS. its tentative knowledge and its tentative nature. Its bias nature, it's you know…you know and how it is manipulated to favour one group and so on and so forth. You do get a hint of both of them…..

Respondent 2: We do get both of them but more of Content knowledge

Interviewer: in terms of assessment, do you think still SMK is assessed than DK? Is DK ever assessed? Where you get asked maybe about the NOS in any of the assessments?

Respondent 1: No….hardly!

Respondent 2: No not even during TE (teaching experience), It's not even assessed. I feel like, it's there for us individually to *wanthola (do you get my point?)…to actually engage le yona (with it*) to make use of it…if…if..if you see the necessity of even going that far, because some people , I feel like most if us ahhh! we personally I go for CK more because we believe if you have it, it's a way forward of helping you to deal with many things and everything like test and assessment per ser, which is the main thing *e leng gore ra e tshaba* (that we are scared of) yah!

Interviewer: Uhmmm…since now that you kinda have an understanding of difference between SMK and DK. To what extent do you think you have gained these two teacher knowledge base since from first year to now? Or rather what sort of knowledge do you think you have gained throughout your teacher training course?

Respondent 1: Uhmm….

Respondent 2: If *nna* (I) base it on years, like from first year…uhmmm like from first year it weighs differently from other years…first year DK *ne e le Biaie* (it was extensive/more)…..yeah! A lot of DK was taught in first year because they were trying to instill that idea of being a teacher from first year. It slowed down in second year I think. Then it came back last year (3rd year) and a bit of it (DK) this year (4th year) they tried to emphasis it although not as compared to first year

Interviewer: and how much of this DK do you know?

Respondent 2: Uhmmm..not much, because I have forgotten most of the things

Respondent 1: Ohhh in terms of DK I think there was a short stance of it last (3rd year). But I do not have a detailed knowledge about it, as I only got to learn the basics. I have detailed knowledge about SMK as it is taught more like a revision of the topics such as photosynthesis, genetics and human reproduction that were taught in high school but now we are covering them in depth.

Respondent 2: I think I got the basics of DK in 1st year and not 3rd year

Interviewer: Do you think if you were taught these two knowledge bases explicitly you could have had a better understanding of them?

Respondent 1: it would have much easier to identify with it than being taught implicitly. But if they taught it explicitly we could have picked the knowledge up.

Interviewer: Would you like to add anything?

Respondent 2: I would have said the same thing.

Interviewer: Thank you so much for your time.

8.2. <u>Transcribed excerpt for semi-structured focus group session 2</u>

Interviewer: Do you know anything about SMK and DK?

Respondents: *All silent*

Interviewer: It's okay if you don't know anything, its fine if you have never heard of anything before

Respondent 1: No….I have never!

Interviewer: Okay, basically Subject matter Knowledge has to do with your understanding of the content knowledge of life science that you have as a teacher and being able to make this knowledge accessible to your learners. Whereas, DK has do with your understanding of the nature of Life science or the whole Science in general. So it will include things like its history, philosophy and other sets of skills such as conducting a practical. So can you now distinguish between the two knowledge bases?

Respondents: yes

Interviewer: How much of these two knowledge bases are you taking away at the end of your teacher training course?

Respondent 1: I think quite a lot, even if I am a primary school teacher. The children that you find in class they challenge you because they want to know more. So the knowledge that I have gained helps me, because for example if you are teaching about photosynthesis **specialisation (<u>SMK)</u>**, in primary it's not as in-depth as in high school. But a child may want to know if it does happen at night, so the knowledge I have gained about the subject will help in such cases, I could be able to explain even if it's not in the curriculum **specialisation <u>(SMK snd DK)</u>**.

Interviewer: Would anyone else like to add something?

Respondent 2: In terms of the subject matter knowledge we have gained more of it as compared to disciplinary knowledge. The subject matter knowledge is more advanced regardless of the grade that you are teaching, Whether primary or high school the knowledge is still advanced.

Respondent 3: I was going to say the very same thing. But, there is no disciplinary knowledge that is taught in this degree. There is more subject matter knowledge because I feel they teach the syllabus in accordance to CAPS.

Interviewer: Do you think if they taught these two knowledge bases explicitly you would understand them better? Like...let us say for example they said "today's lesson is aimed at developing your subject matter knowledge or disciplinary knowledge" would that have improved your understanding of the two knowledge domains if that was the case?

Respondent 2: Of course definitely! If we were taught we would not only pay attention to just the content **specialisation (SMK)** but we would also learn how this content is generated specialisation (**DK)** and other aspects related to the nature of science **specialisation (DK)**

Respondent 3: After how you have explained subject matter knowledge and disciplinary knowledge, I still believe that we were never exposed to disciplinary knowledge, because I would've recalled that particular lesson right now.

Interviewer: So you are saying you were never exposed to DK in your training?

Respondent 3: Yes…..

Interviewer: Now that you have an understanding of both SMK and DK, do you think it has a role in your teacher knowledge bases?

Respondent 1: Yah! I think it is. It is because I feel like the SMK that they are exposing us is limiting us in some ways. We do not get a chance to understand the whole science genre and some of us don't just want to just end up as being teacher. We want to understand more of the Life science knowledge in relation to other scientific disciplines **Density**.

Interviewer: Do you think it takes a special person to study Life science or anybody can?

Respondent 3: Yeah! Anybody can study Life science. I am talking under the bases that some of the students have never done science before but they are here excelling.

Respondent 2: Yeah I also agree. I think it dependents on whether a person wants to do it or not.

Interviewer: What sort of knowledge have you gained throughout your training?

Respondent 1: Yoh! Plenty….Plenty

Respondent2: Considering the fact that we learn NS 1 and NS2 that contains physical science knowledge and the later chose Life science. The subject matter knowledge is quite a lot because we just did not study Life sciences but physical sciences concepts….

Respondent 1: …that were important and we actually saw that there was a link between the physical science knowledge and the Life science knowledge **Density**. This is because over the years you realized that you now need to draw back from the Physical science knowledge and implement it in the Life science. You further realize that ohhh you can't separate them as much as they categorize them as Life science and physical science.

Interviewer: You see that disciplinary knowledge right there. You being able to make those links between the subjects show your understanding of DK. Thank you guys for your time….

8.3. Transcribed excerpt for semi-structured focus group session 3 (lecturer)

Interviewer: As a lecture, do you have a clear structure of the type of SMK and DK that 4th year life sciences student take away after they complete their course?

Respondent: Remember I am one of at least three lectures who teach Life sciences 4th years and I am doing it for the 1st time this year .I have taught 3rd years for so many years and to be honest its tough. We have revised our course so the stuff, I am teaching them now together with my colleagues we used to do it in 3rd year. But we decided that we should put the grade 12 stuff into 4th year, so we have the definite decision around that… to say well look some of the people doing 3rd ^{year}, they really doing it as a sub major and may never get to teach grade 12 .So we put genetics and evolution **Specialisation (SMK)** which are two difficult and big things we took them out at 3rd year and put into 4th year. So what I have taught them at 3rd year, I am now teaching them at 4th year which is essentially the same content as it was at in 3rd year, because it starts to make sure they can start to teach the two concepts in matric.

Interviewer: When structuring your own course do you think about structuring the knowledge in terms of SMK and DK?

Respondent: Uhmmmm…. Develop their subject matter knowledge and the other thing?

Interviewer: Disciplinary knowledge!

Respondent: What is your understanding of the two because I don't think I know it?

Interviewer: SMK is the raw teachers' knowledge in their minds about their teaching subject and their ideas on how to transform that knowledge into accessible ways that their learners can understand. While, DK is a bigger knowledge base that incorporates a holistic understanding about the knowledge of the subject. I think that DK encompasses SMK. I hope that made sense….

Respondent: I thought as much, so well I must admit when planning my course I don't make those distinctions I just teach them to have a well-rounded knowledge that they will need as Life science teachers. I only point out elements of PCK but now that you are interested in it.

Interviewer: Do you think there is a difference in the assessment between SMK and DK?

Respondent: Definitely not! I think your research is premised around DK and SMK; I would have clearer answers if we as biologist in the department actually sat down and discuss the knowledge in terms of SMK and DK. The problem is we as the staff have recently started meeting and discussing ways of teaching the Life sciences content **Specialisation (SMK)** effectively to students. This is because back then the syllabus was haphazard and it is now that we have rearranged things and including things such as evolution and genetics **Specialisation (SMK)** into 3rd year and not 4th year. Also we have rearranged the contents classes to emphasize more on teaching the students how to teach this content **Specialisation (SMK)** rather than just leaving it to the methodology classes. Although we have been doing this, we haven't reached the point of discussing the disciplinary knowledge of Life sciences.

Interviewer: Can you say that DK is still a knowledge domain that is not recognized?

Respondent: No no…we didn't say it's not recognized, we as lecturers just haven't .I mean I personally haven't decided ummm……to structure our courses in that manner, we haven't structured our courses particularly around DK.

Interviewer: Do you think that the Life sciences 4th year PSTs leave the training fit enough to teach the subject?

Respondent: It is difficult to tell, but the shorter answer is yes they can go out and teach. They would struggle to go out and teach grade 12 in their first year and that's partly because they just got to get use to the teaching experiences and I think we cover the stuff well enough. But that's different for them in the end having to teach it. We cover the content **Specialisation (SMK)**, so you know hopefully they will start in grade10 and 11, so we never know they might go to schools where there are no Life sciences teachers' at all and they have to take matric straight away. But, they are individual student everybody is different.

Interviewer: With regards to the two classes that you offer methodology classes and the contents classes what role do they have in teachers' knowledge development?

Respondent: Umm….. Well I would say that content classes that I have already mention it, they cover content that we think is important for student to know which is obviously beyond matric level in the particular topics and also in those classes we try to model the content using the students' everyday examples on how they can teach that knowledge **Density** and other ,examples that are relevant for the classroom, so we do talk about how to teach it, then in methodology that's where we are having problems, I must admit we were talking together recently our structure for the whole of Life sciences including LS4 we haven’t yet got as good structure for the methodology courses, as we have with the content course we think we got the complete content course right. But we haven’t had that discussion to say right where is the sequence all the way through from the Natural sciences to Life sciences all the way through to LS3 into LS4 for methods ,we haven’t got that nailed down yet.

Interviewer: Thank you so so much for your time.