Natural Science teacher attitudes and Pedagogical Content Knowledge for teaching Botany

by

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List of abbreviations

CAPS Curriculum and Assessment Policy Statement

DoE Department of Education

FET Further Education and Training

NCS National Curriculum Statement

NS Natural Sciences

PCK Pedagogical Content Knowledge

RNCS Revised National Curriculum Statement

List of appendices

Abstract

This South African study investigated a sample of Grade 4 to 7 Natural Sciences teachers' attitudes towards botany and botany teaching and these teachers' botany Pedagogical Content Knowledge (PCK). It explored whether a relationship exists between teachers' attitudes towards botany teaching and their PCK. The study provides an overview of international and South African literature and research on the underrepresentation of botany and the teaching of botany in Natural Sciences classes. Throughout the study insight is provided on the universal problems of plant blindness and negative attitudes towards botany and botany teaching in the Natural Sciences classroom.

Data were collected during teachers' interviews, class observations and analyses of lesson plan documents. The results indicated that most teachers harbour negative attitudes towards botany and botany teaching. There are various reasons for this negativity such as past experiences in botany training, zoochauvinism and plant blindness. The Pedagogical Content Knowledge of teachers in this study was insufficient. It was found that teachers' attitudes towards botany teaching influence their PCK and teachers' PCK can, in turn, influence teacher attitudes towards botany, which can affect the teachers' ways of teaching.

This study confirms that problems of plant blindness, zoochauvinism and negativity towards botany and botany teaching that occur elsewhere in the world are also prevalent among South African teachers. This confirmation casts doubts on Natural Sciences teachers' botany PCK. This study adds to the literature on botany teaching and PCK in the South African context.

Keywords: Pedagogical Content Knowledge; teachers; botany; attitudes; teaching strategies; South Africa.

Chapter 1: Introduction

1.1 Introduction

Plants are considered an essential part of the environment and play a key role in supporting life on earth (Fancovicova & Prokop, 2010). Often little attention and appreciation are shown towards plants. The community has the propensity to harbour negativity and disinterest towards plants and the study of plants, referred to as botany, which leads to "plant blindness" (Wandersee & Schussler, 1999). Wandersee and Schussler (1998) refer to plant blindness as "the inability to see or notice the plants in one's own environment", which could cause the failure to see the importance of plants in the environment, lack of appreciation towards plants and zoochauvinism. Zoochauvinism can be defined as the way in which the community considers animals to be more important than plants and therefore prefers zoology to botany (Wandersee & Schussler, 1999).

Plant blindness is associated with the following indicators; overlooking plants in the environment, thinking that plants only blend in with the environment, misunderstanding of plants, not having dealt with plants in a practical manner and failure to carry across the functioning of plants (Balick & Cox, 1996 and Wandersee & Schussler, 1999). Plant blindness and zoochauvinism could be precursors to negative attitudes towards plants. This study investigates whether plant blindness, zoochauvinism and negative attitudes towards botany and botany teaching occur among South African Natural Sciences teachers when teaching botany. Botany is included in the Natural Sciences Learning Area and will serve as the topic of this study. This study does not only focus on Grade 4 to 7 Natural Sciences teachers' attitudes towards botany and botany teaching, but investigates teachers' botany-related Pedagogical Content Knowledge (PCK), and whether a relationship exists between their attitudes and the teachers' PCK. This exploratory study makes use of semi-structured teacher interviews, classroom observations and document analysis of intermediate and senior phase Natural Sciences teachers' botany-related lesson plans.

1.1.1 The Learning Area of Natural Sciences

In South Africa, school sciences are defined by the National Curriculum Statement (DoE, 2003). At the time this study was done, the National Curriculum Statement for Grades R to 9

(DoE, 2003) and the National Curriculum Statement for Grades 10 to 12 (DoE, 2003) were in the process of reform. Two documents were combined into a single document called the National Curriculum Statement Grades R to 12. The NCS Grades R-12 was phased in into the South African school system since January 2012. The NCS Grades R-12 consists of the following three documents: the Curriculum and Assessment Policy (CAPS), the National Policy Pertaining to the Programme and Promotion Requirements of the National Curriculum Statement Grades R to 12, and the National Protocol for Assessment Grades R to 12 (DoE, 2011).

From January 2012, the CAPS (DoE, 2011) programme was implemented with the focus on Grades R to 3 in the foundation phase, and Grade 10 in the FET phase. From 2013, CAPS was implemented for Grades 4 to 6 and Grade 11. In 2014 Grades 7 to 9 and 12 followed. Although implementation of CAPS started in 2012, the Intermediate phase (Grades 4-6) and Senior phase (Grades 7 to 9) only started to follow this programme from 2013. As data was collected in schools during 2012 the National Curriculum Statement of 2003 was used (DoE, 2003).

Natural Sciences is a Learning Area in the National Curriculum Statement of 2003 (DoE, 2003) and is taught from Grades R to 9 (DoE, 2003). This Learning Area consists of the four main unifying themes: Life and Living, Earth and Beyond, Energy and Change and Matter and Material (DoE, 2003). The Life and Living theme places emphasis on life processes, such as how to maintain one's health, body processes, environmental balance and change, and the importance of biodiversity. The theme Earth and Beyond focuses on areas such as structure and transformation of the earth, weather fluctuations and the study of planets in our solar system. The remaining two themes, Energy and Change and Matter and Material, are associated with the physical sciences (DoE, 2003).

1.1.2 Botany in the Grades 4 to 7 Natural Science Learning Area

The Department of Education (2003) delineates a framework of botany-related Core Knowledge and principles that should be integrated in the Grade 4 to 7 Natural Sciences Learning Area. Table 1 is a summary of the botany-related Core Knowledge as grouped in the four unifying themes in the Intermediate and Senior phases of the Natural Sciences Learning Area.

Table 1: Core Knowledge related to botany in the Life and Living, Earth and Beyond, Energy and Change and Matter and Material themes in the Natural Sciences Learning Area (DoE, 2003).

Theme	**Botany-related Core Knowledge and principles in the Intermediate phase (Grades 4 to 6)**	**Botany-related Core Knowledge and principles in the Senior phase (Grade 7)**
Life and Living	Photosynthesis, asexual and sexual reproduction of plants, the role of plants in the ecosystem, the interrelation between animals and plants, soil formation with reference to plants, fossil studies and the relationship to plants.	Photosynthesis, ecosystems, foodwebs, pollution, recycling, exotic species, biodiversity, cells.
Earth and Beyond	Soil erosion, soil formation (related to humus), the water cycle.	The sun as energy source, the way in which plants adapt to different climates, global warming, continental drift, fossils
Energy and Change	Energy sources such as the sun (photosynthesis).	Fossil fuels, energy from ecosystems, environmental studies.
Matter and Material	No related material.	Natural sources and exploitation thereof.

By looking at Table 1 it becomes clear that the Life and Living theme deals with botany in detail, where the other themes only briefly refer to botanical topics. Botany-related knowledge and principles often play an insignificant and uninspiring role in the Natural Sciences classroom compared to zoological knowledge (Honey, 1987). Honey (1987) also added that botany is not a prominently featured component in international science curricula and less time is devoted to botany than to zoology.

In the researcher's prior experience with botany teaching, it was evident that botanical concepts and principles are often neglected in South African Natural Sciences classes. An example is a common concept taught by the researcher in Natural Sciences classes such as

the water cycle which seems to exclude the involvement of plants. Learners are taught the different physical processes in the water cycle such as condensation, rain (precipitation), and evaporation, but the role of plants in the cycle is seldom addressed. The role of plants in the water cycle could be explained by referring to photosynthesis. Photosynthesis is inextricably linked to transpiration, as open stomata enable both gas exchange and water loss through transpiration. These concepts highlight the importance of plants in terrestrial ecosystems and global warming (Audesirk, Audesirk & Beyers, 2006:598). Teachers and learners view the water cycle and other concepts taught in the Natural Sciences class as non-changing processes, teachers often strictly follow textbooks, without integrating other components such as plants. Knott, Lawson, Karplus, Their and Montgomery (1978) concluded that Grade 5 science learners study photosynthesis strictly according to the textbook, but are unable to apply and understand the concept as a whole and relate their knowledge learnt in class to other aspects of science and the environment (Roth, Anderson, Edward & Smith, 1987).

1.1.3 Natural Sciences education with reference to PCK

In order for learners to understand botany as part of Natural Sciences, and to allow learners to expand their knowledge and observe the relationships between different concepts, it is important that the science teacher acquires knowledge in multiple areas to ensure these concepts are integrated by using a variety of teaching strategies and instructional methods in class (Botha & Reddy, 2011). This can be referred to as a teacher's Pedagogical Content Knowledge (PCK).

PCK research concentrates on the use of a variety of teaching strategies, methods, assessment and examples in teaching and whether it might improve understanding and achievement in a subject (Shulman, 1986). Shulman (1986) further argues that "PCK is a distinct body of knowledge that distinguishes teachers from content specialists". We can therefore conclude that PCK is regarded as an important basis for teaching, learning and understanding (Shulman, 1986) and is viewed by international policymakers and scholars as necessary to enhance teaching, learning and understanding (Hill, Ball & Schilling, 2008).

PCK is evident when teachers have multiple areas of knowledge such as distinctive, Learning Area specific knowledge of content, appropriate teaching strategies, instructional methods, assessment strategies and an awareness of learner understanding and misconceptions (Loughran, Mulhall & Berry, 2004; Abell, 2007). Carter (1990) distinguishes PCK to include a teacher's subject matter knowledge and the manner in which this subject matter is taught to

the class. PCK also includes the knowledge of prior conceptions that learners bring to class, the teacher's knowledge of the Learning Area and teaching which develops over time, the attitudes teachers bring to class and their theories, and their beliefs towards a Learning Area which will eventually affect their teaching (Artzt, Armour-Thomas & Curcio, 2008). Although Artzt, Armour-Thomas and Curcio (2008) state that attitudes form part of PCK, in this study teacher attitudes are not defined as PCK, but is seen as a factor that can influence PCK.

International and local research recently shifted the focus to the study of teachers' PCK and the manner in which teachers teach, as it is considered an important facet in teacher education, especially in Natural Sciences (Botha & Reddy, 2011). Science teachers who have an adequate and sufficient PCK could contribute to learner understanding (Van Driel & Verloop, 2002; Miller, 2007; Khetsiwe, 2010) and learner understanding is dependent on the use of effective teaching strategies and methods to present scientific principles (Chick & Harris, 2007). However in South Africa, growing concern regarding Natural Sciences teachers' PCK in terms of their teaching and knowledge of learner understanding encourages South African PCK specialists like Rollnick, Bennet, Rhemtula, Dharsey and Ndlovu (2008) to work towards possible solutions. Rollnick *et al.* (2008) relate this concern to the term "curricular saliency" which is known to be the "teacher's understanding of the place of a topic in the curriculum and the purpose of teaching it". Some teachers find it difficult to teach concepts that are unknown and new to them (Hashweh, 1987). The concern regarding Natural Sciences teachers' PCK may result in teachers selecting uninteresting teaching strategies, instructional methods and assessment in teaching botany, leading to an ongoing cycle of difficulty in teaching scientific concepts in the Natural Sciences classroom regarding botany (Hashweh 1987; van Driel, Verloop & De Vos, 1998).

In the study by Käpyla, Heikkinen and Asunta (2009) who investigated primary school, pre-service science teachers' content knowledge and science PCK, the dilemma surfaced that these teachers had a lack of content knowledge and that it had a negative impact on their science teaching abilities. The lack of teachers' content knowledge may lead to the inability of integrating certain botanical concepts into the rest of the Natural Sciences Learning Area. The teacher needs to be aware of the concepts which seem to be difficult for learners to understand and learner misconceptions (Shulman 1986)."A teacher's content knowledge is part of their PCK, and the teacher's choice of representations (or the lack thereof) reveals information about the structure of their content knowledge" (Rollnick *et al.*, 2008).

1.2 Background and context of the study

1.2.1 The role of botany in the South African Natural Sciences curriculum

The study of botanical topics is limited in international science curricula and it is clear that learners do not understand botany, form negative attitudes and harbour misconceptions towards this Learning Area component (Barman, Stein & Mc Nair, 2003). Honey (1987) remarks that a great part of international science education only focuses on obvious science processes and methods such as different concepts in science and methods. Additionally the study of botany does not take up nearly as much time as the study of zoology does in curricula (Honey, 1987).

The South African Natural Sciences curriculum serves as a starting point of nurturing understanding and appreciation of botanical concepts amongst learners. However, despite the importance of many of these botanical concepts, very few feature in the National Curriculum Statement Grades R to 9 (DoE, 2003) (Table 1, page 4). The National Curriculum Statement (DoE, 2003) focuses on a wide variety of areas, from the study of star formation to the study of the lives of microscopic animals, from the study of crystals to the study and understanding of the earth's climate change.

From the large number of study areas in Natural Sciences, learners will attempt to construct integrated knowledge systems, which could contribute to the formation of misconceptions, because of learners trying to compare botany-related concepts like photosynthesis to zoological functions such as ingestion. According to the researcher's opinion learners in South African schools form various misconceptions when learning botany in the context of general science programmes. Learners struggle to understand the fact that plants produce energy during photosynthesis; consequently plants are referred to as "making food". Numerous international studies have confirmed that learners form misconceptions of plants for example learners associate life with locomotion, therefore misconceptions may arise on whether plants are alive or not (Yorek, Shahin & Aydin, 2009).

Various misconceptions of the teacher or the learner may also cause the teacher to exclude certain botanical concepts in the classroom. Honey (1987) states that the inclusion of botanical concepts in teaching can influence the attitudes of the teacher towards botany. As a result a teacher's PCK functions as an integral component of the learners' attitudes towards a

specific topic such as botany (Hendley, Parkinson, Stables & Tanner, 1995: Woolnough, 1994).

1.2.2 Teaching botany in the Natural Sciences classroom

The importance of botany is evident in our daily lives, impacting on "energy, habitat, oxygen, medicines, foods, lumber and textiles and carbon storage for the plants" (Schussler, Link-Perez, Weber & Dollo, 2010). It is essential that teachers and learners understand the role of plants in the environment, our lives and in the classroom by understanding plant function and structure (Goodwin, 2008: 25). Teachers are the ones to persuade learners of the role that plants play in life and in science, so they firstly have to arouse the curiosity within these learners, through linking botany teaching and learning to the natural, everyday environment (Goodwin, 2008: 25) and by integrating different, fun ways of learning.

Each teacher has different attitudes towards teaching a specific Learning Area. A teacher's content knowledge and views towards botany, which could be caused by different experiences in his own botany education, could be the reason for his attitudes towards botany and botany teaching. Further reasons for negative attitudes towards botany and botany teaching are the use of traditional, uninteresting teaching strategies, instructional methods and methods of assessment (Hershey, 1996; Honey, 1987). If science teachers with negative attitudes can overcome their preconceptions towards botany, the subject component of botany may be viewed and experienced as an inspiring and exciting component in science (Honey, 1987). A Natural Sciences teacher's ways of teaching and the roles the teacher plays in class can influence the teacher's understanding, attitudes and outlook towards a subject (Botha & Reddy, 2011) and in this study particularly botany teaching.

Constructivism can be defined as learning by experience where learning takes place when the learner is exposed to real life circumstances. These circumstances are based on social, personal and community relations. By this method new botanical knowledge can be based on the learners' prior knowledge of plants and (their ability) to measure (which will) ensure maximum understanding (Luera & Otto, 2005; Park, Jang, Chen, Jung, 2010). Constructivism has three characteristics; "Standards based, student centred and enquiry oriented" (Anderson, Anderson, Varank-Martin, Romagnano, Bielenberg & Flory, 1994). Teachers need to adapt to ensure active learning where learners can help to design activities in class, enquire about certain topics and build upon their existing knowledge which is an easy and hands-on manner in learning, whilst the teacher facilitates during this process (Park, Jang, Chen, Jung, 2010).

Active learning supports botany teaching and understanding, whereas rote learning, memorization of facts and transferring knowledge from teacher to learner should not be the key focus (Shulman, 1986; Grossman, 1990). Activities could be constructed and implemented to transform knowledge and skills, not to transfer content knowledge. Activities must also be transformed into pedagogical practices to ensure maximum understanding in the field (Grossman, 1990; Shulman, 1986).

1.2.2.1 Multiple interacting microworlds

Teachers do not only have to persuade learners to participate and understand in class, but the teacher fulfils many roles in class and is exposed to "multiple interacting microworlds" in education (Barnett & Hodson, 2001). Examples of these microworlds are the teacher's professionalism, the school culture, the curriculum and education. The science teacher has to fulfil the microworld of teacher professionalism. This refers to the teacher's prior science experiences and communication with other teachers, whether it is good or bad, that might have an influence on their teaching. Barnett and Hodson (2001) also listed the "microworld of the particular school culture", and the "microworld of the science curriculum", where knowledge, skills and attitudes are identified as microworlds which can have an impact on teaching. In this study the Natural Sciences National Curriculum Statement serves as a guideline to the "microworld of the science curriculum". In this study the "microworld of teaching botany" implies different Learning Outcomes and Assessment Standards that the teacher can use as a guideline towards effective teaching of science and plants. Another microworld is that of "science education" which focuses on the knowledge, skills and attitudes taught to the learners, which, in turn, equip the learner to protect and respect the environment and to obtain scientific literacy. Each of these microworlds might be used by a teacher in different ways. In addition, there is a need to conduct research on science teachers' knowledge on how to integrate these microworlds into their botany Pedagogical Content Knowledge (PCK) and the learner's understanding in class (Barnett & Hodson, 2001).

1.2.3 PCK in the Natural Sciences classroom

PCK can be referred to as a type of "craft knowledge" (Van Driel *et al*. 1998). This reference is also in accordance with Goodwin's (2008: 32) statement of (a teacher) having knowledge of the curriculum and knowledge of the teaching practice itself. In addition, a teacher's content knowledge of science determines what a teacher teaches which could influence his PCK, and the manner in which he teaches (Van Driel *et al.*, 1998; Goodwin, 2008: 32). A

science teacher's PCK should include an exceptional understanding of science, a mastery of combining scientific and curriculum content in the classroom and the knowledge to teach with the help of different teaching strategies and instructional methods whilst having an excellent understanding of how learners learn best in the Natural Sciences class (Goodwin, 2008: 32).

A teacher's knowledge and skills could also be referred to as PCK, i.e. a teacher who is able to include knowledge of relevant content along with the curriculum that serves as a guideline in teaching (Shulman, 1986; Grossman, 1990; van Driel *et al.*, 1998; Gunstone, Berry, Milroy & Mulhall, 2000; Friedrichsen, Abell, Pareja, Brown, Lankford & Volkmann, 2009; Goodnough & Hung, 2009). Success in teaching, learning and understanding primary school Natural Sciences is determined by a teacher's knowledge, skills and attitudes towards a specific discipline, such as botany in Natural Sciences.

A conceptualization of PCK as a crucial component in teaching also stresses the importance of knowledge owned by the teacher to construct and illustrate science and botany Learning Area content (Shulman, 1986). The teacher should be aware of learner misconceptions and must be able to think scientifically, in addition to pedagogical practice and reflection thereof (Loughran, *et al.*, 2000).

In this study the researcher views PCK in the light of South African and international authors' definitions and models of PCK. Definitions and models of PCK given by Rollnick *et al.*, (2008) and by Magnusson, Krajcik and Borko (1999) can be combined to identify six domains. According to Rollnick *et al.* (2008) and Magnusson *et al.* (1999), these PCK domains are teachers' attitudes towards science and botany, knowledge of the science curriculum, knowledge of content, knowledge of learner understanding, knowledge of teaching strategies and the context used in botany teaching. These domains were adapted with reference to Natural Sciences and botany. In this study, the domain of teacher attitudes towards botany is not part of PCK, but a factor that shows relationship with PCK. These domains will be discussed in Chapter 2.

1.2.4 Context of this study

This paper presents a South African case study that explores English and Afrikaans, co-educational, Gauteng primary school Natural Sciences teachers with a specific interest in the Intermediate and Senior phases. The three schools that participated in the study were

selected in accordance with the availability of resources and the location of the schools with regard to rural and urban settings.

Intermediate and Senior phases were selected because these two phases are considered the basic phases of teaching and learning botany as a component of Natural Sciences. In the Intermediate phase curriculum learners are exposed to learning of Natural Sciences for the first time. These phases present a crucial bridge between learners' understanding and attitudes towards botany for future learning.

1.3 Problem statement

A number of problems are addressed in this study:

- In the South African context there is a lack of research material and literature on botany teaching and Natural Sciences teachers' PCK.
- Internationally problems such as plant blindness (Wandersee & Schussler, 1999) and negative attitudes towards botany have been identified. These problems might exist among Natural Sciences teachers in South African schools. However no recent studies have been reported in South African literature.
- In the South African context there are concerns regarding the state of Natural Sciences teachers' PCK towards botany teaching (Goodwin, 2008: 16).

In the TIMMS (1999) and (2003) studies, South African learners scored the lowest in mathematics and science when compared to scores of learners in other participating countries. South Africa's mean scores for both Learning Areas were lower than the average scores obtained in all other participating countries. The science score was also lower than the mathematics score: 244 in both years out of a maximum score of 800 (TIMMS, 1999). According to TIMMS Science report (2011), South Africa only participated in 1999 and 2003, and not again. From the analysis of the results obtained in 1999 and 2003 research should be conducted to explore the roots of the problem in science and mathematics. Most South African studies in science focus on science in general, but do not focus on its components such as botany and, specifically, teachers' PCK in botany teaching along with the focal point on attitudes towards the teaching of botany (Magnusson *et al*., 1999). Although plants are important in our daily lives, the literature and research on how botany is taught still seems to be insufficient. Some international studies focus on problems such as

the relationship between content knowledge and PCK on the topics of photosynthesis and plant growth (Käpyla *et al*., 2009). South African studies concentrate on the development of teachers' PCK in physical sciences, chemistry and mathematics and the teachers' content knowledge in these Learning Areas (van Driel & De Jong, 1999; De Jong & van Driel, 2004; De Jong, van Driel & Verloop, 2005; Khetsiwe, 2010). Khetsiwe (2010) completed a study on the Life Sciences Learning Area where the focus was placed on science teachers' PCK in the teaching of genetics in one of our neighbouring Southern African countries, Swaziland. South African experts in the field of PCK also focussed on teachers' PCK regarding mathematics (Rollnick, *et al.,* 2008).

The problems of plant blindness and disinterested attitudes towards botany among Natural Sciences teachers that appear to be present in every country where studies have been conducted are also factors that led to this study. Honey (1987) highlights that the problem of plant blindness, which refers to the attitude in which people often overlook plants, and do not regard plants as equally important as animals (Wandersee & Schussler, 1999), as a result of the paucity of botany teaching and learning in schools. If plant blindness, according to Uno (2009), is a growing, universal problem among learners in botany classrooms, we can't help but wonder what the possible reasons for plant blindness in South African classrooms could be. The general assumption that zoology is preferred over botany could be seen as a contributing factor to the problem of plant blindness (Honey, 1987). According to this researcher's personal experience, zoology and human biology often serve as a starting point for South African botany lessons to help promote understanding and relevance among learners, rather than promoting botany to be regarded as equally important and exciting. This practice creates a problem in the botany classroom, and leads to a situation of learners who do not appreciate and who overlook plants.

Honey (1987) asks whether the lack of interest in plants in general leads to a decline in botany education. According to Hershey (1996) the problem of plant blindness may also be the result of the teacher's perceived negative and disinterested attitudes towards botany. Negative attitudes and beliefs regarding botany may well have an impact on a teacher's PCK such as a lack of knowledge of the curriculum, of content, poor teaching strategies and assessment methods in botany teaching.

Although botany PCK is influenced by teachers' personal experiences and backgrounds in botany-related matter (van Driel *et al*., 1998), their own primary and secondary botany

educational experiences, pre-service teacher education and experiences and pedagogical experiences in practice could form part of the reason behind disinterested attitudes towards botany among Natural Sciences teachers (Grossman, 1990). Past studies indicate that teachers who find it difficult to teach concepts in a manner that promote learner understanding, have insufficient PCK (Cochran, King & DeRuiter, 1991; Feiman- Nemser & Parker, 1990; Halim & Meerah, 2002; Wilson, Shulman & Richert, 1987). Could this be the case in botany teaching in South African science classrooms? The problems of plant blindness, teacher attitudes and PCK can lead to unawareness of the prevalence of plant blindness in South African and of whether or not this problem is applicable in our education system.

PCK or problems concerning PCK, which form a major part of this study, may lead to teachers who use uninteresting and traditional teaching strategies (Tabachnick & Zeichner, 1999; Mulholland & Wallace, 2001; Appleton & Kind, 2002; Goodnough & Hung, 2009). There are still teachers who find it difficult to teach concepts in different Learning Areas such as Natural Sciences, who report a shortage of confidence, and who only feel comfortable with teaching strategies that will help control the class and passively transfer scientific knowledge to learners (Appleton & Kindt, 2000; Symington, 1980). Although the National Curriculum Statement (DoE, 2003) requires that a learner centred approach should be incorporated in classes, it still seems not to be applied in Natural Sciences classes, especially in the lower grades (Appleton & Kindt, 2000; Symington, 1980). This may have a detrimental impact on teaching and learner understanding among Grade 4 to 7 learners who could consider botany to be rather boring (Tabachnick & Zeichner, 1999; Mulholland & Wallace, 2001; Appleton & Kind, 2002; Goodnough & Hung, 2009). In the researcher's experience, traditional teaching strategies (for example the transmission method) is still mainly used in Natural Sciences classes, rather than actively involving learners in practical botany teaching and learning inside or outside the classroom, where examples of plant material are used that could aid in the learning process. Hershey (1996) states that many science classes encompass a misconstrued view of botany; however we are not certain whether this might be the case in South African Natural Sciences classes.

1.4 Rationale

Research in the field of teachers' attitudes towards botany and the PCK of the teacher are not popular topics in South African research literature. Therefore this study is foremost in the researcher's interest in teacher attitudes towards botany teaching and teachers' PCK. This

study relates to the researcher's scholastic career, tertiary training, current teaching practice and love for the marvels of botany teaching.

We are familiar with international educational research regarding pure science teaching and botany (Abell, 2007 cited in Khetsiwe, 2010:10), but in South Africa there seems to be a lack of research regarding botany teaching and the state of teachers' botany PCK. Internationally various studies exist on PCK and science teaching, but only on the development of pre-service science teachers' PCK. Studies in South Africa mainly focus on the fields of chemistry and mathematics (Rollnick *et al*., 2008), but not on in-service teachers' and botany teaching.

Considering the pervasive role of plants in our daily lives, and the scarcity of South African research in botany PCK, this study was undertaken to explore Natural Sciences teachers' attitudes towards botany and botany teaching and the teachers' PCK in the context of botany education in Natural Sciences.

South African Natural Sciences teachers' knowledge, skills and attitudes towards botany were investigated by Goodwin (2008:16), but this study presented only a preliminary investigation into the topic. This provides a reason to elaborate on research related to South African Natural Sciences teachers' attitudes towards botany and botany teaching and their PCK regarding botany. The results of the study by Goodwin (2008) showed that science teachers need to be knowledgeable in all aspects of botany education to teach the subject effectively.

The findings of this study could improve botany teaching and teacher development programmes (Rollnick *et al*., 2008). According to Goodnough and Hung (2009) the PCK of science teachers should be a focus point when the enhancement of effective teaching is being considered. Therefore a teachers' PCK could act as a contributing factor towards successful education when complicated concepts are taught in science (Magnusson, Borko & Krajcik, 1994 & Magnusson, Krajcik & Borko, 1993).

This study seeks to establish whether South African teachers harbour negative attitudes towards botany and botany teaching. This study also explores the reasons why botany was seen as complicated and uninteresting when teachers' attitudes towards botany and botany teaching were investigated and whether there was a relationship between the teachers' attitudes and their PCK.

1.5 Main research question and sub-questions

The study was guided by the following main research question and sub-questions:

What is the relationship between Natural Sciences teachers' attitudes towards botany teaching and their botany PCK?

- What are Grades 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do they harbour these particular attitudes?
- What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do they choose specific teaching strategies?
- How do teacher attitudes towards botany teaching impact their botany PCK?

1.6 Purpose and aims of the study

The purpose of this study is threefold in nature:

- To explore Grade 4 to 7, Natural Sciences teachers' attitudes towards botany teaching.
- To explore Grade 4 to 7, Natural Sciences teachers' botany PCK in the Natural Sciences classroom.
- To investigate whether a relationship exist between the attitudes of Grade 4 to 7 Natural Sciences teachers towards botany and their botany PCK.

In order to investigate teachers' attitudes and PCK data had to be obtained. Data were collected by means of one-on-one semi-structured interviews with teachers, and classroom observations with Grades 4 to 7 Natural Sciences teachers together with analyses of botany lesson plan documents. These documents helped the researcher to obtain a clear understanding and experience of the classroom atmosphere, the environment of and activities in the classroom and the manner in which botany is carried across to learners.

The findings of this study may be of use in teacher development programmes, and might improve and enhance science teachers' knowledge of their practice. Findings of the study might contribute to teachers' reflexivity of their PCK owned and practised in their classes, and might help them to improve their teaching (Laughran, Berry & Mulhall, 2006). The findings from the research could also lead to improvement in botany instruction and re-

establish botany as an exciting, important, and intriguing component of Natural Sciences in primary schools.

1.7 Declaration of assumptions

In this study three assumptions are used:

- Teachers may have certain preferences regarding teaching concepts and topics in Natural Sciences; these preferences might result in positive or negative attitudes towards botany teaching.
- Natural Sciences teachers' attitudes could be related to the state of their botany PCK.
- Teachers' botany PCK might also be related to the ways in which they teach botany and their preferences in teaching.

The first assumption that teachers may have certain preferences in Natural Sciences teaching is supported by international studies by Kinchin (1999), Wandersee (1986), Schussler and Olzak (2008) of learners' attitudes towards botany. These studies indicate that learners would rather learn about zoology than botany. Hershey (1996) adds that teacher preference of botany over zoology presents a major concern in the science classroom, because teachers might have an influence on learners' preferences and attitudes when botany or zoology is taught in class.

This study explores whether Natural Sciences teachers have similar preferences in South African primary schools, as those preferences might result in positive or negative attitudes in botany teaching. Positive or negative attitudes could furthermore be explained in terms of Wandersee and Schussler's (1999) concept of plant blindness. Plant blindness could contribute to zoochauvinistic attitudes, whereas teachers could prefer to teach zoology over botany (Wandersee & Schussler, 1999). Negative attitudes held by teachers towards botany and botany teaching are expected to be seen as an indicator that botany might be sidelined in the classroom, which will eventually have an impact on understanding, attitudes and class atmosphere. Plant blindness in science may cause teaching and learning about plants to be dull and lifeless (Flannery, 1987; Uno, 1994; Hershey, 1996).

The second assumption is that Natural Sciences teachers' preferences and attitudes could relate to the state of the teachers' PCK. A relationship might exist between the teacher's

knowledge, attitudes and the teachers' outlook on botany and botany teaching and their PCK. Teachers with a well-developed PCK may hold positive attitudes towards botany teaching and have sufficient knowledge about the field, and consequently they might have a better ability to teach botany using various methods of instruction (Treagust & Treagust, 2004). There is a reciprocal relationship between teachers' attitudes and their PCK.

The third assumption in this study was derived from work done by international scholars Halim and Meerah (2002 cited in Khetsiwe, 2010), who state that teachers with a lack of PCK may cause botany teaching, in this case, to be substandard. Teachers' PCK might influence their attitudes when they teach botany. Teachers' PCK could also influence whether they feel comfortable to teach botanical concepts with the use of a variety of teaching strategies, instructional methods and assessment strategies.

Teachers' PCK might not only influence teacher attitudes towards botany in Natural Sciences, but also their teaching of botany. Honey's (1987) argument can contribute to this assumption; "teachers have less interest in plants than animals." Although Honey (1987) placed the focus on an international context, it might be the case in the South African context of botany teaching. Teachers all over the world might fall short of attention-grabbing teaching strategies, assessment strategies and content knowledge of botany (Honey, 1987).

The following chapter will provide an overview of International and South African literature regarding teachers' attitudes towards botany and botany teaching and the PCK held towards botany teaching.

Chapter 2: Literature Review

2.1 Introduction

The literature in this chapter gives the current knowledge on science teachers' attitudes towards botany and their PCK. The first section emphasises botany and attitudes towards botany teaching. The second section in this chapter is concerned with science teachers' PCK. Literature from international and South African studies is considered.

2.2 Botany, the discipline

> *As buds give rise by growth to fresh buds, and those, if vigorous branch out and overlap on all sides many a feebler branch, so by generation. I believe it has been with the great tree of life, which fills us with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications (Darwin, 1859:130).*

The term "botany" is derived from the Greek word *botanē,* signifying "plant" , which derives from the verb *boskein*, "to feed". Botany, known as the study of plants, is a scientific discipline with a large number of sub-disciplines (Raven, Evert & Eichorn, 2005:9). The study of plants inspires us with inspiration to draw attention to "the nature of all life" (Raven, *et al.*, 2005:1). The human race gathers plant material for food and shelter. Humans also saw another use for plants, i.e. to obtain materials from the cultivation of crops (McMahon, Kofranek & Rubatzk, 2007:4). The cultivation of crops evolved and has played a major role in the development of our growing population (Raven *et al*., 2005:9). Given the importance of plants to the human race, animals and the environment, plants provide us with "clothing, wood for furniture, shelter, fuel, paper for books, spices for flavour, drugs for medicines, and the oxygen we breathe" (Raven *et al*., 2005:1).

In order to create an appreciation for plants, we have to develop a love for the study of plants. "Plant physiology, plant morphology, plant anatomy, plant taxonomy and systematics,

cytology, genetics, molecular biology, economic botany, ethnobotany, ecology and paleobotany" form the elements of study in botany (Raven *et al.*, 2005:9).

2.3 The state of botany teaching in an international and South African context

In an international study by Honey (1987), it is stated that botany education is underrepresented in curricula when compared to zoology. Consequently Honey's (1987) argument on the easy identification of the diminished status of botany in science curricula is believable; because of the wide-spread perceived disinterested attitudes and negativity towards plants in general. With regard to science textbooks, in Nuffield (1986) Biology textbooks published in London, only 20% of the content is concerned with botany, whereas 70% of the content deals with zoology (Monger, 1975; Honey, 1987). These figures contribute to the notion that botany has been neglected in textbooks, presented in an uninteresting manner and a lack of teaching strategies has been used. A lack of teaching strategies is associated with deficient PCK (Hershey, 1996). Teachers show plant blindness in botany teaching (Wandersee & Schussler, 1999). Wandersee and Schussler (1999) suggested that one of the reasons for plant blindness might be that the teachers do not use living plants as examples inside or outside the classroom. For this reason there is an absence of excitement, adventure and enthusiasm among learners in science classes towards botany (Hershey, 1996). Wandersee and Schussler (1999) and Hershey's (1996) information shows that this is the case in overseas countries. In this study similar results were expected.

Uno (1994), who investigated the state of precollege botanical education in the USA, highlighted the essential appreciation of and knowledge about botany that should be taught at school level. He discussed the importance of the equilibrium between teaching content and completing tasks in the classroom in order to create understanding of concepts, facts and the relevance of botany in science. The balance between teaching content and doing tasks shows that botany teaching and learning is a practical type of understanding which should be practised in or outside the classroom. This should be done to connect theory to practice in the environment by using a methodology of exploring living plant examples and different strategies when teaching botany (Kahtz, 2000; Taraban, McKenney, Peffley & Applegarth, 2004). Learners could be taught how to name and identify the characteristics of plants, and build upon their knowledge of botany throughout their lives, and this could be achieved with the help of practical learning of botany, which could already be nurtured at an early age (Kahtz, 2000).

An international study, conducted by Wandersee and Clary (2006), explored "students' botanical sense of place", which included measures of the state of these students' prior knowledge, attitudes and experiences towards plants. To determine students' botanical sense of place could have major significance in botany learning in schools world-wide by using special "template writing", to help learners observe, see relevance, and importance of plant life around them (Wandersee & Clary, 2006). This "template writing" may for example include that learners be asked to write answers to short questions related to plants, to write an essay on a topic of their choice, to write about plants, and to write about the concepts learnt in botany and how these can relate to one's memory or childhood (Wandersee & Clary, 2006). Teachers could be encouraged to use this "template" or similar written work as a teaching strategy at the start of botany-related classes to create a sense of learners' perceptions, attitudes and prior knowledge of plants (Wandersee & Clary, 2006). The answers to questions on the template could provide the stepping stones to understand the learners' state of botany knowledge and attitudes, which could help the teacher to identify botany-related misconceptions in class, to work towards solving of these problems and to build on their prior knowledge.

Goodwin (2008) conducted a study in South Africa on building and creating a school garden in a rural school in South Africa, an activity which is becoming very popular in South African schools. Goodwin (2008:16) proclaimed that teachers and learners need to be actively involved in the area of botany teaching and learning. The school garden contributed to a change in the particular school's learners' attitudes towards plants. Learners encounter plants in their daily lives, these encounters are linked to the teachers' knowledge and attitudes towards plants that should be acquired from an early age. Relating knowledge of botanical concepts to learners' daily lives, prior knowledge and attitudes towards botany in the Natural Sciences classroom is considered a crucial component of teaching and learning. A school garden might become part of the botany teaching experience and become a resource to enhance practical learning of botany (Goodwin, 2008:16).

2.3.1 Misconceptions in botany teaching and learning

The literature has shown that learners harbour various misconceptions about botany. The first common misconception is that plants do not need nutrients, because they do not move (Ekici, Ekici & Aydin, 2007). Learners do not see the significance of plants, because they regard them as immobile structures, therefore plants are of less importance than animals and

regarded as "boring". (Ekici, *et al.*, 2007). Studies by Baxter (1989) have shown that learners' conceptions are based on what they see. They might think that plants are "non-living organisms", because they do not move, and often plant nutrition is related to the "food that the plant eats". Smith and Wesley (2000) added that learners conclude that plants "drink" and "suck up" water, but cannot relate this to plant function. Photosynthesis, which is a major source of misconceptions in botany, can therefore not be dealt with in a way of just teaching the scientific facts of the process but to look at it as an integral part of the ecosystem (Ray & Beardsey, 2008).

In order to succeed in botany teaching a pre-assessment could be done to discover learners' conceptions and prior knowledge of plants (Smith & Wesley, 2000). Teachers can base their teaching of new knowledge on the learners' prior conceptions and even their misconceptions. By doing this teachers can improve on their teaching to help learners understand a specific concept (Mosothwane, 2011). Hershey (2004) stated that most learners struggle with botany concepts Some of these learners will become our future teachers who will need adequate content knowledge related to plants.

2.3.2 Learning Outcomes and Assessment Standards in the South African school curriculum

When the researcher commenced with this study in 2011 Outcomes-Based Education (OBE) still formed the foundation of the South African school curriculum, which was the basis for promoting maximum achievement amongst our learners (DoE, 2003). According to the National Curriculum Statement (DoE, 2003), there are different phases of education in South African schools: The Foundation phase (Grades R to 3), Intermediate phase (Grades 4 to 6), Senior phase (Grades 7 to 9) and the Further Education and Training phase (Grades 10 to 12). The Foundation phase implements three Learning Programmes: Literacy, Numeracy and Life Skills. In the Intermediate phase and Senior phase, Learning Programmes are separated into different Learning Areas. Language is grouped into the eleven official languages of South Africa. Learning Areas include Languages, Mathematics, Natural Sciences, Technology, Social Sciences, Arts and Culture, Life Orientation and Business Economic Sciences. According to the National Curriculum Statement (DoE, 2003) these Learning Areas each have different Learning Outcomes together with the Assessment Standards which are described in the following section. It is also stated that a schools' organisational requirements can determine the type of learning and activities that should be included, and the time

devoted to each Learning Area, on condition that the needs of the learners are taken into consideration in each phase (DoE, 2003).

The central area of investigation in this study is botany teaching in the Learning Area of Natural Sciences. The DoE (2003) formulates three Learning Outcomes in the General Education and Training Band (Grades R to 9) of the Natural Sciences Learning Area. Learning Outcome 1 (LO 1) focuses on the learners' abilities to conduct scientific inquiry, Learning Outcome 2 is based on the construction and application of Natural Sciences knowledge, whilst Learning Outcome 3 focuses on learners' understanding of the relationship between Natural Sciences, the society and the environment (DoE, 2003). Assessment Standards are integrated to serve as a guide in determining the level of learners' achievement from the above-mentioned Learning Outcomes (DoE, 2003).

The Natural Sciences Learning Area covers Grades 4 to 7 in primary school and Grades 8 and 9 in high school. In Grades 10 to 12 this Learning Area is separated into Life Sciences and Physical Sciences. Life Sciences include the study of life in a fluctuating, natural and synthetic world, utilising critical inquiry, reflection, and the understanding of concepts and processes and their application in society (DoE, 2003). Physical Sciences place the impetus on learning physical and chemical concepts by involving the learner in scientific inquiry. Investigative approaches and application of scientific concepts, models, theories and laws aim to make learners aware of their physical environment and to contribute to the importance of science and technology change in South Africa (DoE, 2003). In this study the attention is focussed on Grade 4 to 7 Natural Sciences teachers' botany teaching in the Intermediate and Senior phases.

The Natural Sciences Learning Area, Grades R-9, consist of four main unifying themes in which a variety of knowledge domains are taught and activities completed in the Natural Sciences class; Life and Living, Earth and Beyond, Energy and Change and Matter and Material. The Life and Living theme places emphasis on life processes, required to maintain one's health, environmental balance and change, and the importance of biodiversity. This theme does not, however, focus individually on and distinguish between traditional science disciplines such as botany, zoology and biochemistry. The theme of Earth and Beyond focuses on the structure and transformation of the earth, weather fluctuations and the study of planets in our solar system. The remaining two themes are Energy and Change, and Matter

and Material, associated with the physical sciences (DoE, 2003). These four unifying themes in Natural Sciences focus on the integration of aspects of botany, zoology and biochemistry.

2.4 Attitudes towards botany teaching and learning

The human race has a tendency to be more affectionate towards and interested in animals (zoology) than plants (botany). This is known as zoochauvinism, a term coined by Bozniak (1994). Zoochauvinism can easily interfere with the balance in science in general and therefore could be the main reason for the community's perceived plant blindness (Conley, 2009). This might have an impact on the community's knowledge and attitudes toward botany (Schussler & Olzak, 2008). Schussler and Olzak (2008) tested the plant blindness of university students in the USA to see whether these students could identify animal and plant images to test if they could name plant and animal images equally fast. Their findings indicated that from the 25 animal images, 92% were named correctly, and from the 25 plant images, only 65% had been named correctly. The results had implications for teaching by botany teachers, because of the lack of knowledge of botany held by students. (Schussler & Olzak, 2008).

Plant blindness as mentioned before, seems to be a concern in all science classes where learners are not acquainted with plants and the crucial role plants play in our environment and society and seem to be blind to the role of plants in the environment (Uno, 2009). In general, Grade 5 learners in primary schools report that they find botany very difficult (Prokop, Prokop & Tunnicliffe, 2007). There is also a decline in interests and attitudes towards botany when learners' ages increase (Prokop *et al.*, 2007). Results from this study indicated that learners in the 6th Grade are very interested in zoology and preferred learning about animals, this shows a zoochauvinistic attitude in the Natural Sciences class compared to younger learners.

There has been a concern that negativity towards botany held by learners may be caused by science teachers spending too little time on educating learners about plants and their role in the environment (Schussler & Olzak, 2008). Consequently the notion exists that teachers also prefer animal studies above those of botany, therefore the teachers' prior knowledge, content knowledge and teaching strategies of botany may be insubstantial (Honey, 1987). This could be related to the teachers' prior experiences of botany studies. The teaching strategies that teachers use are very important in learning botany, without proper strategies learners may

see botany as an uninteresting and dull section of the Learning Area Natural Sciences which is not pertinent to their lives, resulting in growing disinterested attitudes in learners as their age increases (Ramsden, 1998; Prokop *et al*., 2007). Curiosity, set goals, and encouragement are the key points for education and achievement in the field of botany teaching (Hidi & Harackiewicz, 2000; Prokop *et al*., 2007). Learners' positive attitudes towards science should be enhanced by creating curiosity and interest in plants which is seen as facilitating factors in a science curriculum (Koballa & Crawley, 1988; Laforgia, 1988; Prokop *et al*., 2007).

2.5. The possible reasons for negativity towards botany teaching

Teaching and learning differ in each learning environment. In some science classes textbooks are the only source of information for teaching and learning, especially in the primary grades (Tolman, Hardy & Sudweeks, 1998; Schussler *et al*., 2010). Textbooks have a large amount of information and normally in science textbooks there are a myriad of interesting and fascinating images and information on animals when compared to the paucity of botany information (Tolman *et al*., 1998; Schussler *et al*., 2010). Therefore if textbooks lack substantial information on botany it can be a precursor to negative attitudes towards botany, botany teaching and learning in the classroom. Classes where teachers only use textbooks as a method of teaching and learning indicate that teachers might have a lack of botanical knowledge and teaching strategies which might lead to lack of interest in botany and negativity held by learners (Wandersee, 1986).

Teachers' teaching strategies and methods might result in acculturation, leading to learners harbouring the same misconceptions, perceptions and attitudes towards botany as teachers (Roth, 2001; Schussler *et al*., 2010). In classes where teachers normally transfer their knowledge directly to the learners using teacher centred approaches, there is a lack of practical work (Zhongua, 2005). As a result learners become reliant on knowledge transferred to them by the teachers when knowledge is based on "memory and recall". This could lead to passive learners in the Natural Sciences classroom who hold negative attitudes towards botany, because of the lack of exciting teaching strategies used in class. Teaching should not only focus on "skills and knowledge", focus should also be placed on "attitudes, aptitudes and problem solving skills" (Zhongua, 2005). Teachers are in control of the learners' and their own attitudes, tasks, involvement, teaching and learning strategies, and instructional methods in their own classrooms.

Negativity towards botany can also be related to a number of botany-related concepts that have been characterised as complicated for learners to understand (Wood-Robinson, 1991). Misconceptions contribute to negativity and may arise when for instance class work and practical work become segregated. This segregation may be a result of uncertainty and ignorance by teachers and learners in the field of botany (Cottrell, 2004). Misconceptions and uncertainty about concepts in the botany class can be lessened by capturing learners' interests and letting learners become involved in practical work whilst connecting practical work to theory to improve their understanding in a hands-on manner (Cottrell, 2004).

As previously stated, learners favour zoology, which might result from interesting experiments conducted in science classes with particular relevance to zoology (Wandersee, 1986 & Kinchin, 1999; Schussler & Olzak, 2008). Bozniak (1994); Schussler and Olzak, 2008) state that some science teachers may also have a zoochauvinist view, because when plants are a component of study, animals will always be a focus and starting point of discussion. Peter Bernardt (1999 in Wandersee *et al*., 2006) wrote in his book called *The rose's kiss. A natural history of flowers*, which "biology teachers at high schools in New York have told me that they have eased botany out of the syllabus because it bores their students". From this statement it is obvious that the teacher is the aid in making learning about botany interesting by using adequate teaching strategies and instructional methods in class. Negative attitudes can not only be caused by uninteresting teaching pedagogy but also by teachers' "botanical illiteracy" (Flannery, 1987).

Failure by teachers and learners to appreciate the relevance of plants can also be the reason for harboured negative attitudes, and the fading of botany in the science curriculum (Suydam, 1902; Clute, 1908; Works, 1912; Ewers, 1912; Kauffman, 1917; Kirkwood, 1918; Hershey, 1996). Plants are not appreciated, because botany is neglected in science classes and seen as uninteresting instructional methods and dull teaching strategies form the basis of botany teaching and learning (Flannery, 1987& Uno, 1994; Hershey, 1996). Flannery (1987) also stated; "…I am not alone in my prejudice, too much botany is synonymous with what is dry, complicated and uninteresting in biology". Hershey (1996) disagrees with Flannery (1987) by arguing that plants are easier to study than animals and botany as a discipline can be taught as a very exciting and interesting component of science by utilizing a variety of teaching strategies to draw learners' attention in the science class.

Botany education could be easy to apply, because most of the phenomena discussed in the botany class occur close at hand and are available for practical application in our environment (Hershey, 1996). It is crucial that learners understand, appreciate and preserve plants in their immediate environment, because if learners aren't knowledgeable about these concepts, biodiversity will not be sustained. Lack of understanding and appreciation of plants will increase world environmental issues such as the growing phenomenon of climate change and global warming (Schussler *et al*., 2010).

2.6. Pedagogical Content Knowledge (PCK)

2.6.1 Overview

Lee Shulman (1986), a master of Pedagogical Content Knowledge, divides general teacher knowledge into seven groups; "content, pedagogy, curriculum, learners and learning, contexts of schooling, educational philosophies, goals, objectives and pedagogical knowledge". Shulman also states that these groups of knowledge can collectively be defined as a "distinct body of knowledge that distinguishes teachers from content specialists". Shulman (1986) further classifies PCK as a characteristic of a teacher's professional knowledge. This professional knowledge compliments, yet differs from content knowledge and contributes to the view of PCK as a hands-on expertise or skill utilized by teachers to guide them in their classrooms (Shulman, 1986). PCK aids in creating awareness among teachers about misconceptions held by learners of a specific topic and enables teachers to use appropriate pedagogical methods to approach the learners' requirements in class (Shulman, 1986). As Shulman (1986) gave meaning to the term Pedagogical Content Knowledge as "topic specific knowledge for teaching a particular subject", Davis and Krajcik (2005) contributed to Shulman's (1986) definition, declaring that teachers require detailed and distinctive field specific PCK. The PCK that teachers require in this study is to teach botany in the Learning Area of Natural Sciences.

Natural Sciences teachers' distinctive field PCK differs from any other teacher's teaching in a different Learning Area (Davis & Krajcik, 2005). Shulman (1986) adds that PCK includes specific knowledge for teaching a specific Learning Area, but should still be connected to the appropriate teaching of content; therefore the teacher must be aware of different teaching strategies that will aid in teaching and learning together with the teaching of content.

Rollnick *et al*. (2008) describe PCK simply as the way in which teachers teach: their knowledge of a subject, of the learners, of the curriculum and their attitudes towards teaching the specific Learning Area. Rollnick *et al*. (2008) include teacher attitudes in their definition of PCK, however in the framework used for this study attitudes are seen as separate from PCK. Attitudes could have an influence on teachers' PCK, whereas Rollnick *et al*. (2008) refer to the term "curricular saliency" from Geddis and Wood (1997), who uses this term to describe how teachers select topics for inclusion into their teaching plan. Curricular saliency may also lead to teachers' flexibility when teaching certain concepts in a Learning Area, such as science. Rollnick *et al*. (2008) views PCK as a "transformative model", where teachers have to be flexible in their teaching. In other words teachers have sufficient PCK when they are able to use new content and strategies every day, to reduce the one way transmission of knowledge to the learners, but to transform it in a way for maximum understanding and learning.

Studies of Chick and Harris (2007) lead to the construction of an overview of PCK as provided in Table 2. The table includes important characteristics of botany PCK and the connection between these characteristics and the teacher.

Table 2: A modified overview of the characteristics of PCK (Chick & Harris, 2007).

Characteristics of botany PCK	**Apparent if the teacher…**
Teaching strategies	utilises relevant methods to carry knowledge and skills across.
Learner conceptualizing	identifies how learners think and their perceptions of a topic.
Harboured misconceptions	identifies and approaches misconceptions of a specific topic.
Cognitive thinking	approaches the difficulty of the concept.
Comprehensive delineation of the topic or concept	utilizes methods and models to indicate certain concepts.
Clarifications	elucidate certain topics or concepts.
Understanding of examples	make use of examples to enhance understanding.
Understanding of resources	make use of resources to substantiate teaching.

Understanding of curriculum	understands the way concepts and topics are joined in the curriculum.
The motive for content knowledge	understands why content and usage thereof is important in the curriculum.

2.6.2 PCK in Natural Sciences teaching

Research has shown that learners' "attitudes towards science already show decline by the time they reach middle school" (McNall, Krall, Lott & Wymer, 2009). This is not a surprise, because most teachers feel that learners have a lot of information to deal with in science and a heavy work load, therefore teachers teach in the traditional lecture format, not helping learners to be actively involved in science learning (Anderson & Smith, 1987; McDermott, 1991; McDermott *et al.*, 2006; McNall, Krall & Lott, 2008). Few studies have surveyed in-service elementary or middle school teachers' understanding of life science concepts and the route to improve learner understanding is to know whether science teachers have an understanding of what they are teaching (McNall Krall, Lott & Wymer, 2009).

A survey done by Rowan, Schilling, Ball and Miller (2001) shows the importance of the education of teachers' PCK in terms of learner accomplishment. According to the National Research Council (2001), research indicated that the teachers play a vital role in learner achievement. Knowledgeable and skilled science teachers' teaching methodologies consist of a combination of understanding, values and convictions (van Driel *et al.*, 1998). An outstanding science teacher with sufficient PCK may develop superb teaching and learning strategies, organise and control the class, also compose interesting additional activities and methods to use in class that might enhance learner achievement (De Jong, van Driel & Verloop (2005) in Khetsiwe 2010).

Gess-Newsome (1999) argues that teachers, especially primary school teachers are confronted with teaching as a challenging task, because most of them teach in a variety of Learning Areas. Consequently teachers often compartmentalize their knowledge of the Learning Area and cannot access information or build connections between the knowledge and the teaching thereof.

PCK includes a teacher that has knowledge of teaching strategies to use in the science class, for example the use of technology such as Powerpoint Presentations, the use of live

specimens and other media and resources which capture learners' attention in science and to avoid the traditional lecturing, didactic method of teaching. PCK also requires a teacher to have knowledge of the science curriculum, the outcomes to be achieved, knowledge about assessment strategies and the way in which performance can be measured (Friedrichsen, Abell, Pareja, Brown, Lankford & Volkmann, 2009).

Magnusson, Krajcik and Borko (1999) in Friedrichsen *et al*. (2009) recognized nine teacher "teaching orientations" in science teaching; skills (to help learners develop the use of scientific skills); academic rigidity (to use the knowledge they own and compose a specific body of knowledge towards science); teaching (to help learners to remember the facts concerned with scientific knowledge); tentative thinking (to help learners not to have static knowledge and to overcome their misconceptions); hands-on learning (learners should be active in learning, using live specimens to improve their understanding, be involved and experience science); discovery (learners should discover science in order for them to achieve, not to be passive in class); project-based science (learners should engage in science projects that can help them deal with day-to-day science trends); investigation and guided inquiry (to let the learners see science as inquiry based and to guide them in this process).

Magnusson *et al.,* (1999) composed a PCK model based on Grossman's (1990) definition of PCK concerned with science education. Friedrichsen *et al*. (2009) conceptualized Magnusson *et al's*. (1999) model by adding an element of "knowledge of assessment". This PCK model includes a teacher's knowledge and attitudes towards science teaching, in other words the way in which they see science and the teaching thereof. Another component of this model includes that a teacher should have understanding of how learners learn in science, their misconceptions, prior knowledge that they bring to class and the way in which they learn best (Friedrichsen *et al*., 2009). The manner in which botany is taught in the Natural Sciences Learning Area could have a major impact on learners' outlook and attitudes towards the Learning Area, as "teachers' PCK appears to play an important part in the development of pupils' attitudes towards subjects" (Hendley, Parkinson, Stables & Tanner, 1995; Woolnough, 1994; Johnston & Ahtee, 2006). If the teacher has difficulty in teaching the Learning Area due to past experiences, this will have a negative impact on the teachers' PCK (Johnston & Ahtee, 2006).

2.6.2.1 Teaching strategies and instructional methods

Mastrilli (1997 in Friedrichsen *et al*., 2009) examined experienced science teachers' use of teaching strategies and found that they rely on traditional teaching methods and strategies. The traditional lecturing methods are used, because of teachers being used to these methods due to their teaching experiences. Mastrilli (1997) concluded that these experienced teachers do not want to use new teaching strategies. In addition to Mastrilli's (1997) research, Grossman (1990) stated that different methods of teaching developed from the teacher's teaching experience. PCK and different methods of teaching can develop by learning from learners' conceptions in class and from the questions they ask. This can be done by marking learners' scripts and learning from their different answers, learners' answers on projects and assignments, also by observing the behaviour of learners (van Driel *et al*., 2002).

Learners often receive and have to deal with a vast amount of information in class due to teachers' traditional teaching strategies. This might result in a lack of enthusiasm, boredom, irritation and memorisation among learners without contributing to understanding (Tekkaya & Yenilmez, 2006). Learners are prone to rote learn and memorize facts and concepts without understanding or relating to their real life or prior knowledge. Therefore teachers need to provide interesting teaching methods together with a learning environment using "models, simulations, diagrams and concept maps". Even though some schools might be short of resources, teachers can improvise to make learning more interesting.

Friedrichsen *et al*. (2009) found that science teachers hold on to their didactic teaching strategies and find it difficult to deviate from these strategies. Teachers view teaching as "telling" and learning as "memorization". Science teachers should make use of inquiry teaching to challenge learners, and to challenge themselves to enhance their teaching methods. The enhancement of teaching strategies is addressed by Friedrichsen *et al*. (2009) who agree with Shulman (1986) that PCK development programmes should play a major role in teacher education and training to keep the teachers challenged and motivated.

Science classes have two components; theoretical sessions and laboratory or practical work, for instance in the lower grades experiments might be conducted inside or outside of class (Cooper, Hanmer & Cerbin, 2006). Learners often enjoy the practical part more than the theoretical part, because the practical sessions are more interesting and exciting than the theoretical sessions. Learners like to be actively involved in more hands-on activities to help them concentrate better on a specific concept taught in class (Cooper, Hanmer & Cerbin,

2006). Active learning enhances learners' abilities to learn and they become motivated by interesting teaching strategies utilised in class. These in turn improve their learning and understanding and their thinking skills (Goldberg & Ingram, 2011). Active learning is reported to be helpful and a fun way to learn, because learners focus more on the topic of study and may be very intrigued by the teacher's ways of teaching (Bligh, 2000). In Natural Sciences however, learners need to do more than active learning, they have to recall and incorporate different sections of knowledge, "interpret data, and evaluate and explain data and phenomena". Teachers can succeed in teaching by using a variety of teaching strategies (Bligh, 2000). An example of a teaching strategy that can be used in the botany class when teaching the morphology of the plant is by having a human sized drawing of a plant made out of cardboard or polystyrene, brightly coloured with labels where learners can paste labels on the cardboard in class, for example "roots", "stems" and "leaves". This exercise can help learners remember the tree in class when they study for the test to make it more accessible and easy to study, because of the notion that learners do not see plants as living organisms (Staub, Pauw & Pauw, 2006).

A teaching strategy useful in teaching photosynthesis is to take the learners out of the classroom and to the school grounds. The teacher could start the lesson by asking them what they see on the playground. When they come to plants, the teacher could ask them; "What makes the plants grow?" "Why are they green?" Learners will be able to observe their surroundings, learn from others' answers, touch plants and sense the whole process in an enjoyable, hands-on manner (Piper & Lewis Shaw, 2010).

When teaching life cycles of plants, for instance the bean, it is sometimes difficult to cover the entire life cycle because the real bean plant could die, or when learners return to school after the weekend, the plant could have grown to such extent that it is impossible to let them see the growth process. A study has shown that by integrating technology, some of these problems, where there might be difficulties in working with real plants can be avoided (Cherubini, Gash & McClaughlin, 2008). Technology can help the learner understand concepts and the learners relate to technology. Cherubini, Gash and McClaughlin (2008) designed a "Digital Seed", which is considered a toy where simulations of the life cycle are displayed while learners for example water the plant through a funnel built into this device, to connect real life to technology. Research has shown that it fascinates learners, keep them interested and wanting to learn more (Cherubini, Gash & McClaughlin, 2008). Although this

could be a helpful method in the botany class, most schools in South Africa do not have the funding or available resources to use such a teaching method in class.

Constructivism as a learning process in science education focuses on learner engagement in class, on understanding and enabling learners to construct their own learning (Choi & Ramsey, date unknown). In order to teach science effectively at primary school level, science needs to be accessible, applicable and appealing to learners. Learners also want to learn by own experiences and their prior knowledge can be connected to the teacher's knowledge and the way in which concepts are taught (Garbett, 2011).

Constructivism however does not mean that "anything goes" in class, although it may seem like learners could figure out any answer themselves, regarded as correct, and that the teacher does not need to have scientific knowledge (Garbett, 2011). Teachers still need to know scientific content together with their pedagogical knowledge to teach science and to guide learners in the process of learning. According to Garbett (2011) in order to use a constructivistic approach in science teaching, the teacher must have confidence and be ready to answer any type of question that will arise when learners combine their prior knowledge with the new. Teaching will also be less transmission oriented (Appleton & Kindt, 2002).

Even though active learning and inquiry teaching is regarded as beneficial to teaching and learning, teachers still struggle to implement this method of teaching in their classrooms. Research has indicated that teachers' attitudes and their knowledge of teaching can influence the way in which they teach and whether they want to adjust their ways of teaching (Choi & Ramsey, date unknown).

2.6.3 Development of science teachers' PCK

The term "professional development" is described as an enterprise of tasks to strengthen professional teaching development and lifelong learning in all Learning Areas (James, Naidoo, & Benson, 2008). James *et al*. (2008) also state that through professional development, teachers may acquire innovative ideas and teaching strategies to enhance learners' development in the process of learning. During in-service professional development programmes teachers gain admission to a developing and growing framework of knowledge with exceptional interest in content knowledge and pedagogical content knowledge (James *et al*., 2008). According to the Third International Mathematics and Science Study (TIMMS) (1998), it was reported that South Africa's stance towards professional development and

skills was inadequate when compared to that in other countries. As a result there is a need to increase the number of professional development programmes in South Africa.

Teachers who encounter difficulties with their PCK, may find it challenging to illustrate concepts and principles to their learners in order to enhance learners' understanding thereof (Wilson, Shulman & Rickert, 1987; Feiman-Nemser & Parker, 1990 cited in Cochran, 1991). According to Adler and Reed (2002) and Kriek and Grayson (2009), developing science teachers' content knowledge is a vital element in professional development programmes. Therefore content knowledge should be coupled with teachers' PCK, in order for them to teach content knowledge effectively by using a variety of skills and teaching strategies. Kriek and Grayson (2009) state that there is a need for such professional development programmes by referring to the results of a South African study that included science and mathematics teachers. Kriek and Grayson (2009) measured teachers' professional attitudes which can be linked to a teacher's PCK.

In the study conducted by Grayson, Ono, Ngoepe and Kita (2001) it is stated that a diversity of teachers' "unprofessional attitudes were widespread, such as coming late to class, not preparing for class and omitting sections of the syllabus that teachers did not understand" (Grayson, Ono, Ngoepe & Kita, 2001). It is said that some teachers have the tendency to ultimately depend on their static content knowledge and strictly follow textbook knowledge and material (Cochran *et al.*, 1991). Teachers are also not acquainted with methods and strategies to demonstrate and teach in such a manner that enriches the understanding of learners (Cochran *et al.*, 1991).

Smith and Neale (1989) and van Driel *et al*. (1998) in Friedrichsen *et al.* (2009) emphasise the importance of PCK development of science teachers. PCK development will train teachers to be more knowledgeable and understand what they teach , to connect their content knowledge to their development of PCK. A study by Käpyla *et al*. (2009) concluded that teachers with well-developed content knowledge are more prone to focus on content when teaching, referring to the transmission method. As a result content knowledge had little influence and support in the presentation of concepts taught in class.

Another study by van Driel *et al*. (2002) in Friedrichsen *et al*. (2009) investigated pre-service teachers' PCK development with the "macro- and micro-level representations in chemistry". They found that with chemistry teachers, PCK developed through teaching practice, by means of questions posed by learners, marking scripts, contact with learners in class, remarks

in assignments and by noticing learners' attitudes in class. This answers the question of Friedrichsen *et al.*, (2009) "Do beginning teachers develop topic-specific PCK from teaching experience alone, without the benefit of reflective teacher education programmes?". There is a need to teach PCK as an explicit part of teacher training programmes in order to link teachers' content knowledge with their pedagogical knowledge (Käpyla *et al.*, 2009).

2.7. Concluding remarks

The literature reviewed in this study illustrates the paucity of literature in the South African context of primary school Natural Sciences teachers in teaching botany-related concepts. The literature presents a small amount of research conducted in the field of attitudes towards botany in primary schools. Although a considerable amount of research and literature was completed in the field of PCK of Natural Sciences teachers in divergent disciplines, it is reported that there is the need to elucidate the PCK of science teachers with a focus on botany teaching. Therefore this study explores teachers' attitudes regarding botany in the Natural Sciences Learning Area studied in the specified Grades 4 to 7, and teachers' PCK with reference to botany teaching and whether attitudes and PCK are related.

2.8 Theoretical framework

PCK is considered a workable theoretical framework in this study. This framework enabled the researcher to explore Natural Sciences teachers' PCK and their attitudes towards botany teaching and whether a relationship exists between the attitudes and PCK (Abell, 2007; Friedrichsen *et al.*, 2009; Magnusson, Krajcik & Borko, 1999).

Figure 1 illustrates the theoretical framework that was used in this study. Figure 1 is a modified and combined framework from Magnusson, Krajcik and Borko (1999) and Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu (2008) which is applied to teaching and learning of botany content. This framework highlights the science teacher's role in the Natural Sciences classroom when botany-related concepts are taught. This framework also serves as a guide when teachers' botany PCK are compared.

Figure 1 shows that a teacher's PCK includes teacher knowledge that consists of having general pedagogical knowledge, knowledge of scientific and botanical content, knowledge of the Natural Sciences curriculum and teaching in context, knowledge of learners with regard to misconceptions, of how they learn best and understand best. Teachers who have these

domains of knowledge should be able to provide results in terms of various teaching strategies used in class (Rollnick *et al*., 2008; Magnusson *et al*., 1999). Teaching strategies are used in botany teaching and are referred to as the outcomes of teacher knowledge. Teaching strategies may include *representations* in the form of posters, pictures, and live plants; *the integration of technology* in class, showing DVDs to learners, using Power Point presentations; *employing hands-on activities* to let learners be actively involved in class or outside the class in the school garden, using live specimens for practical work, using a *constructivistic perspective* in class to let learners discover new knowledge, and lastly, using *different forms of assessment*, to indicate whether learners have reached the outcomes. Teachers' knowledge which consists of the botany teachers' PCK influence the outcomes of the teacher's knowledge, in other words the way in which teachers teach botany.

Teacher attitudes also form part of this theoretical framework, but not part of PCK, and is seen as a separate entity. A teacher's attitude towards botany such as displaying zoochauvinism, plant blindness, enjoyment of botany and his training in botany, could influence the way in which the teacher teaches.

In this theoretical framework teacher attitudes towards botany and botany teaching can be influenced by a botany teacher's PCK, and a botany teacher's PCK can influence teacher attitudes. Another influence is that teacher attitudes can consequently influence the way in which teachers teach botany.

The theoretical framework of this study is applied to the teaching and learning of botany content.

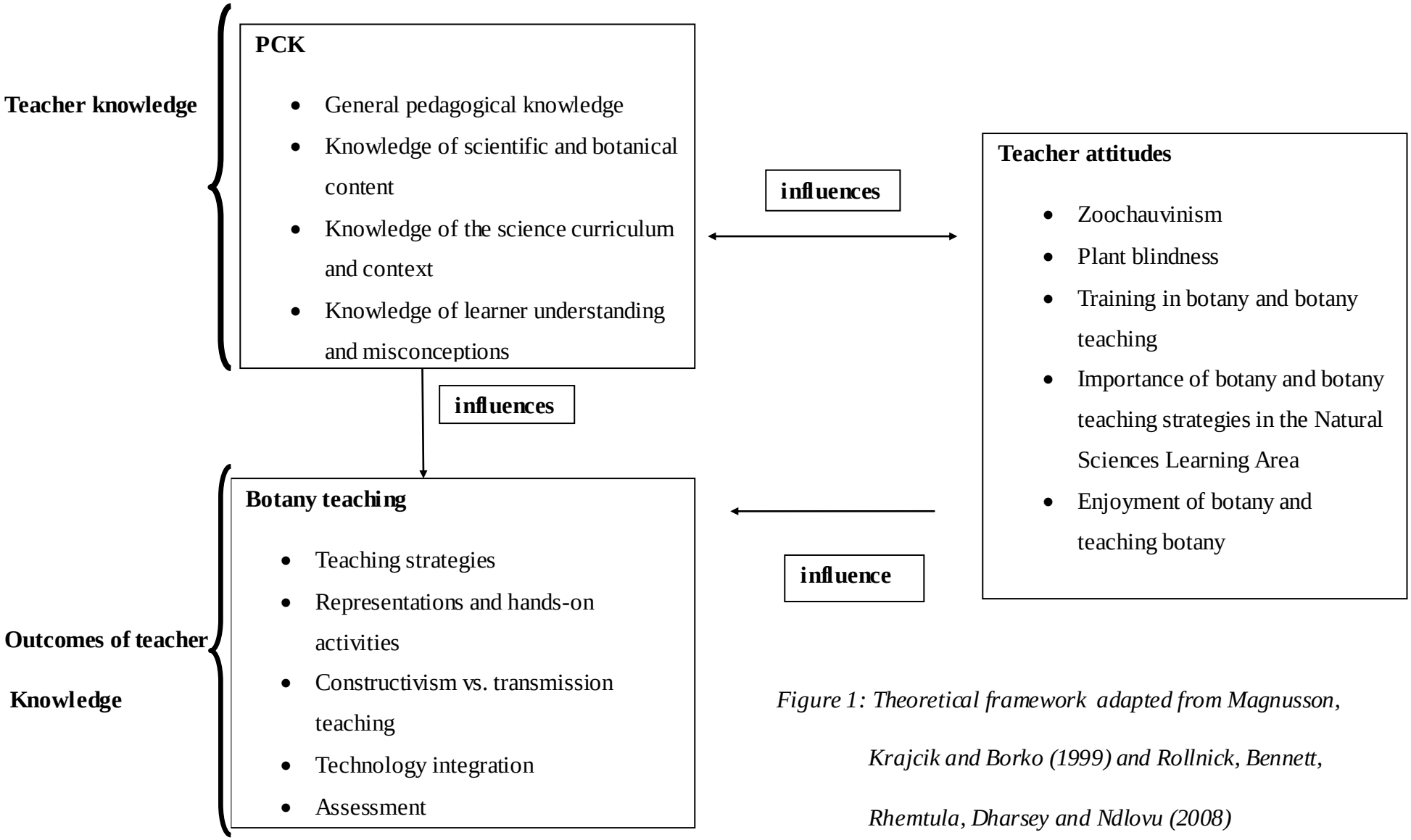

Figure 1: Theoretical framework adapted from Magnusson, Krajcik and Borko (1999) and Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu (2008)

Chapter 3: Research Methodology

3.1 Research paradigm

An interpretivist paradigm was the best approach to follow. In this study interpretivism focuses on different forms of reality (Hartley, 2010) and places the focus on people's lived experiences and subjective nature of knowledge and understanding. Different teachers' views and ways of teaching was the focus.

The researcher followed an interpretivist approach which pursues a worldview where attitudes are influenced by people's subjective experiences (Maree, 2010). This study aims to explore and understand the way in which teachers' attitudes towards botany are constructed in their everyday teaching environment and to explore whether there is a relationship between their attitudes and their PCK. The researcher adopted a general interpretivist perspective, because this study is based on reality being "socially constructed" and the situation of the study should be kept in mind to make sense of the findings (Maree, 2010). The research could make sense of how people, in this case the teachers, build upon their different opinions and meanings, therefore the researcher gained insight into the research problem and generated knowledge.

The researcher was also open to another approach, i.e of constructivism. The paradigm of constructivism is closely related to interpretivism, because of the focus placed on issues of knowledge (owned by teachers) and how they carry this knowledge across to learners in the real life environment (Morgan, 2007).

The researcher attempted to stay objective by not forcing her opinion or knowledge on the teachers and was open to different responses (Morgan, 2007). However as the paradigms of interpretivism and constructivism are considered to be very broad, this could be seen as a limitation. It should be borne in mind that the paradigm of interpretivism takes people's different worldviews, opinions and attitudes into consideration, which serves as the main focus in this study. A general overview of the research approach and design can be seen in Table 3.

Research approach	Research design	Research questions	Data source	Data collection techniques	Data analysis
Qualitative approach	Multiple case study research design	Main research question: What is the relationship between Natural Sciences teachers' attitudes towards botany teaching and their botany PCK?	Grade 4 to 7, Natural Sciences teachers.	One-on-one, , semi-structured d interviews, botany classroom observations and botany lesson plans. June 2012	Transcription of tape-recorded interview responses. Summaries of observations and lesson plans. Verification and linking data. Thematic summaries.
Objectives of the sub-research questions To determine the following: • Teachers' attitudes towards botany • Teachers' attitudes towards botany teaching • The reasons for teachers' attitudes towards botany teaching		Sub-research question: What are Grade 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do teachers harbour these particular attitudes?	Grade 4 to 7, Natural Sciences teachers.	One-on-one, , semi-structured interviews. June to August 2012	Transcription of tape-recorded interview responses. Summaries, development of themes, thematic summaries.

To determine the following: • Teachers' PCK in terms of botany teaching • Teachers' ways, methods and strategies used when teaching botany • The reasons for choosing the specific teaching strategies	Sub-research question: What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do they choose these methods?	Grade 4 to 7, Natural Sciences teachers.	One-on-one, semi-structured interviews, botany classroom observations , and botany lesson plans. June to August 2012	Transcription of tape-recorded interview responses. Summaries of observations and lesson plans. Induction. Verification and linking data. Thematic summaries.
To determine the following: • Whether teachers' attitudes towards botany are related to their PCK	Sub-research question: How do teacher attitudes towards botany teaching impact their botany PCK?	Grade 4 to 7, Natural Sciences teachers.		

Table 3: Summary of the research approach and research design

3.2 Research approach and design

The research approach utilized in this study was of a qualitative nature. A qualitative approach is characterised as a method of inquiry, by making sense of a central phenomenon, in studying participants in the context of their real life and generating insight of their views in terms of textual data collection (Cresswel, 2007; Maree, 2010).

A multiple case study research design was selected to facilitate this study's qualitative approach. Case study research is described by Bromley (1991:302 and Maree, 2010) as a "systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest". A number of different data gathering techniques associated with the case study design are surveys, interviews, document analysis, observation and the assembling of artefacts (Yin, 1994; Maree, 2010).

In this study a multiple case study research design helped to identify, describe and explain teachers' attitudes towards botany teaching and their PCK towards botany teaching and the relationship between attitudes and PCK. The data gathering techniques associated with this study's multiple case study research design were one-on-one teacher interviews, observations of class lessons and document analysis of lesson plans.

3.3 Research methods

3.3.1 Sampling

The unit of analysis included three purposive selected primary schools in Gauteng with conveniently available Grade 4 to 7 Natural Sciences teachers. A purposeful method of homogenous sampling includes teachers who own a particular attribute (Cresswel, 2007), for example, Grade 4 to 7 Natural Sciences teachers that teach botanical topics as part of the Natural Sciences curriculum. This homogenous sample of teachers included the number of two Grade 4 to 7 Natural Sciences teachers per school, from each of the three different schools. A total number of six teachers became part of the homogenous sample.

3.3.2 Data collection

The qualitative study data collection occurred in the second and third quarters of 2012. A total number of three schools and six teachers were involved. The following section will give insight into the data collection process.

3.3.2.1 Data collection process

Qualitative data collection in this study included three strategies. The first strategy consisted of one-on-one semi-structured interviews with a set of predetermined questions to a total number of six Grade 4 to 7 Natural Sciences teachers, two teachers from each of the three selected schools. Although interviews are considered as time consuming and costly (Cresswel, 2007), this seemed to be the most relevant method to collect data, because of the small number of teachers who participated in the study and because of the personalised nature of interview data. Only six teachers participated in the interviews for a maximum time of one hour after school or in their free time. The interview responses were tape recorded for data collection and analysis purposes only.

Classroom observations served as a useful strategy for data collection. The observations were done after the interviews. The strategy of classroom observations were chosen because the researcher wanted to experience the teachers' attitudes and PCK towards botany teaching first-hand to compare whether the teachers' interview responses were reflected in their classroom teaching. The observational role most suited for this study was the role of a non-participant observer who did not interfere with activities and did not participate in the teaching.

The other data collection strategy used in this study was document analysis, which consisted of examining botany-related lesson plans designed by the Natural Sciences teachers. The advantage of collecting documents throughout this study was that the lesson plans were designed by the teachers themselves and information was stated in their own words (Cresswel, 2007). Botany-related lesson plans were collected from five of the Grade 4 to 7 Natural Sciences teachers from the three selected schools. One of the teachers decided not to participate in the observation, therefore no lesson plan was submitted. A summary of the data collection process can be seen in Figure 2.

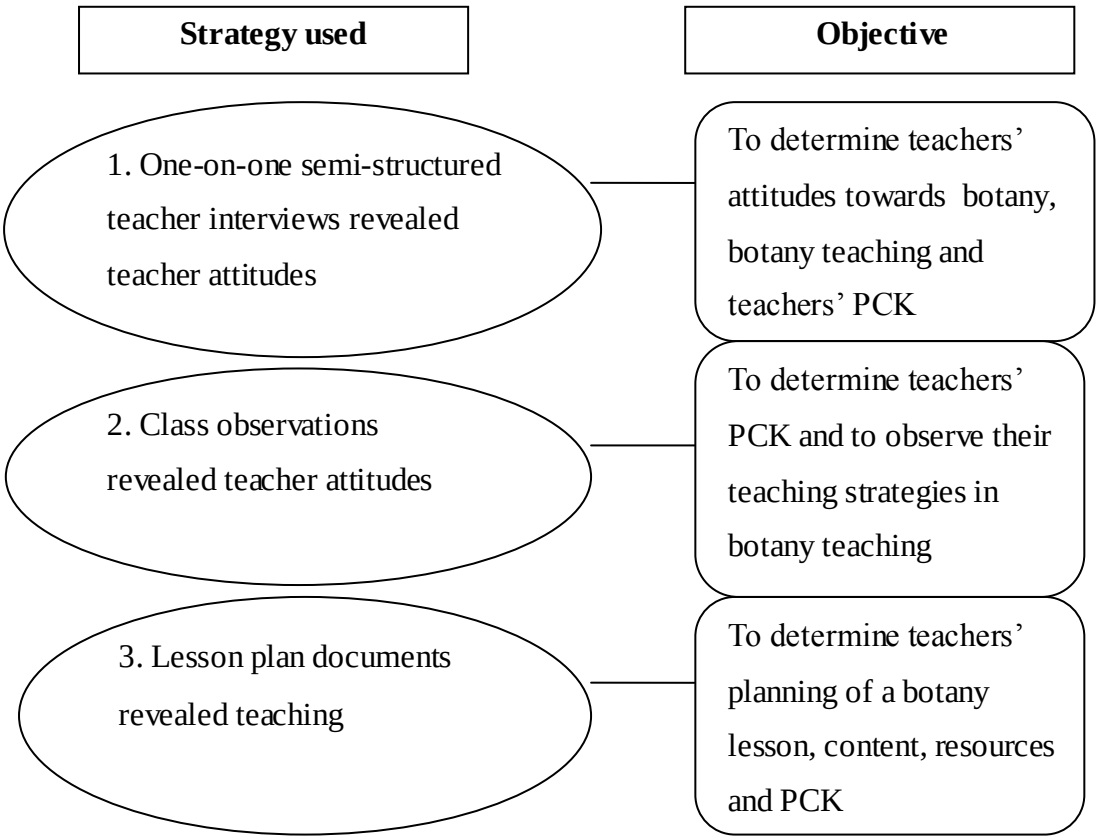

Figure 2: Summary of the data collection process

3.3.2.2 Teacher interview protocol (Appendix A)

One-on-one semi-structured interviews were conducted with two Grade 4 to 7 Natural Sciences teachers from each of the three schools, in their free time, after school or in a free period as preferred by the teacher. The interview did not take longer than half an hour. These interviews were completed in the second quarter of 2012. A total of six interviews were conducted during this study. The interview schedule (Appendix A) and the interviews were conducted in Afrikaans, the language preferred by the teachers. The interview responses were translated into English during transcription and data analysis.

Interview questions were clearly stated and understandable, however, some questions were rephrased if the participant did not understand. The protocol contained administrative information regarding the time and place of the interview, biographical information and interview questions which explored teachers' attitudes towards their botany PCK. Questions ranged in content from the teachers' attitudes towards botany, prior study experience with botany teaching, knowledge of the curriculum and the PCK held by these teachers in terms of teaching and assessment strategies and whether there might be a relationship between

teachers' attitudes towards botany and their PCK. A summary of the interview process is stated in Table 4.

Table 4: Summary of the interview process

Purpose of the semi-structured interviews		
To determine teachers' attitudes towards botany and botany teaching, including: • Preferences in Natural Sciences teaching. • The Natural Sciences Curriculum. • Past botany training and experiences.	To determine teachers' ways of botany teaching in the Natural Sciences class, including: • Teaching strategies used when teaching botany. • The importance of these teaching strategies. • Learner understanding. • Assessment strategies. • The use of practical examples and technology when teaching botany.	To determine the relationship between teachers' attitudes towards botany teaching and teachers' PCK: • To determine whether the teachers' attitudes towards botany teaching have an effect on their teaching.

3.3.2.3 Observational protocol (Appendix B)

Observations of botany-related lessons took place with five teachers in total, in other words, one observation per teacher. Only five teachers participated, as one teacher decided not to participate in the observation process. The five teachers were observed for a period of approximately 30 minutes per class. The observations occurred during the third quarter of 2012. Identifying information on the observational protocol included demographic information such as the classroom number, the name of the observer, the role of the observer and the estimated time of the observation, together with a checklist of various aspects related to the classroom environment, teaching and lesson detail. Descriptive field notes were also recorded during these observations. The descriptive field notes included own reflections such as ideas, experiences, opinions and views held by the researcher. An overview of the observation process is provided in Table 5.

Table 5: Overview of the observation process

Objective	Key aspects in the observations
To describe Natural Sciences teachers' botany PCK.	• Teaching strategies. • Assessment strategies. • Classroom environment. • Teachers' content knowledge. • Class lesson presentation. • Learner misconceptions.
To verify the teachers' interview responses.	• Beliefs, values and attitudes promoted in class when teaching botany.
To determine whether the teachers' attitudes towards botany teaching has an effect on their PCK.	• Beliefs, values and attitudes towards botany teaching. • PCK.

3.3.2.4 Lesson plan documents (Appendix C)

Document analysis of the botany-related lesson plans were obtained from five of the six teachers in this study. All six teachers were firstly interviewed and thereafter asked for a copy of a botany-related lesson plan which served as the teacher's guideline to the specific botany lesson taught in the Natural Sciences class during the observation. These documents were obtained from the teachers during the third quarter of 2012. These documents served as a helpful aid in comparing the teachers' interview responses with the observations of their actual teaching..

3.3.3 Data analysis

Qualitative interview data that were collected from the six teachers' interviews were transcribed to textual data. A preliminary exploratory analysis gave the researcher an overall idea of the data (Cresswel, 2007). A preliminary set of a priori codes and themes for data analysis was identified from the literature with reference to the research questions in this study. This set of codes and themes (Table 6), was planned prior to the analysis, other codes and themes emerged during the latter part of this study and can be seen in Chapter 4.

The interview data and the observation protocols and lesson plan documents were coded using these a priori codes. Data and findings are presented in Chapter 4. Narrative discussions are provided and are related to the final themes and research questions.

Table 6: Preliminary themes and a priori codes emerging from the literature.

Themes or research questions	A priori codes
Teacher attitudes toward botany teaching.	Teacher experiences with botany in past training and current teaching.
	Zoochauvinism.
	Plant blindness.
	Importance of botany in the classroom.
PCK held by teachers when teaching botany.	Knowledge of content.
	Teaching strategies.
	Awareness of learner understanding.
	Knowledge of the curriculum.
	Measures of assessment.
The relationship between teacher attitudes and other aspects of PCK.	These codes will emerge during the document analysis process, to validate whether teachers'' attitudes are related to their PCK.

3.4 Methodological norms

3.4.1 Credibility, dependability and trustworthiness

Credibility is an indication that the conclusions from data collected in terms of interviews, observations and lesson plan documents are accurate (Maree, 2010). Credibility of this study's interview protocol, observational protocol and lesson plan documents were established by sharing these instruments among academics from the University of Pretoria, and the teachers to assure the content validity of the interview protocol, observational protocol and lesson plan documents. Stakeholder checks also enhance credibility when other parties or individuals with interest in and knowledge of this study remark on the findings (Maree, 2010).

Maree (2010) defines dependability as follows: "Dependability refers to the degree to which the reader can be convinced that the findings did indeed occur as the researcher says they did". In order to validate responses and ensure the dependability of these responses, each teacher who was interviewed was asked to provide the researcher with a botany-related lesson plan and to allow the researcher to attend a class where the application of these lesson plan documents was observed. Observations validated the interview responses and contributed to the trustworthiness of the data collected.

Trustworthiness indicates whether the researcher is able to persuade the audience that the findings in the study are worth paying attention to and that the research is of high quality (Maree, 2010). Dependability and trustworthiness of the qualitative collected data were established through member checking (Cresswel, 2007), where the researcher in this study restated and summarised the responses of the participants after each question, in order for them to validate and correct the researcher's understanding of what was said (Maree, 2010). In this study trustworthiness was established by means of utilizing various data sources (Maree, 2010). The researcher triangulated the interview, observational and lesson plan document data to validate emerging themes and to establish whether these themes were useful to this study and appropriate to use.

The researcher endeavoured to eliminate bias in the study with the help of reflective notes held during the investigation (Maree, 2010). Interviews were conducted and tape recorded.

3.4.2 The Hawthorne effect

During this study the Hawthorne effect was taken into account. The Hawthorne effect refers to a situation where participants might change the way in which they act in their daily lives due to the presence of the researcher, in providing false answers to questions to present themselves in a good or bad way (Maree, 2010 and McMillan and Schumacher, 2001).

The Hawthorne effect might have been present during the interviewing process; however teachers were asked to give their honest responses. The Hawthorne effect was taken into consideration during the observation process, where descriptive and reflective field notes accompanied the situations of the classroom environments described in Chapter 4. The Hawthorne effect might have been eliminated by validating and triangulating the interview responses with the classroom observations and by validating the classroom observations with the lesson plan documents.

3.5 Ethical considerations

Ethics clearance was sought and obtained from the Ethics Committee of the University of Pretoria prior to data collection. The researcher adhered to ethical principles towards research. The main ethical principles are informed consent, safety, privacy and trust. The researcher followed the principles of voluntary participation in research, implying that the participants could withdraw from the research at any time. Informed consent was sought and research participants were at all times fully informed about the research process and purposes. The teachers gave consent to their participation in the research. Safety in participation was also adhered to and human respondents were not placed at risk or harm of any kind. The issue of privacy was adhered to, where confidentiality and anonymity of human respondents were protected at all times. Pseudonyms were used in the teacher interviews and for documents collected. Trust of participants was throughout respected which implies that human participants were not subjected to any acts of deception or betrayal in the research process or its published outcomes.

Permission was obtained from the Gauteng Department of Education to conduct research in the selected primary schools in this province. Thereafter informed consent was obtained from each headmaster in each of the three schools that formed part of the sample. Once permission was obtained from these authorities, Informed Consent Documents were sent to the Grade 4 to 7 Natural Sciences teachers to request their consent for participation in this research study. The Informed Consent Documents consisted of a description of the research study, biographical information of the researcher, the supervisor of the study and the University of Pretoria. The duration of the interviews and the tape recordings of responses were stated in the consent documents. It was also stated that all participants were free to refuse participation and that participation could be withdrawn at any time. The informed consent documents consisted of a cover page with relevant information and a consent form which required the participants' names, signatures and dates.

In this chapter all techniques, methods and processes of data collection and analysis and the ethical considerations for this study were described. In Chapter 4 the data will be presented and discussed by referring to the teachers' interview responses, class observations and lesson plan documents.

Chapter 4: Presentation of the data

4.1 Introduction to the data

In this chapter an overview of the data is presented by discussing the demographics of participants and describing the data analysis approach that was used. The data is presented in terms of each sub-research question and theme. Interview data, observation data and lesson plan data form part of this chapter. Discussion of the data will follow in Chapter 5.

4.1.1 The research questions

The following main research question formed the basis of this study where the sub-research questions facilitated data collection for the main research question.

The main research question:

What is the relationship between Natural Sciences teachers' attitudes towards botany teaching and their botany PCK?

The sub-research questions:

- What are Grade 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do teachers harbour these particular attitudes?
- What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do teachers choose these methods?
- How do teachers' attitudes towards botany teaching impact their botany PCK?

4.1.2 The theoretical framework

The data are discussed in relation to the theoretical framework. The theoretical framework of this study, as stated in Chapter 2, page 36, was adapted from Magnusson, Krajcik and Borko (1999) and Rollnick *et al.* (2008) and applied to botany teaching and learning.

4.1.3 Demographics of participants

Six teachers from three schools formed part of this study, two teachers from each school. Five of the teachers were females. All the schools had different socio-economical statuses and resource availability. The researcher divided the three schools into resource rich schools, medium resourced and medium to low resourced schools. The resource rich school had an abundance of resources such as a fully equipped laboratory with a projector and television and videos to show to the learners. The medium resourced school also showed resource availability such as a projector, but had no laboratory. It had a classroom, which was used for Natural Sciences teaching, but also used for teaching of other Learning Areas. The medium to low resourced school had a laboratory, but it was not as fully equipped. The reason why this school was viewed as medium to low resourced was because there was no updated science equipment, or projectors, and also no television as resource, because the school was situated in a high crime area. Pseudonyms were given to the teachers and to the different schools.

Each of the six teachers participated in the interviews held at the various schools. Only five teachers participated in the observations of classroom teaching and the provision of lesson plans. Only three of the five teachers provided the researcher with a complete lesson plan, in other words a lesson plan set up and structured by the school and the teacher. The rest of the teachers handed the researcher the learners' notes that were copied from the textbook and from worksheets that were routinely regarded as lesson plans by the teachers. The grade of instruction ranged from Grade 4 to 7. Table 7 provides a summary of the demographics of the teacher participants.

Table 7: Background information of each teacher and school that participated in the study

School and pseudonym	Gender	Grade of instruction	Description of each school	Data collection strategy		
				Interview	Observation	Complete lesson plan
Teacher A school A TEACHER A	F	Grade 4	Resource rich school.	✔	✔	✔
Teacher B school A TEACHER B	F	Grade 7	Resource rich school.	✔	✔	✔
Teacher A school B TEACHER C	F	Grade 7	Medium resourced school.	✔	✔	Notes
Teacher B school B TEACHER D	M	Grade 4	Medium resourced school.	✔	✔	Notes
Teacher A school C TEACHER E	F	Grade 4	Medium to-low resourced school.	✔	✔	✔
Teacher B school C TEACHER F	F	Grade 7	Medium to low resourced school.	✔	✘	✘

4.1.4 The data collection timeline

Data collection took place in the second and third quarters of 2012. Table 8 provides an overview of the data collection timeline.

Table 8: Interview, observation and lesson plan dates

Activity	Participants	Date
Interviews	Teachers A to F	June to July 2012
Observations	Teachers A to E	July to August 2012
Lesson plan documents	Teachers A to E	July to August 2012

4.1.5 Data analysis approach

Data analysis took place from June 2012 to February 2013. Interview responses were transcribed and the classroom observations and lesson plan field notes were summarised by the researcher.

4.1.5.1 Transcribing the interview, class observation and lesson plan data

Interview responses were transcribed and then translated from each tape recording and saved by the researcher as transcripts in Word document files. The translated interview schedule (Appendix A) consists of a table with the interview questions and responses, codes and themes (Cresswel, 2007). In Chapter 3 a set of a priori codes and themes were shown in Table 7, however as the study progressed and during data analysis a new set of themes and codes was compiled. The interview responses were categorised into different codes, whereas the codes were grouped under each theme. The themes were formulated to answer the research questions and were based on the theoretical framework of the study. The final themes and sub-themes were extracted from the data and are provided in Table 9.

Table 9: Final themes and sub-themes from the interview, class observations and lesson plan data.

Research question	Theme	Description	Sub-themes
What are Grade 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do the teachers harbour these particular attitudes?	1. Teacher attitudes towards botany teaching	Natural Sciences teachers' personal beliefs and attitudes regarding botany teaching in the Natural Sciences Learning Area, Grade 4 to 7	• Preferences in Natural Sciences teaching (Zoochauvinism) • General attitudes towards botany and botany teaching • Difficulty in teaching botany • Plant blindness • Importance of botany and botany teaching
	2. Botany content in the curriculum *	The prominence of botanical concepts in the Grade 4 to 7 syllabus, according to Natural Sciences teachers *	• The old curriculum versus the current curriculum and CAPS • Content detail *
	3. Teacher training in terms of botany *	Teachers' past teacher training in botany whether at university or college *	• Lack of botany training * • Enjoyment of botany • Teachers' preferences of Learning Areas*
What PCK do Natural Sciences teachers use to teach botany in the Natural Sciences classrooms and why do the teachers choose these methods?	4. Teaching strategies and PCK towards botany teaching	Teachers' methods , strategies and different ways in which botanical concepts are taught for maximum understanding	• Types of teaching strategy • Technology integration in botany teaching * • Importance of teaching strategies * • The role of the teacher and assessment *
How do teachers' attitudes towards botany impact their botany PCK?	5. Relationship between teachers' attitudes and PCK	Whether teachers' attitudes towards a subject in a Learning Area has an impact on the teachers' ways of teaching, i.e. their teaching strategies	• Effects on teaching • Attitudes • PCK *

*All themes, descriptions and sub-themes refer to a priori categories, except the new themes marked with **

The themes presented in Table 9 were either a priori themes identified from the literature, or new themes identified from the data. These themes will be discussed later in this chapter and will elaborate on the data gathered from the interviews, observations and lesson plan documents.

Five botany lesson observations took place during Natural Sciences periods whilst the teachers taught botany lessons. The researcher's role was strictly non-participatory; the researcher did not interfere with the lessons. The length of each observation was approximately 30 minutes. The observational protocol's layout contained a section for descriptive field notes which described the classroom environment, the duration of the lesson, the use of teaching strategies, the use of plants as examples, learner misconceptions and learner activities completed in the class after the lesson (Appendix B). Reflexive field notes included the researcher's opinion based on the events in the class and literature studied.

The lesson plan documents (Appendix C) were summarised in tables to extract useful information such as the teachers' descriptions of the lessons, the use of resources, Learning Area integration, the learning outcomes for the lessons and assessment used during or after the lessons.

4.2 Presentation of the data

In the following section data is presented according to the responses to the interview questions (Appendix A). The lesson observations are presented according to the way in which the teachers taught the lessons by referring to the researchers' field notes and the teachers' lesson plan documents. The lesson plan documents are further presented according to the way in which botany lessons were prepared and the content of the lesson plans. Data is collectively presented according to the research questions and themes of this study.

4.2.1 Interview data

Different teachers' interview responses are presented by referring to the sub-research questions of this study and the themes and sub-themes identified from the data.

Sub-research question 1: What are Grade 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do teachers harbour these particular attitudes?

Theme 1: Teacher attitudes towards botany teaching.

4.2.1.1 Teacher preferences in Natural Sciences teaching

Teachers were asked about their favourite topics and those that they dislike to teach. Teacher A disliked teaching the theme of Matter and Material, because of its abstract nature. Teacher A stated that teaching that theme was difficult because learners did not like it and they could not relate it to their daily lives. Teacher A stated that learners had to rote learn this theme. Teacher B could not state a theme of less preference. Teacher C disliked the Earth and Beyond theme. Teacher C stated that learners struggled with the terminology in this strand. Teacher F disliked teaching the plant and animal cell to Grade 7 learners, because learners struggled with the terminology and the lack of resources at this school where only two microscopes were provided by the Department of Education.

Teachers D and E both disliked teaching about plants. Teacher E's response was: "Uhm... I don't like the plant thing, it is boring." The reason provided was that learners did not find it interesting and because they did not enjoy it, the teacher also did not enjoy it. Teacher E added that "we see plants everyday" and that learners would rather learn about different animals. Teacher D responded that we could not touch plants in the way we touch animals, that plants do not talk back and that plants are there "every day" Teachers D and E struggled to enjoy botany and botany teaching. Teacher E added that developing a "love" for plants was difficult.

Teachers A, B, C and F preferred teaching the theme of Life and Living because learners could relate to it, and therefore the four teachers found it easier to teach. Teacher A also preferred to teach about animals and water, because animals move, therefore learners enjoyed animals. Teacher C did not have a preference. Teacher C stated her preferences for plants, animals and the human body, but contradicted her statement later on during the interview by stating that she loved to teach about the human body. Teacher F also preferred to teach about animals, because she could bring animals to class to show the learners. Teacher F added that she enjoyed plants.

Teacher D and E both preferred to teach about outer space, because of the "x factor", and stated that it was "something else". Teacher D was fascinated by outer space and stated that he showed learners DVDs on the topic.

4.2.1.2 General attitudes towards botany and botany teaching

The interviewed teachers' attitudes can be presented in two sub-themes:

plant blindness and the importance of botany and teaching thereof.

Plant blindness

Wandersee and Schussler (1998) refer to plant blindness as "the inability to see or notice the plants in one's own environment", which could cause the failure to see the importance of plants in the environment, lack of appreciation towards plants and zoochauvinism. Teachers A, D, E and F showed plant blindness, because of the common idea of plants being invisible, less important than animals, uninteresting and just part of the background. Teacher A stated that she loved Natural Sciences, but found plants boring, she preferred to teach about animals, because they "move", she also stated that she could relate more to animals, that learners see plants as non-living and that plants did not react like animals do; "they are not emotional". Teacher D also enjoyed the Learning Area of Natural Sciences, but felt that plants were not as enjoyable as animals, because animals were more interactive. Teacher D emphasised throughout the interview that "to develop a love for plants is difficult, that you will develop it over time, if you understand it." Teacher E added that she did not enjoy Natural Sciences in general and did not want to teach this subject in 2013. Teacher F preferred to teach about animals, because of the diversity and because she could physically bring them to class; she then described her attitude towards botany teaching as "more or less positive".

The importance of botany and botany teaching

The importance of botany and botany teaching were prominent topics of discussion between Teachers B and D only. Teacher B in general did not reveal a lot about her attitude towards botany and the teaching thereof, but she stated that she preferred teaching about plants and animals, because they were parts of our lives. Teacher D repeatedly emphasised the importance of botany and botany teaching during the interview. Teacher D preferred not to teach about plants or soil, but acknowledged the importance of plants and soil and that soil gave "essence to plants". She also referred to photosynthesis and the fact that it provided us with oxygen.

Most of the teachers reported that botany content could be difficult for learners to learn. They also found that botany teaching was a difficult task. Teacher A stated that she understood botany, but that teaching botany to Grade 4s was a very difficult task, because of the difficult terminology. Teacher A stated that photosynthesis was a very difficult concept to teach, because of new terminology and the fact that learners could not relate to it, although she tried to make botany fun. Teacher C felt that botany was more difficult than zoology. Teacher E clearly stated that botany was difficult and that you needed to be a subject specialist in order to teach that section in the Learning Area. Teacher E also found Natural Sciences a difficult Learning Area to teach. She had preconceptions about Natural Sciences being an interesting Learning Area, but found that it consisted of a lot of work and research.

Later on in the interview Teacher E contradicted her previous statement by saying that "plants are easy", and learners loved practicals. Here, Teacher E did not specifically refer to practicals about plants, but to practicals in general. Teacher F, however, stated that botany was not difficult, because you could use practical examples when teaching that section; she added that when she prepared and used resources they were helpful. Teacher D's previous statement could be of use here: "You develop a love for plants over time, if you understand it."

Theme 2: Botany content in the Natural Sciences curriculum.

The old curriculum vs the new curriculum vs CAPS in terms of botany content

Teachers A and F felt very strongly that the old curricula, Curriculum 2005 and the Revised National Curriculum Statement [(RNCS) DoE, 2002], had more detail on botany-related concepts and content. Teachers A and F added that the current curriculum, National Curriculum Statement [(NCS) DoE, 2003], had too little relevant detail on botany and that botany was "rushed". Teacher A taught Grade 4 Natural Sciences and stated that in the NCS (DoE, 2003) there was a lack of time to complete topics, she referred to the situation as "too much, too little". Teacher A also observed that Grade 4's started with botany when they entered Grade 4, they struggled with the subject and therefore carried a negative connection to botany from then onwards. Teacher A had a child in Grade 3 who started with the CAPS (DoE, 2011) curriculum in 2012, she noticed that CAPS (DoE, 2011) placed more emphasis on botany and that it contained greater detail. Teacher A added that plants were taught for a very short while in the year, only in the first quarter.

Teacher F stated that she added more information during her lessons than that which was provided in the textbooks. She felt that the textbooks lacked information and that the NCS (DoE, 2003) combined different themes such as the Life and Living theme with the Earth and Beyond theme, which could be very confusing.

Teachers B, C and D felt the current curriculum placed insufficient emphasis on botany. Teacher C stated that there was too much information on plant structure and too little general information about plants such as their role in the environment, also that there was a lot of information on botany in Grade 7. On the other hand Teacher D stated that there was too much information on soil, therefore she chose not to follow the Natural Sciences work schedule.

With regard to content detail, Teachers B and F stated the botany section did not provide sufficient detail. Teacher F added that the only detailed section was on plant growth and the curriculum required insufficient detail on indigenous and exotic plants. Botany was a small section of the work, however she sometimes omitted it, because there was not enough time to complete the section and it caused "chaos", when she had to rush to other topics. Teacher F added that the curriculum required learners to study plants at wrong times of the year, for example when no flowers were available in winter, the work schedule stated that flowers had to be taught. Teacher E felt there was enough information on botany and that the section on plant reproduction went into enough detail.

Theme 3: Teacher training experiences.

This theme is concerned with the level of enjoyment of botany content in past training and the fact that some of the teachers did not receive botany training.

Enjoyment of botany during teacher training

Teachers A, B, and C admitted that they did not enjoy botany as part of their teacher training. During her training, Teacher A found botany very difficult and she stated that she could relate more to animals and enjoyed zoology more than botany, because of good lecturers who made zoology interesting. Teacher B stated that she had positive botanical training, but she did not enjoy botany; however, she added that the positive training was because of a good teacher: "Very positive, because I had a wonderful teacher". Then later on Teacher B stated that she enjoyed zoology more, because it was more interesting than botany. Teacher C stated that she enjoyed zoology more, because of fun excursions: "The excursions were very nice!"

The reasons for the enjoyment of botany were not related to the intrinsic love for botany, but to other factors such as the quality of teaching. Teachers D, E and F could not answer the questions related to this theme, because they did not receive training in botany.

Lack of training in botanical content

Teachers A, B and C received training in botanical content, but Teachers D, E and F received no botanical training at a tertiary institution. However, because it had been expected of them to teach botany, they developed experience in the subject. Teacher B was trained as a consumer studies teacher and stated that she only had training in biology. Teacher D was trained as a history teacher. Teacher E was trained as a language teacher and Teacher F was an art teacher. All these teachers were teaching botany in Natural Sciences. Teacher D, being a history teacher, stated that he was enjoying Natural Sciences as a Learning Area at that moment, but that he had no botany training. Teacher D only had teaching experience in Natural Sciences in general, but not specifically in botany. Teacher E had no training in botany and was a language teacher, she only taught Natural Sciences because of the classroom location. Teacher E wanted the bigger classroom, so the Learning Area came with the class! She also stated that she received help from her colleagues in teaching Natural Sciences. Teacher F stated that she had actually been an art teacher: "I am an art teacher, art is my passion and I like to draw plants and animals, that is the nearest that I have come to plants in training." Teachers who had no or little training in botany or even in science teaching were appointed to teach Natural Sciences.

Sub-research question 2: What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do teachers choose these methods?

Theme 4: Teaching strategies and PCK in botany teaching.

Teaching strategies

Teacher A:

Teacher A taught Grade 4 Natural Sciences. She liked to teach visual lessons by showing the learners pictures, practical examples and she likes to draw upon associations. She felt practical examples helped the learners realise that plants were living organisms. She demonstrated one practical activity per quarter while the learners observed. Videos were available in the media centre, but there was no television in the class, however there was a

television in the media centre. Teacher A stated that she did not show the learners any videos in the media centre, because of extra arrangements that had to be made. Teacher A did however mention that she would like to show the learners videos and "stuff on the computer, because learners react more to technology". She summarised work from the textbook and stated that the textbook had "nice" pictures that helped the learners to remember the work. Teacher A also asked the learners questions in class. "They want to tell you stories". She added that this was how the learners learn from one another. There were pictures about photosynthesis that showed associations for example a picture of a camera to remember the word "photosynthesis". Teacher A took the learners out onto the schoolyard , but she would have liked to have more time to do that and to do more practicals. Teacher A felt that you could not have a "proper" lesson without using resources, because the learners would lose interest. *The teaching strategies used by Teacher A: question and answer sessions, textbook narrative, associations and practical examples in the school environment.*

Teacher B:

Teacher B taught Grade 7 Natural Sciences. She was an experienced teacher who preferred to link the learners' prior knowledge to new concepts and to use practical examples like the parts of plants under the microscope. Teacher B stated that she regularly told the learners about something related to Natural Sciences and botany that was shown on television or mentioned in the news. "To keep their attention is very difficult". Teacher B did not show the learners any videos, because of the lack of time and facilities. Teacher B mentioned that she showed the learners posters that she had in her storeroom. She did not like to work straight from the textbook, because: "The new textbooks are more play time rather than study time". She added that the use of different teaching strategies would help learners understand the work better than when only using textbooks. "They want to see the real thing, it is like monkey see monkey do". Teacher B also bought fruit to show the learners parts of the plants we eat. She said that practicals were difficult, because of the lack of discipline. She normally drew on the board and showed the learners posters. *The teaching strategies used by Teacher B: practical examples, posters, demonstrations and the transmission method, narratives.*

Teacher C:

Teacher C taught Grade 7 Natural Sciences. She preferred to demonstrate the work to learners and mentioned that learners had to see plants; therefore she showed the learners

pictures to help them understand a topic. Teacher C added that learners had to feel science: "That is why they like the human body so much, because they can feel it. A child has to feel science". She also regarded question and answer sessions a method of keeping the learners' attention in class: "I ask them questions on what they think and then I build on their prior knowledge, that they experience it first". Teacher C showed the learners videos and pictures and brought seeds to class. She felt that learners need to observe on a visual level: "Especially today's learners, they have to be actively involved". The researcher asked the question: "Would you say that plants are interesting to teach?" Teacher C answered by stating: "It depends, because with fungi, they look it up on the internet." Here teacher C stated that she also learnt from the learners. Teacher C (if her statement on plants is considered), stated that plants were not really interesting and she referred to fungi as plants. Teacher C stated that she gave learners a topic to research and she preferred to add to the learners' previous knowledge. She also mentioned that learners struggled with plants, because they did not "notice plants and how they function around them", which could be recognised as one of the characteristics of plant blindness. *Teaching strategies used by Teacher C: question and answer sessions, narratives, practical examples, videos, research in groups and the transmission method.*

Teacher D:

Teacher D taught Grade 7 Natural Sciences and described himself as an "old school teacher" who liked to use his overhead projector and showed the learners pictures while teaching. He did not believe in bringing plants to class, because he felt you could not bring animals to class, they would get harmed. He also did not want soil in his class and on the learners' books. He took learners out only on special occasions, but admitted that it was better for them to see the "real thing". He believed that you could show learners more by using pictures than you could show them outside. This teacher mentioned that he lost the learners' interest when he taught botany. He encouraged learners to look at the leaves outside and believed that it would help develop their thinking skills and encouraged them to ask questions. "Visual aids are very important, otherwise it is a dead lesson. You cannot stand in front of the class and talk and not show them how something works". *Teaching strategies used by Teacher D: transmission method, narratives, question and answering sessions, no use of practical examples.*

Teacher E:

Teacher E taught Grade 4 Natural Sciences. When the researcher asked her to describe her teaching strategies, the researcher had to explain what teaching strategies were. She stated that she used posters, showed the learners videos and used practical examples, took them outside and actively kept them busy. She added: "I use anything". She believed that it was very important to use visual strategies and that the learners had to touch the plants and the soil: "If not they don't understand". *The teaching strategies used by Teacher E: posters, videos, practical examples and Power Point presentations, which is mainly audiovisual.*

Teacher F:

Teacher F taught Grade 5 and Grade 7 Natural Sciences. She was a very experienced teacher. She preferred to do practicals (not only botany-related practicals): "I love practicals, I let them see, touch and smell". The learners wrote notes in their observation books during the practical. Teacher F mentioned that the learners enjoyed the "starch and glucose tests" because of the colour changes that they observed. "I have a lot of apparatus, so I pack it out and they work together in groups". The learners often went outside to collect seeds and she mentioned that the learners like it, because it was something new to them. She believed that different teaching strategies were important, because the different strategies motivated the learners to think. This teacher often observed the learners outside during break and noticed how they looked at and observed different plants. The learners also worked in groups, and whilst the teacher demonstrated during a practical, the learners watched. *Teaching strategies used by Teacher F: demonstrations, transmission method, demonstration and practical activities.*

Teachers A, B, C and E used a similar range of teaching strategies, from the traditional transmission method to the use of practical examples and demonstrations. Teacher D did not make use of practical examples, but Teacher F made use of practical activities and demonstrations. Teachers B and E pointed out that they believed the learners had to touch plants to understand them. It seems that all the experienced teachers preferred to use their old traditional teaching strategies and did not like to deviate from them. The resource availability in each school also played a role in the teachers' choice of teaching strategies.

The role of the teacher and assessment

Teacher A stated that she asked the learners a question then provided the learners firstly with an informal written assessment and thereafter a formal written worksheet. She stated that she explained the worksheet over and over again. "So basically it is about repetition, repetition, repetition". She stated that she handed the learners projects, tests and exams, which were mostly completed in class. When the learners completed an "experiment" or practical task they had to complete a worksheet. Worksheets were the major form of assessment.

Teacher B stated that she repeated topics over and over again. She also asked questions. "I try to tell them for example; a dicot seed has two cotyledons, like a brain has two lobes", a useful anthropomorphic reference. Informal question and answering sessions, worksheets and tests were methods of assessment in Teacher B's botany class. Teacher B conducted "experiments" or rather practical tasks with the learners, but she did not allocate marks for these tasks. "It is very difficult, because of the lack of discipline". Teacher B mainly used both formative and summative assessment.

Teacher C stated that she preferred to give the learners short assessments. If there was something the learners did not understand, the concept would be explained again. Teacher C preferred to give the learners tests, random questions and worksheets.

Teacher D gave the learners quick quizzes and general questions. "The way they react will tell you whether they have listened or not". Teacher D mentioned earlier on: "I look at the use of plants instead of letting them learn about the morphology of the seed". In these questions he responded that if he wanted to assess plant structure he would give the learners a diagram where they could fill in the labels. When the researcher asked whether he used worksheets or experiments, he replied: "Yes, but not really experiments, our classes aren't equipped for that. We do not have laboratories". Teacher D stated that he did however demonstrate to the learners how to form a rainbow with a bucket of water and a mirror, but this was not botany related.

Teacher E stated that the teacher had to be part of the class and interact with the learners. She called the learners to her table to let them explain a concept to her: "Especially with our children, they can't really write everything down". She stated that when she marked the learners' books she picked up on misconceptions and explained the concept again. Teacher E

gave the learners worksheets to complete, class tests and drawings. Teacher E also stated that the learners did experiments where they observed and then wrote their observations in their observation books.

Teacher F stated that she loved practicals: "I let them see, touch and smell". She made use of a lot of repetition and revision. Learners had to write paragraphs in their own words. She stimulated learners by giving a comprehension test about plants in an exam. Teacher F stated that formative assessment tasks were marked during each lesson. She mentioned that the learners also made posters in class and then had to report back to the class on what they did.

Teachers A to F all preferred to use repetition as a strategy to ensure understanding in learners. The teachers used formative, summative and continuous assessment tasks which included comprehensions, drawings, observations, worksheets and quizzes. The teachers mainly used these methods to identify misconceptions and analyse learner understanding.

Technology integration in the botany class

Teachers A and B were from the same school. The school was situated in a good neighbourhood and was known as a well-resourced school with various resources available and additional help such as homework tutors. However, Teachers A and B both did not integrate technology into their teaching, because of a lack of availability of communication technology. Teacher A stated that technology would be implemented in the near future and that she was looking forward to it. The researcher asked whether Teacher A used any other form of technology in the botany classroom, and she responded: "Yes, well pictures aren't really technology, but yes there are videos available". Teacher A added that the television at home was a resource, even though it wasn't literally used in class.

Teacher B stated that they did not have any form of electronic technology available at school, for example digital projectors. She added: "Discipline is a crisis, you can't really do group work or practicals anymore". Teacher B mentioned that a system was demonstrated at their school where an experiment could be projected on the whiteboard whilst the teacher dissected a plant, but stated that there was no funding for systems like that. The researcher asked whether Teacher B used a digital or overhead projector when teaching, and she responded: "My class is very bright, so I don't really use it. So I draw on the board, show them posters, you know, practical stuff... that's the best that I can do".

Teachers C and D taught at the same school. The school was known as a medium- to well-resourced school, with resources available, but not as good as in school A. Teacher C did not use technology with botany teaching, because, according to Teacher C, it was difficult to obtain general information about botany concepts from the internet. Teacher C mentioned: "As for example volcanoes, you get a lot of information, yes!" Teacher C was asked whether she used any other form of technology in class, like showing Power Point presentations on the digital projector. She laughed and said: "No! Not anything yet, it depends on availability and content of the syllabus". Teacher D added that he did not integrate technology when teaching botany, he rather showed the learners pictures or photos, but he liked to use his overhead projector and showed the learners a DVD on "God's wonders" that was related to plants.

Teachers E and F taught at a school reported to be poorly resourced and situated in a poor area, but Teacher F mentioned that she had a lot of apparatus in her class. Teacher E, a younger teacher, responded to the question: "Yes, definitely, not in my class, but I will take the learners to the media centre". She stated that she showed the learners how seed growth occurs by using a PowerPoint presentation on her laptop, where she connected it to the television. She added that the learners enjoyed it: "Our generation is very visually oriented, they don't listen, but when the learners watch they do better than when you stand in front of the class trying to explain". Teacher F stated: "I use the old overhead projector with transparencies". She added that the school had DVDs available in the media centre, but that it created organisational problems: "and they stole our television...[laughs]". Teacher F, in contrast to Teacher E, added that the learners did not want to sit still and watch videos, she obtained images from the internet and tried to show them these pictures from her laptop. When the researcher asked whether Teacher F thought there was a shortage of resources at her school, she responded: "Yes, and money, we can't afford it, I would love to have that" (resources).

It was clear that it was difficult for schools to incorporate a variety of technology based teaching strategies into the class. A lack of funding and resources seem to be an issue in all schools. However, all the schools have media centre facilities, but the teachers prefer not to deviate from the traditional teaching, because of "extra arrangements" that have to be made. Teachers think that showing learners pictures and writing on the board serve as technology integration in class.

Sub-research question 3: How do teachers' attitudes towards botany teaching impact their botany PCK?

Theme 5: The relationship between teachers' attitudes and PCK.

According to this study's theoretical framework, a teacher's attitude could influence the teacher's PCK and PCK could in turn influence a teacher's attitude towards a Learning Area or subjects. Teacher attitudes could also influence a teacher's ways of teaching within the Learning Area, such as the subject of botany in the Natural Sciences Learning Area.

All teachers replied that there was a positive relationship between a teacher's attitude and the teacher's PCK, but with different explanations. The term "PCK" was used and explained to each teacher at the beginning of each interview. Most of the teachers did not answer the question regarding PCK, they avoided talking about PCK and rather mentioned how the learners enjoyed a Learning Area if the teacher also enjoyed the subject.

Teacher A stated: "If *you* love what you are teaching, then the learners will love what you are teaching". She also added that if you as a teacher were motivated, it would be fun to teach, but if you did not have content knowledge of the Learning Area, the learners would not like your subject.

Teacher B stated: "Yes, I say that I won't be able to teach a Learning Area that I don't enjoy. Your attitude towards a Learning Area will have an effect on what the children's' attitude will be". She added that you had to actively involve the learners. "I also keep sweets in my class, so I will ask a question and say if they know the answer they can eat it in the class".

Teacher C stated that a teacher's attitude and enthusiasm had an influence on the learners and that the teachers also had to have adequate subject knowledge, pedagogical knowledge, and love for the subject. "I had to teach a Learning Area that I didn't know anything about, it was very difficult, you have to teach the Learning Area that you like, but it doesn't always work like that". She added that the learners would pick up the teacher's love for the Learning Area.

Teacher D taught Economical and Management Sciences five years ago: "I didn't understand it, so I gave the learners the answers. I didn't like it or did not want to learn about it. You and your attitude will be carried across, even though you try, they pick it up. They know absolutely".

Teacher E stated: "If you don't like it, you won't do a lot of research and remember it. If you are in to it, then you make it more interesting, because it is interesting to you". This teacher did however relate to PCK by referring to the teachers' knowledge of the subject, by expanding this knowledge by doing extra research, and trying to make the topic of teaching interesting by using different teaching strategies.

Teacher F stated: "If *you* aren't positive, the learners won't be, but with plants as well. You have to be practical; you have to know the learners". She added that that was what she liked about the Learning Area, she also mentioned that teaching was acting and that you had to prepare. "Luckily with my experience, I am always prepared".

4.2.2 Observational data

The following section is a discussion based on the different teachers' botany classes that were observed. A narrative discussion will be provided of each teacher's lesson, by relating to the researcher's reflexive field notes. The class observations validate the teachers' interview responses in a way of verifying the teachers' responses and whether the teachers' responses were reflected in their teaching. The following research questions will be answered in this section:

Sub-research question 2: What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do the teachers use these methods?

Sub-research question 3: How do teachers' attitudes towards botany teaching impact a teacher's botany PCK?

Teacher A

Teacher A's lesson topic was "Plants in the ecosystem", taught to a Grade 4 class. Teacher A's class only had a few botany-related posters displayed on the walls together with posters of animals, some posters displayed photos of animals. The live plants in the class included the teacher's pot plant on her table for decoration purposes. She also had bean seeds available to hand to the learners during her lesson. This teacher seemed to be strict and organised in her class by being in control, but also allowed interaction in class.

Teacher A started the lesson by asking the learners questions about plants in general, the uses of plants and what plants need to grow. The learners co-operated by answering the questions. The teacher then told the learners about photosynthesis in general The learners knew what the process was about when she asked questions to the class. The teacher referred to the plant making "food". She also talked about the reasons why humans need plants; she showed the learners three posters: one poster showed different plants, another poster showed weeds, and a third poster showed vegetables. Learners had to distinguish between useful plants and harmful plants while she held each poster in front of the class. The teacher also briefly explained why the plants on the one poster were harmful. Learners asked questions throughout the lesson. The teacher limited the questions to show the learners the bean seeds. She also told the learners that the bean seed would grow into a useful plant. The learners looked at the bean seeds, some learners referred to the seeds as "baked beans". The teacher told the learners to take two seeds and plant them at home in cotton wool and water them when they felt dry.

The teacher told them to bring their plants to school in two weeks' time. Teacher A had to explain again what the learners needed to do with the bean seed. The learners then had to complete an informal assessment in their workbooks, which consisted of the completion of a word bank on useful and harmful plants.

Teacher B:

Teacher B taught Grade 7s Her topic of study was "Gymnosperms". Teacher B's classroom was a science laboratory with laboratory desks and chairs at the front of the class. There were basins and laboratory equipment at the back of the classroom. The basins and the laboratory equipment were not utilised. The back of the class served as a type of storeroom, where the basins were filled with unused posters. The classroom was very colourful. There was only one flower poster on the back wall whereas an abundance of animal posters dominated the walls of this classroom. There were no examples of plants in the class for example plant growth demonstrations, such as the growth stages of bean plants on display. The teacher had examples of dried pines and leaves on her table.

This teacher was very comfortable with the learners and her teaching. She talked freely to the learners and shared jokes with them. The teacher only then started the lesson by checking the learners' homework from the previous day and marking as the learners gave the answers. As a learner put up his hand to answer a question, the teacher just said "no" if incorrect and

went on to the next learner's answer without providing the correct answer. The teacher started to talk about amber and mentioned interesting facts about amber. She asked the learners what they thought "amber" was and what it could be used for. She explained to the learners that gymnasts use the powder to give them better grip on apparatus. When the teacher talked about amber, she related the function of amber to human functions; to "heal and repair".

She also explained to the learners that pine trees had amber and gave them some examples of gymnosperms by writing on the board, for example pine trees. As the teacher talked about pine trees, the learners took down notes in their books. There were questions and answer sessions throughout the lesson. The teacher then held up examples of pines and leaves where she elaborated on the structure, but she did not circulate the examples in the class. When the teacher talked about different Gymnosperms and the learners asked for the spelling of *Welwitchia mirabilis*, the teacher told them to look up the spelling in their textbooks, but did not give it to them. A worksheet was provided to be completed by the learners on the topic of Gymnosperms. The learners asked a lot of questions and the teacher answered as well as she could. This teacher however limited the number of questions asked, because the learners still had to complete their work.

Teacher C:

Teacher C's topic of study with her Grade 7 class was "Ferns ". Teacher C had a few botany posters in her class, but Teacher C was also an Afrikaans language and Social Science teacher. She had more Afrikaans posters on the classroom walls. She had a pot plant on her table with examples of fresh fern leaves to show to the learners. There were no plants related to curriculum content on display. It seemed Teacher C had a lot of experience in teaching. She was very relaxed, in control and very strict in her class, because the class was well-mannered and she had a firm way of addressing the class. Although it was obvious that this was an arranged lesson where the learners were briefed about the observation, they sat in groups and co-operated by participating as Teacher C asked questions.

The teacher started her lesson by referring to the learners' worksheets on ferns. She started by telling the learners about the origin of ferns and that they existed in the dinosaur era. The learners seemed to enjoy talking about dinosaurs, because some of the learners asked questions about this era with reference to other prehistoric organisms such as cockroaches and crocodiles. The teacher answered the questions but then started to talk about the ferns'

habitat and referred to a habitat as a home. This anthropomorphism made the concept easier to understand. She asked if the learners had seen "this plant" before by showing one of the leaves to them. She asked whether they had seen it in their gardens and told the learners where ferns "like to live". Learners co-operated by saying that they had seen it before.

Question and answer sessions occurred throughout the lesson as the teacher showed them the leaves. The teacher then handed each group a fresh fern leaf. The learners were excited to look at it, because of the involvement in each group. The teacher then talked about the morphology of the fern leaf and showed them the different parts while they were looking at it. She then told the learners that the whole structure was a leaf that consisted of smaller leaflets called "pinnae". She showed them the sori underneath and stated the function which is reproduction. The learners were fascinated by the sori and the function and could not believe that a plant can reproduce by means of the spores inside the sori. The teacher allowed the learners to look at the leaf structure for a few minutes. Some learners asked questions, and struggled to see the frond as the leaf. The teacher answered the questions by showing the class the fern leaf again and using her leaf to explain while they were watching . She asked if there were any more questions. The learners then had to complete an activity on their worksheets together with a drawing of a fern leaf. The teacher advised the learners to look at their real example and to draw what they saw by using the labels on the worksheet. She also asked the learners to each take a pinna and paste it in their books with Sellotape that she provided.

Teacher D:

Teacher D's topic of study was "plant habitats". He taught Grade 4 learners. Teacher D had a variety of decorations in his class. He had botany- and zoology-related posters, a lot of religious and inspirational posters together with mathematics posters, because he also taught mathematics. This was also a planned lesson, because the Grade 4 learners were supposed to do botany in the first quarter. He did not make use of any plant examples in class. The teacher mentioned in the interview that he did not follow a lesson plan or schedule and the lesson also seemed disorganised.

Teacher D was very relaxed and liked to sit on his table and talk to the learners. His way of teaching was to tell the learners stories. He eased them into the lesson by asking them; "what is a home". The learners co-operated by answering. He then told the learners that a "habitat is an animal's home". Then he asked them to recall examples of living and dead animals.

Learners' hands went up and they provided examples. One child answered that plants were dead, but the teacher corrected him and said that plants also lived by referring to the characteristics of life. The teacher then again talked about habitats, but told the learners about the habitat of plants and explained "hydrophytes, mesophytes and xerophytes". The teacher told the learners to look at their worksheets in their books, where there were examples of these hydrophytes, mesophytes and xerophytes. Some learners did not co-operate and sat and talked. He only referred to the examples on the worksheets and started to relate hydrophytes to "animals such as fish that only live in water". The teacher started to talk about animal habitats and eventually started to talk about Christianity. The learners were very curious about different animal habitats and a question and answer session followed. The teacher tried to return to the topic of plant habitats, and therefore told the learners to complete the activity on their worksheets for the rest of the period. There was a lack of time, because the teacher talked about different topics and stories such as Christianity, therefore the learners did not finish the work in class.

Teacher E:

Teacher E's topic of study for her Grade 4 lesson was "Useful plants and germination". Teacher E had an enormous classroom, the size of a laboratory, but no science equipment. There was an abundance of animal and decorative posters such as pretty flowers on the walls and a pot plant on her table.

The teacher started her lesson by adding to learners' prior knowledge in talking about "useful plants". She told the learners that vegetables were useful plants and asked them to give examples of vegetables. The learners co-operated. . Then Teacher E started to talk about germination. She asked the learners what germination was and she waited for an answer. One learner put up her hand and answered: "it is when something grows". The teacher nodded and then explained the process of germination to the learners. She explained the process again and then asked the learners questions to make sure they understood germination. The teacher used a poster that showed vegetables. She showed it to the learners and asked the learners to choose their favourite vegetable. She referred to the bean and maize seed, told the learners they were useful plants and then asked the learners why they were useful. The teacher held up the poster and pointed to different vegetables to let the learners name the different types. The learners co-operated.

The teacher then told the learners to bring a bean and cotton wool to class in a week's time. She briefly explained what they would do with the bean seed. The learners asked a lot of questions, but Teacher E limited the questions because of a lack of time. She rushed the lesson to let the learners complete their worksheets. She told the learners to start working on their worksheets: as the teacher held up the poster, the learners had to fill in a graph. She started the class activity by asking "Who likes potatoes?" Five of the learners liked potatoes and the class had to colour five units on their graphs. The learners completed the worksheet, but most learners struggled so Teacher E went to their desks and helped them with the graph.

4.2.3 Lesson plan data

In the following section a description of each teacher's lesson plan is given, summarised in table format. A number of five lesson plans were collected. Three of the five documents were fully completed lesson plans, filled out in accordance with the school's format. The rest of the documents consisted of notes handed to learners in class from which the teachers taught the lesson. These lesson plans were based on the following theme and sub-research question: *Teaching strategies and PCK towards botany teaching*, sub-research question 2; *What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do teachers choose these methods?* Sub-research question 3 also plays a role here. Tables 10 to 14 show the content of each teacher's lesson plan which were used to teach the observed botany lessons. The lesson plan documents will be discussed in the section *Discussion of the data*.

Table 10: Teacher A, lesson plan A. A complete lesson plan.

Date of the lesson	**Topic of the lesson**	**Strand/theme and context of the lesson**	**Learning Outcomes**	**Assessment Standards**	**Learning Area integration**	**Resources used during the lesson**	**The lesson structure**	**Learner activities during or after the lesson**
January 2012	Grade 4; plants in the ecosystem	Life and living: Life processes and healthy living Interaction in the environment	LO 1.1.1 Planning investigations and collecting data LO 1.1.2 Do the investigation LO 1.1.3 Evaluating and communicating findings LO 2.2.1 Remembering useful information	Observation and comparison Interpreting information Predicting Planning a scientific investigation Communicating scientific information	Languages	Black Board Own experience Practical examples such as beans Textbook	Connection with prior knowledge: Animals and humans eat plants General knowledge about plants Core knowledge: Plants produce their own food Use of plants Different plants- useful and harmful What do plants need? Intervention: Plant and grow your own seed	Informal assessment

Table 11: Teacher B, lesson plan B. A complete lesson plan.

Date of the lesson	**Topic of the lesson**	**Strand/theme and context of the lesson**	**Learning Outcomes**	**Assessment Standards**	**Learning Area integration**	**Resources used during the lesson**	**The lesson structure**	**Learner activities during or after the lesson**
July to August 2012	Grade 7; Gymnosperms	Life and living: Life processes and healthy living Interaction in the environment Biodiversity change and continuity	LO 2.2.2: Categorise information LO 2.2.3: Interpretation of information	Assessment and comparison Taking notes Sort and classify Interpret information Communicating scientific information	Languages Social science	Textbook, "to show learners examples of plants help them understand and remember"	Connection with prior knowledge The structure of ferns Core knowledge: Examples; pine tree, yellowwood, cycad. Male cones and female cones. Bark protects against fire and disease. Tree secretes tree sap to protect against insects, gives off odour and heals wounds	Learners take notes during the lesson Examples of plants are studied Completion of a worksheet and drawings of male and female cones

Table 12: Teacher C, lesson plan C. A summary of the learner handout.

Teachers C and D did not submit lesson plans, but a page from the handouts used in class from the schools' system of worksheets called "Smart". Smart is a programme that is used by the school to teach from. No textbooks are used in this school, but the copies of worksheets and text from Smart (Smart education solutions, 2012).

Topic	Lesson	Learning Outcomes
Grade 7: Ferns	Ferns are older than some terrestrial animals and older than dinosaurs. There are 9500 different fern species in the world. Habitat: tropical areas, warm and moist. Morphology: leaf like stem called the fern leaf. Small leaflets with sori producing spores for reproduction. Leaf stem is called the rachis and the fern has an underground stem growing horizontally. Diagram of the external structure of the fern and the pinna. Activity: draw the external structure of the fern plant, match column A with column B.	LO 1: Construction of scientific knowledge

Table 13: Teacher D, lesson plan D. A summary of the learner handouts.

Topic	Lesson	Prior knowledge
Grade 4: Plant habitats	Definition of habitat: natural environment where plants and animals live and spend most of their time. Different habitats: Hydrophytes are plants living in water such as ponds, rivers and lakes. Mesophytes are plants living in a habitat with adequate water supply. Xerophytes are plants living in dry habitats such as a dessert. Diagram/ activity includes a picture of a dessert habitat, water habitat and terrestrial habitat, learners had to match the habitats with pictures of a cactus, water plant and terrestrial plant.	Living and non-living organisms. Non-living: sun, clouds, water, soil, rock, air, house. Living: trees, grass, flowers, fish, bird, cat, butterfly, frog. Living organisms respire, move, reproduce, grow and eat food

Table 14: Teacher E, lesson plan E. A complete lesson plan.

Date	Topic	Learning Outcomes	Assessment Standards	Lesson	Resources
February 2012	Grade 4: Useful plants and germination	LO 2	ASS 1,2	Prior knowledge: Useful plants. Find out if they know what germination is. Introduction: Different useful plants with examples. Ask learners what their favourite vegetables are and fill this in on a graph. Learners should bring cotton wool and a bean seed to do experiment on germination. Activities: Complete and paste worksheets on useful plants. Paste and complete blocks on graph. Formal assessment with rubric.	Magazines, workbooks, posters, cotton wool and beans.

Teachers A and B presented lesson plan documents set up by the school, where the teacher only had to fill in the information. The topic of Teacher A's lesson was stated as *Plants in the ecosystem*. The lesson plan contained the Learning Outcomes and Assessment Standards for this lesson, and also Learning Area integration. The lesson plan included how this particular lesson connected to prior lessons and learners' prior knowledge. Teacher A's observed lesson was a general lesson on plants, where the teacher talked about the importance of plants, photosynthesis, and harmful and beneficial plants. She also handed the learners bean seeds to be grown at home and not in class. The core of this lesson correlated with the information on the lesson plan, but with less information stated on the lesson plan and lack of detail.

As stated in the lesson plan, the resources used by the teacher were the *black board, own experience, practical examples* and the *textbook* with no textbook number. In the observation the teacher only used a poster to show different vegetables to the learners. As stated in the lesson plan this teacher only had a discussion with the class and gave them an informal activity to do in class on harmful and beneficial plants. Learners did not read from their textbooks.

Teacher B stated in her lesson plan that she used various examples of plants and that the learners took notes as the lesson commenced, also that the learners studied the parts of the plants as they were circulating in the class. Teacher B stated in her interview that learners learn better when they see the physical plant; she also stated this in the lesson plan. She did, however, state that the only resource used was the Grade 7 textbook, although she did not use it in class, but only referred to it to look up the spelling of a plant's name. This lesson was a discussion without using a textbook. Teacher B did not state that the real plants were examples of resources used in class.

Teachers C and D did not make use of structured lesson plans. When asked for a copy of their lesson plans, the teachers provided a copy of the *Smart* worksheet that the learners pasted in their books. During Teacher C's lesson on ferns, she read from the worksheet and discussed it with the learners. As she discussed it she referred to the physical fern leaf as an example, where all learners were sitting in groups and studied the leaf, thereafter the learners completed a short activity on the worksheet. The worksheet provided stated one Learning Outcome that had to be reached at the end of the lesson, i.e. the Construction of Scientific

Knowledge. This lesson did not state the Assessment Standards and resources used, although the physical plant was used in class.

Teacher D's lesson was more of a discussion around plant habitats, where he talked to the learners and referred to their notes. This lesson was also taught form the school's *Smart* learning programme, but this worksheet did not state the Learning Outcomes, Assessment Standards, core knowledge or resources.

Teachers E and F were interviewed, but only Teacher E's lesson was observed. Teacher E provided a lesson plan copy of her observed lesson. As mentioned before, Teacher F refused to take part in the observations. Due the ethical principle of voluntary participation, no observation was made in her classroom.

Teacher E had a structured lesson plan set up by the school which stated all relevant information such as the term, the week, the date started and completed and also the theme and topic of the lesson. Learning Outcomes and Assessment Standards and the learner activities were provided. The teacher stated that she referred to the learners' prior knowledge on germination. This lesson format was exactly as the lesson was presented in class, but magazines, worksheets, posters, cotton wool and beans were listed as resources to be used during the lesson. However, during the lesson only a poster was used. Learners were asked to bring beans and cotton wool to school for the next lesson.

4.3 Summary of the data

In the following section a summary is given of the data generated from the teachers' interviews, class observations and lesson plans. The data is summarised as narratives with reference to the research questions in this study. Data from the teachers' interviews and class observations are summarised collectively and data from the lesson plan documents are summarised towards the end of this section.

4.3.1 Teachers' interviews and class observations

Science teachers' attitudes towards and PCK of botany teaching can be formed by different factors. Teachers' attitudes can be influenced by plant blindness, by their knowledge and conceptions of botany with regard to their teaching and the curriculum as their guideline, and also by the factor of enjoying botany, and their past training in botany. Teachers' PCK towards botany can in turn be influenced by their use of a variety of teaching strategies,

practical examples, awareness of learners' understanding, assessment strategies and the teachers' botanical content knowledge.

Sub-research question 1: What are Grades 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do teachers harbour these particular attitudes?

Despite the importance of science education in every school and with the emphasis on environmental awareness, there seems to be negativity towards botany in Natural Sciences classes regarding botany teaching and learning among teachers and learners. During the interviews, teachers were asked to state their preferences when teaching Natural Sciences. Two out of the six interviewed teachers admitted that they preferred not to teach botany, because the teachers found it "boring". The teachers admitted that they did not enjoy teaching botany. Statements such as "you see plants all the time, it is not something different" and that you could not "touch plants like you do with animals" were prominent during the interviews. One of the teacher's responses "seeing plants all the time" could be interpreted in a different light, since teachers "see plants all the time", but do they really see them ?

Plant blindness

Wandersee and Schussler (1998) refer to plant blindness as "the inability to see or notice the plants in one's own environment", which could be inferred as the failure to see the importance of plants in the environment, the lack of appreciation of plants, and zoochauvinism. Plant blindness could be associated with the following indicators; overlooking plants in the environment, thinking of plants to only blend in with the environment, misunderstanding of plants, not having dealt with plants in a practical manner and failure to carry the functioning of plants across (Balick & Cox, 1996; Wandersee & Schussler, 1999). Plant blindness seemed to be a prominent factor among the teachers in this study. The teachers preferred to teach about animals or any other concept in Natural Sciences, except botany. At the same time the teachers in this study acknowledged the importance of plants, but did not really see the plants around them. If teachers do not *see* plants the learners will also show plant blindness.

Often little attention is given to and little appreciation is shown towards plants and learners and teachers have the propensity to harbour negativity towards plants and botany, which leads to plant blindness (Wandersee & Schussler, 1998). Negativity towards botany held by teachers and learners may be caused by teachers who spend too little time on educating

learners about plants and their role in the environment (Schussler & Olzak, 2008). In this study it was clear that teachers would rather teach zoological concepts in class because learners related better to animals than to plants.

Zoochauvinism

Zoochauvinism is a factor that influenced teachers' attitudes in this study. Teachers stated that they were more affectionate towards animals than towards plants and that learners preferred to learn about animals rather than about plants. Teacher C stated that she preferred to teach about plants, animals and the human body, but later in the interview stated that she preferred to teach about the human body, because the learners found it more interesting.

Zoochauvinism can lead to plant blindness in science education where teachers are acquainted with the crucial role plants play in our environment, but do not emphasise the importance in the classroom (Uno, 2009). The reason for this situation might be the teachers' negative attitudes towards botany teaching, which in turn can be carried across to the learners, which can lead to a decline in interest and negative attitudes toward botany as learners grow older.

Teachers prefer to teach about animals because it does not require the use of interesting teaching strategies, because the learners are already interested (Honey, 1987). In this study teachers preferred zoology above botany because learners related to animals and not to plants, because of animals' emotion. Not only did the learners show zoochauvinism, but the teachers also showed zoochauvinism. Teachers in this study found botany teaching more difficult than teaching zoology; therefore they expressed a preference for zoology. Teacher A found botany difficult, because the learners found animals more interesting and because the learners saw plants as "dead things". Three out of the six teachers (Teachers A, C and E) stated that botany was more difficult to teach and learn than zoology. Teachers also stated that when teachers struggled with a subject and its content, they did not like to spend time on that subject because the subject was difficult to teach. As one of the teachers (Teacher D) stated, he had to teach a subject that he did not like. Consequently this teacher gave the learners the answers to the questions in class activities, rather than spending time teaching the subject.

Botany content in the Natural Science curriculum

Despite the vast number of concepts in the Natural Sciences Learning Area that range from different themes such as Life and Living to Energy and Change, botany is underrepresented in the Natural Sciences curriculum and is integrated with other areas, as can be seen in Table 15, page 81. Botany-related Core Knowledge and principles that are present in this curriculum are listed. Botany-related content in the Natural Sciences curriculum consists of photosynthesis, reproduction in plants and exotic species. Other botany-related areas include plants in the ecosystem, plants' relationship to animals, soil, fossils, food webs, pollution, global warming and the water cycle. All these areas pertain to botany, but are dealt with in relation to other non-botanical concepts. Plants are described as part of the surroundings and not as key concepts when these botany-related subjects are taught.

Table 15: Core Knowledge related to botany in the Life and Living, Earth and Beyond, Energy and Change, Matter and Material themes in the Natural Sciences Learning Area (DoE, 2003).

Theme	Botany-related Core Knowledge and principles in the Intermediate phase (Grades 4 to 6)	Botany-related Core Knowledge and principles in the Senior phase (Grade 7)
Life and Living	Photosynthesis, asexual and sexual reproduction of plants, the role of plants in the ecosystem, the interrelation between animals and plants, soil formation with reference to plants, fossil studies and the relationship to plants.	Photosynthesis, ecosystems, food webs, pollution, recycling, exotic species, biodiversity, cells.
Earth and Beyond	Soil erosion, soil formation (related to humus), the water cycle.	The sun as energy source, the way in which plants adapt to different climates, global warming, continental drift, fossils.
Energy and Change	Energy sources such as the sun (photosynthesis).	Fossil fuels, energy from ecosystems, environmental studies.

Matter and Material	No related material.	Natural resources and exploitation thereof.

Teachers in this study felt that botany was neglected in our curriculum. They felt there was little emphasis on botany a lack of time to teach botany, and that it was difficult to teach botany, and therefore they sometimes omitted botany-related sections. Teachers stated that zoology and other concepts were dealt with in more detail in the current curriculum and that botany was just "touched upon". Teacher F also stated that botany was integrated into other themes and not given in detail in this curriculum.

Teacher A referred to the current curriculum (RNCS) when she mentioned that the previous curriculum (NCS) had more detail on botany-related concepts than the current curriculum. Teacher E on the other hand stated that the RNCS placed enough emphasis on botany. When asked to compare the number of botany concepts to zoology concepts Teacher E mentioned that animals in the curriculum took up most of the time. She explained that her teaching about the habitat, different mammals, reptiles, birds and reproduction in the first and second quarters took up half of the Grade 4 year.

Teacher F, being a more experienced teacher, stated that she added information to her lessons from previous curricula, the current curriculum lacked relevant information on botany. Textbooks based on the curriculum contained a large amount of information and normally in science textbooks there was a myriad of interesting and fascinating images and information on animals and humans when compared to the paucity of botany information (Tolman, *et al*., 1998; Schussler, *et al.,* 2010). Even though Teacher F did not make use of textbooks, but of worksheets, a lack of information on botany could be the precursor to negative views towards botany teaching and learning in the classroom. Teacher F admitted that she sometimes omitted botany-related content, because of the lack of time. International research stated that teachers "eased botany out of the syllabus because it bored their students" (Bernardt, 1999 in Wandersee *et al.,* 2006). During this study it became clear that the same was happening in the South African context.

Botany can also be neglected because of uninteresting teaching strategies used in class (Hershey, 1996). Pedagogical Content Knowledge (PCK) plays a role in teaching botany. Teacher A for example found that she struggled to teach difficult concepts that the RNCS required her to teach. She stated that the first section of the Grade 4 Natural Sciences

curriculum was botany, that learners were confronted with difficult botany-related terminology and therefore the learners had a negative association with the subject. Difficult concepts were avoided by the teacher and the teacher did not stimulate the learners to enjoy botany.

Lack of time to teach botany and difficulty of teaching botany seem to be prominent problems in Natural Sciences classes. A lack of botanical relevance to teachers' and learners' lives and the fading of botany in the curriculum can also be reasons for the harboured negative attitudes (Hershey, 1996).

The influence of past teacher training in botany on botany teaching

It is the personal opinion of the researcher that learners find the teaching of botany very negative and learners refer to it as "boring". It is not different when you ask Natural Sciences teachers to give their views on botany and how they experienced it in their past training. Even though three of the teachers (Teachers D, E and F) did not receive botany training, they showed zoochauvinism when asked how they experienced botany in their current teaching practice. Teacher E commented: "I don't like the plant thing, it's boring". This comment is synonymous with negativity towards botany.

The other three interviewed teachers (Teachers A, B and C) received general training in botany during their college or university careers. They were Natural Sciences teachers and taught Natural Sciences with botany. On the other hand Teacher D was a history teacher, Teacher E was an English language teacher and Teacher F an art teacher and all of them taught in the Learning Area of Natural Sciences. The teachers who received past training in botany (Teachers A, B and C) all showed zoochauvinism. They all preferred animals to plants, and because animals had human characteristics they found it is easier to relate to animals, which made it easier for them to teach zoology.

One of the teachers (Teacher A) found botany difficult during her training. Teachers A, B and C stated the importance of a teacher when botany is taught. They stated that the teacher should be the one who "makes it interesting". One of the teachers also referred to having a "wonderful teacher" and the other mentioned interesting excursions.

It is evident that all the teachers remembered the way that they were taught themselves. They referred to their own learning experiences and demonstrated that they experienced these teaching strategies (teaching of the topic) as important. These prior experiences helped

to form their attitudes towards a topic. Even though all the teachers stated that a good teacher made botany interesting, they still harboured negative attitudes towards botany and showed zoochauvinism. Past experiences, such as the teaching strategies used to teach these teachers botany during their training and content knowledge can impact teacher attitudes towards botany and the teaching thereof. Consequently the notion exists that teachers prefer zoology above botany, therefore the teachers' prior knowledge, content knowledge and teaching strategies related to botany seem to be insufficient (Honey, 1987).

Sub-research question 2: What PCK do Natural Sciences teachers use to teach botany in their classes and why do teachers choose these methods?

The following section discusses the PCK that Natural Sciences teachers use when teaching botany. The discussion is based on the teacher interview and class observation findings. The findings will be discussed under the following headings; *teaching strategies used in botany teaching, the importance of teaching strategies when teaching botany, teacher awareness of learner understanding and assessment.*

Teaching strategies used in botany teaching

During the interviews all teachers stated the types of teaching strategy they use when teaching botany, such as practical examples, associations, videos, pictures, the use of textbooks, narratives (telling stories), posters and practicals. During the class observations most of the teachers did not make use of the teaching strategies they mentioned.

Only Teachers B and C used practical examples in their classes. All the other teachers mainly used the transmission method as a teaching strategy in the botany class. The teachers did not take their learners outside to teach them about plants in the school garden where they could see real plants. Teachers A and F complained about the time constraint and the lack of discipline among learners. Where this was a constraint some of the teachers (Teachers B and C) brought the plants into their classes, but one teacher (Teacher B) failed to send the examples around in the class for observation by learners. One teacher (Teacher D) did not like to have real plants in his classroom because he felt it was being cruel to the plant and he did not want soil in his class. Teachers did not want to use the practical examples in a lesson. They rather used posters or pictures or just taught from the textbook and talked to the learners. The way in which a subject is carried across has a big influence on learner attitudes and understanding. Teachers' teaching strategies are very important in teaching

botany. Without good teaching strategies learners may see botany as an uninteresting and dull subject which is also not pertinent to their lives, resulting in growing disinterested attitudes as their age increases (Ramsden, 1998; Prokop *et al*., 2007). Teachers' teaching strategies and methods might result in acculturation, leading to learners harbouring the same perceptions, misconceptions and attitudes towards botany as teachers (Roth, 2001; Schussler *et al*., 2010).

Technology integration in the botany class

The use of technology in classes, especially in botany classes is still lacking, mainly because of a lack of resources in various schools with different resource availability. Technology in class includes the use of overhead projectors, digital projectors with videos and slideshows and internet integration during the lesson. One international study showed that when it was impossible to use real plants in the classroom, technology could be integrated as a substitute (Cherubini, Gash & McClaughlin, 2008).

Only Teachers E and F stated that they integrated technology into their botany classrooms. This was stated during the interviews, but none of the teachers used technology during their observed lessons. The reason why the teachers integrated technology into their lessons was that some learners did not have technology at home, so when it was used during the lesson the learners were intrigued and wanted to learn about that topic. The majority of the teachers (Teachers A, B, C and D) were against using technology in the botany class, because of a lack of funding, "the learners do not want to sit still and watch" and organisational problems. An organisational problem was that the media centre had to be booked in advance and taking the class to the media centre wastes valuable teaching time. Another reason for not using technology in class was that teachers did not want to deviate from their traditional teaching strategies and would rather be regarded as an "old school teacher".

Research has shown that the use of technology fascinated learners and kept them interested and wanting to learn more (Cherubini, Gash & McClaughlin, 2008). Technology can be used, for example a digital projector, which is connected to a computer or tablet, to show learners a video on plant growth or even photosynthesis. This can help the learners understand and remember different botanical concepts.

Teachers stated in the interviews that they "would love to have that", that is technology, and that teaching and learning would be improved. Friedrichsen *et al*. (2009) state that a teacher's PCK includes them using technology, live specimens and other media and resources which

capture learners' attention in science and to leave the traditional manner of lecturing behind. Research has shown that learners' attitudes towards science already show a decline by the time they reach middle school grades (McNall Krall, Lott & Wymer, 2009). Therefore teachers need to involve learners actively in class (Anderson & Smith, 1987; McDermott, 1991; McDermott *et al*., 2006; McNall Krall & Lott, 2008).

Importance of teaching strategies when teaching botany

Most of the teachers in this study stated that the use of teaching strategies was of the utmost importance when teaching botany, because it improves learner understanding. The previous statement is in agreement with the literature. Not only are learners more involved in class when teachers use a variety of teaching strategies, but hands-on learning and discovery will also aid in learner understanding (Magnusson *et al*., 1999).

However, only a few teachers' responses during the interviews were reflected in their botany teaching. Teacher E did not know the meaning of a "teaching strategy". Teachers D, E and F stated that they used a variety of teaching strategies such as videos, examples such as seeds and pictures, and their senses while teaching botany, but these teachers' botany lessons showed otherwise. Despite the various teacher responses about the importance of teaching strategies in the botany class, some of these teachers still followed their traditional methods in teaching, because they did not want to change, try new methods or do something different. One of the teachers, Teacher D, stated that he did not like to use resources, but then later on in the interview contradicted his statement by stating that "teaching strategies are important otherwise it is a dead lesson". This was however not reflected in his teaching.

Teachers A, B and C also stated the importance of teaching strategies and it was clear during the observations that they regarded teaching strategies as important for teaching and learning. Although these teachers used teaching strategies, they did not use a variety of teaching strategies. The use of posters and the transmission method were the most popular teaching strategies observed in these teachers' classes.

In these observed classes the learners enjoyed the lessons presented to them, especially in Teacher C's class where she used a real fern frond to teach the lesson. Literature shows that learners often enjoy the practical part of science classes more than the lecturing part, for the reason that learners like to be actively involved which helps them to concentrate better on a specific concept taught in class (Cooper, Hanmer & Cerbin, 2006). As a result of active

learning and involvement in class, the learners are interested in the topic, so active learning helps learners to focus more and they are intrigued by the teachers' ways of teaching (Bligh, 2000). Primary school teachers are faced with teaching as a challenging task, because most of the teachers teach a wide variety of Learning Areas. Consequently teachers compartmentalise their teaching in each Learning Area, because of the complexity thereof, which leads to a lack of time to make botany teaching and learning interesting (Gess-Newsome, 1999).

The role of the teacher and assessment

PCK aids in creating awareness among teachers about misconceptions of a specific topic held by the learners, in this case botany concepts, and enables teachers to use appropriate pedagogical methods to approach the learners' requirements in class (Shulman, 1986). Most teachers used repetition and question and answer sessions to determine whether learners understood a topic. These are the two prominent methods to ensure understanding of botanical concepts. One of the teachers stated that she liked to relate plant topics to human activities, because this helped learners to understand, since learners related more to animals (and humans) than to plants. Another teacher stated that active involvement of the teacher was very important. This active involvement of the teacher is part of a teacher's PCK that is described in Chick and Harris' (2007) modified framework of PCK (Table 2, p. 27). Active involvement encompasses the outcomes of PCK.

Not only is the role of the teacher important in the class when teaching botany, but assessment of botanical concepts also plays a role to help teachers to identify misconceptions. Most of the teachers used traditional assessment strategies such as tests, worksheets, exams, projects to assess botanical work, but practical work still seemed to be lacking. Practical work was absent during the observed botany lessons and the use of worksheets was more prevalent. If practical work is omitted in botany classes it can lead to passive learners with negative attitudes towards botany that seems to be presented and assessed in a dull and uninteresting manner (Zhongua, 2005 and Schussler *et al.*, 2010).

Teacher F stated that she liked to develop learners' thinking skills by letting the learners write paragraphs in their own words, she used comprehension tests of botany concepts in exams, did revision and let her learners do projects where they had to explain their projects to the class. Teacher F therefore fits into Magnusson's *et al.* (1998) teacher orientations, where the teacher helps develop thinking skills, tentative thinking, hand-on learning, project

based science and discovery to help asses botanical concepts. According to Magnusson (1998) these orientations are synonymous with PCK. Therefore PCK requires a teacher to have knowledge of the science curriculum, the outcomes to be achieved, knowledge of assessment strategies and the way in which teacher performances can be measured (Friedrichsen *et al.*, 2009).

Sub-research question 3: How do teacher attitudes towards botany teaching impact their PCK?

All the teachers who participated in this study agreed that a relationship exists between the teachers' attitude and the teachers' PCK. Most of the teachers also referred to the *learners* who will be affected by the teachers' attitudes. Teacher A highlighted that if the teacher was motivated, he or she would enjoy teaching the Learning Area, but if the teacher was negative it would have an influence on the way he teaches, and his content knowledge. Teacher A earlier on stated that learning about plants was not easy and felt that they had to begin the Grade 4 year with something interesting like animals. Therefore it can be said that Teacher A had a negative attitude towards botany, because learners were not enjoying the subject in the Learning Area of Natural Sciences.

Teacher B stated that she would not be able to teach a Learning Area that she did not enjoy. "Your attitude towards a subject depends on what the children's' attitudes will be". Teacher B's expressed the same opinion about botany, but she liked zoology more, because it was interesting and because she herself had a wonderful teacher. Some teachers also prefer teaching zoology to teaching botany, because of their learners' preferences, prior teacher knowledge and experience as well as their content knowledge and teaching strategies used in class (Honey, 1987).

Teacher C felt very positive that a "teacher's attitude and enthusiasm has a direct influence on the child". She also stated that she had to teach a Learning Area that she did not like and it was therefore difficult to teach, whereas teachers do not always have a choice to teach the Learning Area they like. Teachers then normally transfer their knowledge directly to the learners in using teacher centred approaches In these classes there is a lack of practical work (Zhongua, 2005). Teacher C seemed very comfortable with teaching botany. Although she earlier stated that she found botany more difficult than zoology, she also enjoyed it. Teacher C also stated that if you did not make botany interesting to the learners you would lose their interest in that lesson. It could be inferred that teachers showed plant blindness, perhaps

because of the lack of living plants as examples in lessons, as a result there will be an absence of excitement, adventure and enthusiasm among learners towards botany (Hershey, 1996).

Teacher D stated that if the teacher did not like what he was teaching, he would rush through his lessons. Teacher D also had to teach a Learning Area he did not like and he did not do anything beyond what was expected of him. When he asked questions he actually gave the learners the answers, because of his lack of interest and knowledge harboured in that Learning Area. In any Learning Area the teachers' teaching strategies might result in acculturation, leading to learners having the same perceptions and attitudes towards a Learning Area as the teacher (Roth, 2001; Schussler *et al*., 2010).

Teacher E stated that a teacher would not do any extra research on a topic if he did not like what he was teaching. It can be said that curiosity, set goals and encouragement are key points for education and achievement in botany teaching. If the teacher does not like the Learning Area, nothing out of the ordinary will be done to make the lesson interesting (Hidi & Harackiewicz, 2000; Prokop *et al*., 2007). Earlier on Teacher E stated that she did not like to teach Natural Sciences and that she did not want to teach the Learning Area in 2013. She also did not have a choice on what Learning Area to teach and got the Learning Area with the classroom. She added that "you as teacher will make the Learning Area fun, because you find it interesting". However it seemed Teacher E liked to be actively involved in learning, she liked to take the learners outside to learn more about plants, but she also stated earlier on that she "does not like the plant thing, it is boring, children don't find it very interesting, and because they don't like it I don't like it". Teachers and learners need to be actively involved in botany teaching and learning, to contribute to the school's attitude towards botany, relating to their prior knowledge and their daily lives (Goodwin, 2008; 16).

Teacher F stated that the teacher had to be involved in class, also that teaching was acting which gives the impression that she enjoyed teaching and that the teacher always had to prepare. She also stated that a teacher's negativity could influence learners' attitudes. Teaching should therefore not only focus on skills and knowledge, focus should also be placed on attitudes, aptitudes and problem solving skills (Zhongua, 2005). Teachers are in control of these actions in class. Teacher F also mentioned something similar to Wood-Robinson (1991), i.e. that a teacher had to be practical in such a way that class work and practical work would not be segregated because this may result in misconceptions and

negativity towards botany. It would be better to capture the learners' interest and let them become involved in practical work by connecting practical work and theory (Cottrell, 2004).

According to the National Research Council (2001), research indicated that teachers play a vital role in learners' achievement. The manner in which botany is taught could have a major impact on learners' and teachers' outlook and attitude towards the Learning Area. Teachers' PCK appears to play an important part in the development of pupils' attitudes towards subjects (Hendley, Parkinson, Stables & Tanner, 1995; Woolnough, 1994; Johnston & Ahtee, 2006), and if the teacher had difficulty in teaching the Learning Area due to past experiences, this would have a negative impact on the teachers' PCK (Johnston & Ahtee, 2006).

The following chapter will provide the discussion and the findings that emerged from this study. This material in this chapter will be discussed in relation to main themes and sub-research questions of the study.

Chapter 5: Discussion and findings

5.1 Introduction

Chapter 5 presents the discussion of the interviews, class observations and lesson plan data. The discussion is in line with the literature associated with the study and the findings that emerged by referring to the major themes of the study. A set of preliminary themes and codes were formulated from the literature related to this study, however as the study progressed a new set of themes and sub-themes were developed which emerged from the data. This new set of themes and sub-themes showed similarities with and differences from the literature.

The preliminary set of themes covered the following topics: *Teacher attitudes towards botany teaching, PCK held by the teachers when teaching botany and The relationship between teacher attitudes and PCK* (Table 6, page 45). The final themes and sub-themes (Table 9, page 52) were similar to the preliminary set, but were formulated to provide answers to the specific sub-research questions and in general the main research question. The preliminary set of themes was based on international and South African literature, whereas the final themes and sub-themes emerged from actual South African class environments and from the interviews with teachers and their opinions.

As most of the themes and sub-themes confirmed what was found in the literature, this study is regarded largely confirmatory. However new themes and sub-themes emerged from the South African context. These new themes and sub-themes were novel contributions to the existing literature. The first theme; *Botany content in the curriculum.* This theme gave rise to the sub-themes; *The NCS vs. CAPS* and *Content detail in the NCS*. The second theme; *Teacher training in terms of botany*. The sub-themes; *Lack of teacher training in botany, Level of enjoyment of botany and Preferences in botany*. The theme of *PCK towards botany teaching* gave rise to a new sub-theme; *The integration of technology in botany classes* and *The importance of teaching strategies*.

5.2 The sub-research questions and major themes of the study

Sub-research question 1: What are Grades 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do they harbour these particular attitudes?

5.2.1 Zoochauvinism

It appeared that zoochauvinism was present in most of the teachers in this study. Zoochauvinism can influence the teachers' and the learners' attitudes towards botany. The teachers displayed zoochauvinism that may result in learners being zoochauvinistic; the learners' zoochauvinism can lead to the teachers developing the same attitude. Not only will zoochauvinism influence the teachers' attitudes towards botany, but it can also interfere with the balance in science teaching and could lead to teachers having plant blindness (Conley, 2009).

In general the teachers who participated in this study showed negativity towards botany and the teaching thereof. Findings associated with teacher attitudes towards botany and botany teaching include factors such as zoochauvinism, which is regarded as the teachers' preferences to teach zoology above botany; plant blindness, which is characterised by Wandersee and Schussler (1999) as the community's way of overlooking plants for their role in our environment; difficulty in botany teaching, failure to see the importance of botany and negativity towards botany teaching in the teachers while teaching the Learning Area of Natural Sciences.

Zoochauvinism played a role in Natural Sciences teachers who participated in this study. Five out of the six teachers displayed zoochauvinism during the interviews and class observations. As plants are not "emotional beings", teachers argued that it was difficult to "relate with a plant". As a result teachers found it more pleasant to teach zoology topics, because the learners found animals more exciting. Similarly to other studies (Prokop, 2007; Honey, 1987; Schussler & Olzak, 2008), South African teachers preferred to teach the zoology content of the Natural Sciences Learning Area.

One of the teachers referred to plants being boring and stated that because the learners did not enjoy sections on plants, she as the teacher also did not enjoy teaching about plants. According to a study by Prokop *et al.* (2007) learners are very interested in zoology and preferred learning about animals. Therefore teachers also prefer zoology teaching because of their prior knowledge of animals, their content knowledge and the interesting teaching strategies that can be used to teach about animals (Honey, 1987).

One teacher also mentioned that she preferred teaching about animals because of the diversity of animals and because she could physically bring animals to class (despite the greater diversity of plants and the fact that plants could also be brought to class). According to Wandersee (1986) and Kinchin (1999); Schussler and Olzak (2008) teachers and learners display zoochauvinism because teachers preferred to conduct practical work and experiments in zoology.

Most of the teachers in this study also showed anthropomorphism where plants were given human characteristics for example by referring to a plant's habitat as its "home" and referring to a dicotyledonous seed as a brain with two lobes. One of the teachers stated that a plant did not have a digestive system, which was regarded as interesting to the learners and also that you could not "pet" a plant and that a plant was not "emotional" like animals or humans. Studies by Baxter (1989) showed that learners' conceptions are based on what they see therefore they might think that plants are dead. As a result, these associations can lead to misconceptions in learners and teachers, which can contribute to zoochauvinism.

Two of the teachers (Teachers C and D) used a zoological concept as a starting point to explain a plant topic. The one teacher referred to an animal's home when talking about plant habitats, as a result the class discussion deviated from botany to zoology. Another teacher talked about the dinosaurs when discussing the origin of ferns. The reason why teachers like to use zoology as a starting point in discussing a plant topic is to capture the learners' attention.

5.2.2 Plant blindness and the importance of botany

Most of the teachers in this study showed plant blindness, where they were unable to see the significance of plant examples that can be used as a teaching strategy in teaching botany (Hershey,1996). In this study it can be said that some of the teachers showed plant blindness in their classes because of the lack of practical examples used while teaching botany. One teacher out of the six used a practical example, the fern, where the learners could see, touch and feel the plant, where other teachers only briefly demonstrated with the help of a practical example without letting the learners observe it for themselves. Elkins (1996) stated that "No matter how hard we look, we see very little of what we look at". The learners had to observe and touch plants in order to understand what they were learning. Learners should be visually aware of plants in the class and around them. Emphasis should be placed on plants by the teacher in order to help the learner remember what he or she saw. Rugg (1998) mentioned

two elements that will help us to understand and remember something; "the degree of attention paid to it, and the meaning or importance we assign to it". Teachers should integrate these elements into botany teaching, otherwise learners would possibly display plant blindness, because they are not acquainted with the crucial role of plants in the environment and they do not see plants while they are learning botany (Uno, 2009).

The importance of botany to the teacher and the importance of botany teaching were emphasised by two teachers whereby they acknowledged the importance of plants in their providing us with oxygen. One teacher stated that plants should be regarded as equal in importance to animals, but also stated that plants were boring to the teacher and the learners. The possible reason why botany seems boring is because of plant blindness in botany classes. There has been a concern that negativity towards botany held by teachers and learners was caused by teachers spending too little time on educating learners about plants and the role of plants in the environment, because of negative attitudes and the lack of proper teaching strategies (Schussler & Olzak, 2008; Honey, 1987).

Botany and botany teaching may be seen as equally important to all teachers in this study, but it is also regarded as a difficult section of Natural Sciences and that it is difficult to teach botany. Botany could possibly be regarded as difficult because of plant blindness and a lack of practical and interesting teaching strategies used in the botany class. Botany is regarded as a difficult subject and is neglected because of uninteresting teaching strategies used in the Natural Sciences class when teaching botany (Flannery, 1987 & Uno, 1994; Hershey, 1996). This perceived difficulty of botany in teachers could lead to botany neglect, as stated by some of the teachers. In this study the class observations were associated with uninteresting teaching strategies, as a result of the perceived difficulty of botany.

It was clear that during the interviews, the teachers' reported use of teaching strategies in class differed from the actual class observations. Some traditional teaching strategies were used, which will be discussed in the latter part of this chapter, because of the content detail of botany in the curriculum and because of botany being underrepresented in the Natural Science curriculum (Table 16, page 95).

5.2.3 Botany in the Natural Sciences curriculum

Five out of the six teachers mentioned that the current curriculum (NCS) lacked emphasis on botany. These teachers felt that the curriculum lacked detail that they had to add themselves.

The teachers also felt that if they had to do a botany lesson there was not sufficient time provided in the syllabus, therefore botany lessons were rushed and sections on botany omitted. Curricular saliency, characterised by Rollnick *et al.*, (2008) from Geddis and Wood (1997) is the way in which teachers fit certain topics for teaching into their teaching schedule and in which they decide whether they would teach a topic or leave it. In decisions of this kind teachers would rather omit sections on botany. One of the teachers (Teacher D) stated that he did not follow the work schedule provided by the curriculum and another teacher admitted that she omitted certain botany sections, because of the rush and "chaos".

A new finding that emerged in this study is that the CAPS curriculum in Grade 3 places more emphasis on botany than the NCS curriculum did. The botany related core concepts in the CAPS curriculum Grades 4 to 7 (DoE, 2011) can be seen in Table 16.

Table 16: Botany core content in Grades 4 to 7 CAPS curriculum (DoE, 2011).

Topic	Content
Biodiversity of living things past and present	Different plants in past and present, fossils of plants.
Biodiversity of plants	Different species of plants; sizes and shapes. Comparison of leaves, fruits and stems.
Medicinal plants	Use of indigenous plants, conservation.
Photosynthesis	"Plants make their own food", soil for anchorage.
Food chains	Plants' and animals' interdependence .
Life cycles of plants	Pollen, egg, seed, seedling, different terminology for example germination, fertilisation.

It is clear that in the CAPS curriculum there is more emphasis on botany and more detail about botany than in the previous NCS curriculum. In the international literature, textbooks were found to have fewer botany images and information compared to zoology (Tolman *et al.*, 1998; Schussler *et al.*, 2010) which could lead to negative attitudes towards botany. Textbooks does not form part of the focus of this study and could be seen as a limitation, but in the South African context it could be said that there was a shift from the old curriculum

(NCS) to the CAPS and that CAPS contains more information and detail on botany. This situation could aid in contributing to improve attitudes towards botany. Therefore textbooks will also have to change in order to accommodate the change in content.

5.2.4 Teacher training in botany

Few studies have been done on in-service primary school teachers' understanding of life science concepts such as botany (McNall, Lott & Wymer, 2009). This study is intended to help fill this gap in research in the South African context. The route to improve learner understanding of a botanical concept is to know whether the teachers understand what they teach (McNall, Krall, Lott & Wymer, 2009). Teacher training in botany needs to ensure that a teacher understands what he or she is teaching and how he or she teach.

Enjoyment of botany and botany teaching and preferences in Learning Area are related to the teacher's teaching. Teachers are not always employed to teach the subject in which they have received training. Only two out of the six teachers who feature in this study received training in botany and botany teaching, the other four teachers developed knowledge of botany while teaching. The teachers in this study taught in different Learning Areas such as language, history, consumer studies and art before they taught botany. All of them were appointed to teach Natural Sciences with botany, although with insufficient training.

One teacher who received botany training stated that she enjoyed botany during her training and that she found it difficult. Four teachers admitted that they did not enjoy botany during their training, and two of these teachers mentioned that good teachers and interesting excursions helped them to enjoy the subject during training. Botany content in the curriculum and teacher training in botany are two new themes that emerged during this study with little reference to the international literature in this study.

Sub-research question 2: What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do they choose these methods?

5.2.5 Teaching strategies and PCK

According to Gess-Newsome (1999) primary school teachers are often faced with teaching as a challenging task, because most of the teachers teach a variety of Learning Areas. Consequently teachers compartmentalise their knowledge of the Learning Area and cannot access information or build connections between the knowledge and the teaching thereof.

According to Shulman (1986) PCK is referred to as a teacher's professional knowledge, where it compliments, yet differs from content knowledge and acts as a hands-on expertise or skill utilised by teachers to guide them in their classrooms. It also enables teachers to use appropriate pedagogical methods to approach the learners' requirements in class. Rollnick *et al.,* (2008) stated that PCK is the way in which teachers teach, their knowledge of the Learning Area, the learners, the curriculum and their attitudes towards teaching the specific Learning Area, in the study of botany. Although attitudes are regarded as a separate entity in this study, it is clear that teacher attitudes can influence teachers' PCK.

Most of the teachers in this study displayed zoochauvinism, plant blindness and overall negative attitudes towards botany and the teaching thereof; as a result their negative attitudes also influenced the learners' attitudes towards botany. The role of the botany teacher in the botany class is also to contribute to a positive atmosphere among learners. However, it is shown in this study that some of the teachers omitted sections on botany, because the learners find the class boring. The reason why learners found botany boring could be because of uninteresting teaching strategies used in the botany class.

During the interviews the teachers stated the variety of teaching strategies they used to teach botany, but during the class observations a variety of teaching strategies was not evident. The stated teaching strategies during the interviews varied from question and answer sessions, showing of pictures, associations, practical examples, posters, demonstrations, videos, group discussions and power point presentations. During the observations the teachers made use of question and answer sessions, the use of posters and pictures, narratives, some practical examples and mostly, the traditional transmission method.

Teachers normally transfer their knowledge directly to the learners in using teacher centred approaches (Zhongua, 2005). During the observations in most of these classes there was a lack of practical work and the prominence of passive learners. In using the transmission method learners become reliant on knowledge transferred to the learners by the teachers based on memory and recall, leading to passive learners with negative attitudes towards the subject, in this case botany (Zhongua, 2005).

Learners want to learn by their own experiences, their prior knowledge and connect these to the teacher's knowledge (Garbett, 2011). One teacher (Teacher B) stated that she used real life events in her classes to explain a concept, when she referred to the Olympics during the class observation. Teachers also liked to build on learners' prior knowledge, relate concepts

to their daily lives and let the learners experience concepts at first hand. According to Garbett (2011) in order to use a constructivistic approach the teacher must have confidence and be ready to answer any type of question that will arise when learners combine their prior knowledge with new knowledge. Teaching should also be less transmission oriented (Appleton & Kindt, 2002).

The balance between teaching content and doing practical work shows that botany teaching and learning is a practical type of understanding which should be practiced in or outside the classroom. Theory needs to be converted into practice in the environment by using a methodology of exploring living plant examples and different strategies when teaching botany (Kahtz, 2000; Tarraban, McHenney, Peffley & Applegarth, 2004). In this study most of the classes did not represent this balance between content and practical work.

The South African author, Goodwin's (2008) statement that teachers and learners have to be actively involved in the area of botany teaching and learning in order to change attitudes towards botany is relevant, because of the lack of practical involvement in the observed botany classes. The only involvement from the teachers and learners were during the question and answer sessions with a lack of practical involvement.

Another method or teaching strategy is technology integration in the botany class. In this study the schools had a lack of funding and resources such as overhead projectors, computer projectors, computers and internet integration. A study has shown that integrating technology in class could help with problems where there might be difficulties in working with real plants (Cherubini, Gash & McClaughlin, 2008). One of the teachers (Teacher D) stated that plants would make a mess in his class. Research has shown that technology fascinated the learners and kept them interested in botany and wanting to learn more (Cherubini, Gash & McClaughlin, 2008).

All teachers in this study considered teaching strategies to form the core of a lesson, also that the use of teaching strategies would impact learner understanding, for example that the use of practical examples as a teaching strategy would help the learners to visualise, understand and see plants around them. Yet most of the teachers used the transmission method as a teaching strategy during the class observations and contradicted their statements on the importance of teaching strategies when teaching botany.

The fact that teachers stated they only took the learners out onto the field or into the school garden on special occasions to teach botany shows the lack of practical activities when teaching and learning botany. Relating knowledge of concepts in botany to the learners' daily lives, prior knowledge and attitudes towards botany in the Natural Sciences classroom is considered a crucial component of teaching and learning. Therefore a school garden might become part of the botany teaching experiences to enhance practical learning of botany (Goodwin, 2008). Negative attitudes may be caused by science teachers spending too little time on educating learners about plants and their role in the environment (Schussler & Olzak, 2008). Therefore misconceptions arise and learners see plants as non-living and uninteresting.

The use of teaching strategies is very important when teaching botany. Without a variety of teaching strategies learners may see botany as an uninteresting and dull subject, resulting in negativity towards botany (Ramsden, 1998; Prokop *et al.*, 2007). In this study teaching strategies did not form the basis of the lesson.

It is apparent that some teachers use traditional methods to teach botany, therefore the learners become bored with botany and harbour negative attitudes towards the subject. Teachers in this study did not contribute to the learners' attitudes creating a positive attitude towards botany by making the subject interesting to the learners; as the manner in which the Natural Sciences Learning Area with botany is taught, can have a major impact on learners' outlook and attitudes towards botany.

Sub-research question 3: How do teachers' attitudes towards botany teaching impact their botany PCK?

5.2.6 Attitudes and PCK

All teachers in this study agreed that teacher attitudes towards botany could impact their PCK. Teachers mainly stated that if the teacher harboured a negative attitude towards a subject, the learners would be affected. The teachers however did not refer to PCK i.e. the way in which they taught botany to the learners but referred to the learners that would be affected. Although the learners would be affected by the teacher's attitude, it would be in an indirect manner, because the teacher has to fulfil the role to carry botany across in a positive way by using a variety of teaching strategies.

Most of the teachers in this study did not like botany and botany teaching which could be the reason why these teachers did not use any interesting teaching strategies when teaching botany. The last teacher (Teacher F) also mentioned that the teacher had to prepare with regard to different teaching strategies, because these would influence the learners' attitudes.

In this study it was clear that the teachers felt a teacher's attitude would influence the learners' attitudes. Five out of the six teachers indirectly stated that teachers' attitudes would influence the teachers' PCK in teaching botany. Therefore the manner in which botany is taught could have a major impact on the learners' attitudes towards botany. Teachers' PCK appears to play an important role in the development of learners' attitudes towards a subject (Hendley, Parkinson , Stables & Tanner, 1995; Woolnough; 1994; Johnston & Ahtee, 2006). Teachers who encounter difficulties with their PCK may find it challenging to illustrate concepts and principles to their learners in classes in order to enhance learner understanding (Wilson, Shulman & Rickert, 1987; Feiman-Nemser & Parker, 1990 cited in Cochran, 1991).

Therefore it can be said that teachers' PCK influences teacher attitudes towards botany and that teachers' attitudes influence teachers' PCK and botany teaching and whether they use a variety of teaching strategies when teaching botany.

This chapter presented the discussion of the data and the findings of this study and how these can be related to international and local research studies and to new findings that emerged. The following chapter is the concluding chapter which will go over the main points of the study and conclude on the findings.

Chapter 6: Conclusion

The following chapter is the last chapter of this study, which will describe the main findings of this study and the limitations of the study and will provide suggestions for future studies.

In this study a number of problems were identified;

In the South African context there is a lack of research and literature about botany teaching and Natural Science teachers' PCK

This problem could be seen as a limitation of the study, because of the lack of South African literature to support this study. In the South African context there are only a few authors who investigated PCK, such as Goodwin (2008) and Rollnick *et al.* (2008). No South African studies have investigated PCK with reference to botany. In the South African context there are also (to date) no studies that focussed only on teacher attitudes towards botany and botany teaching. Although the lack of literature on these topics could be seen as a problem, it was seen as an opportunity in this study. This study aimed to solve this problem and to add to South African literature regarding the negativity among teachers towards botany and botany teaching and the lack of PCK towards botany and botany teaching and to help fill the void in the literature regarding botany teaching and Natural Sciences teachers' PCK.

Internationally problems such as plant blindness (Wandersee & Schussler, 1999) and negative attitudes toward botany exist. Therefore problems such as these might exist among Natural Science teachers in South African schools.

Sub-research question 1: What are Grades 4 to 7 Natural Sciences teachers' attitudes towards botany teaching and why do they harbour these particular attitudes?

No studies regarding the problems of teacher attitudes towards botany and botany teaching have been reported in South African literature. In this study, however, it was clear that Natural Sciences teachers held negative attitudes towards botany and botany teaching for various reasons such as a lack of training in botany, past experiences with botany, botany being an uninteresting topic to teach and learners who wanted to learn zoology rather than botany. Plant blindness was also common in this sample of South African Natural Sciences teachers. The teachers involved in the study struggled to see plants around them and to

realise that they could make use of plants in the botany class as an interesting teaching strategy. Therefore it could be said that the problems of negativity towards botany and botany teaching are not only prominent in other countries, but also in South African Natural Sciences classes. Wandersee and Schussler (2001) have a "solution to the plant blindness problem" in that teachers need to teach plants in a significant, attentive and interesting manner combined with hands-on practice with physical plants. According to Goodwin (2008) there is a concern regarding the state of Natural Sciences teachers' PCK towards botany teaching in the South African context.

Sub-research question 2: What PCK do Natural Sciences teachers use to teach botany in their classrooms and why do they choose these methods?

As Appleton and Kindt (2000) stated that there are still teachers who have difficulty to teach concepts in different Learning Areas, this is also the case in South African Natural Sciences teachers' classrooms when teaching botany. Teachers struggled to teach botany and did not enjoy teaching botany, because they were still using traditional teaching strategies while teaching. The teachers used traditional teaching strategies that helped them to control the class, because of disciplinary problems, but consequently had passive learners in the class who formed negative attitudes towards botany. The end result was teachers who held negative attitudes towards botany and botany teaching and carried this negativity across to the learners. Teachers did not feel the need to use their PCK to teach botany in an interesting manner. PCK, in this study, included a teacher who has general pedagogical knowledge, knowledge of botany content, knowledge of the science curriculum and knowledge of learner understanding which could have an impact on botany teaching.

In general teachers had adequate Pedagogical Content Knowledge. Most of the teachers were not trained Natural Sciences teachers and struggled with botany content. Teachers had knowledge of the science curriculum, but felt that botany was neglected in the curriculum and did not even teach prescribed botany concepts in their classes. Most teachers had knowledge of learner understanding, but used traditional assessment strategies in order to assess what learners should know. Teachers' botany teaching was influenced by the absence of active learner involvement, transmission teaching, minimum technology integration and the use of traditional teaching strategies and they chose not to deviate from these strategies.

Natural Sciences teachers could create a "botanical sense of place" in the botany class. A botanical sense of place was used by Wandersee and Schussler (2001). Finding your

botanical sense of place would only take a few minutes of the lesson. Teachers could ask the learners to write down what they remember about plants when they were younger and use this as a teaching strategy. The teacher could guide the learners by asking what plants they learners played with, what they used them for and what they smelt like. By doing this the teacher would help the learner to connect plants to their world, by relating with plants and making them part of their lives (Wandersee & Schussler, 2001). If learners struggled to find their "botanical sense of place", the teacher should help create it by bringing different plants into the botany classroom, use them as learning aids to let the learners touch, smell, feel and even taste the different plants. As Goodwin (2008) stated; we have to arouse the curiosity within learners by linking botany teaching and learning to the natural, everyday environment by integrating different and fun ways of learning.

In this study the methods of data collection namely the one-on-one semi-structured interviews, botany class observations and lesson plan documents were successful in generating data. The teachers' interviews mainly revealed the teachers' attitudes towards botany and botany teaching and how some of these teachers changed their minds during the interview by stating in the beginning that they absolutely loved plants and then later on stated that they enjoyed animals more. The interviews also pointed out the types of teaching strategy together with their PCK in botany teaching. Most teachers stated that they used a variety of teaching strategies to help the learners enjoy botany.

The botany class observations validated the teachers' responses during the interviews and whether their responses reflect in their teaching. The interviews mainly measured the teachers' attitudes where the class observations demonstrated the teachers' PCK in botany teaching. Most of the teachers' responses did not reflect in their teaching.

The lesson plan documents validated the teachers' botany lessons during the class observations. Some of the lesson plans were not regarded as complete and teachers stated areas in their lesson plans that were not prominent in their observed classes.

The main research question in this study: What is the relationship between Natural Sciences teachers' attitudes towards botany teaching and their botany PCK?

In this study the findings confirmed local and international literature, as a result this study is regarded as confirmatory, but as more findings emerged new areas were highlighted that are current in South African schools such as *teachers enjoying botany and botany teaching*, *their*

lack in botany training and also *teaching a Learning Area that did not form part of their training*, the *role of the botany teacher* in helping learners develop a love for botany, the *content in the curriculum versus the new CAPS curriculum* and the *way in which teacher attitudes towards botany influence their PCK*. The new findings are stated in Table 17.

Table 17: The study's contribution to new findings

Theme	Sub-theme	Finding
Botany content in the Natural Science curriculum.	Old curriculum (RNCS) versus the current curriculum (NCS) versus CAPS.	The NCS curriculum shows a lack in botany content when compared to the improvement in detail with regard to botany in the CAPS curriculum.
Teacher training in terms of botany.	Lack of botany training, enjoyment of botany, choices in teaching different Learning Areas.	Teachers found botany difficult and not enjoyable in their past training. Half of the interviewed teachers did not receive botany training.
PCK and teaching strategies in botany teaching.	The role of the botany teacher and assessment.	The teachers do not aid in creating a positive attitude among themselves and the learners towards botany in Natural Sciences.
The relationship between teacher attitudes and PCK.	Effects on teaching, attitudes and PCK.	Teachers confirmed that a teacher's attitudes towards botany will affect the way in which teachers teach.

The limitations of this study included one teacher who could not participate in the class observations and did not hand in a lesson plan. The concept of the use of textbooks in the botany class and the amount of botany content and images compared to that of zoology in textbooks were topics that emerged during the study, but did not form part of the main focus of this study. Another limitation was that the data was collected in 2012, which was the last year that the NCS for Grades 4 to 7 was used. From 2013 the CAPS curriculum was implemented, whereas this study did not collect data and information related to CAPS.

Another limitation, as mentioned before, was the lack of research and literature that was of use in this study.

This study can conclude that South African Natural Sciences teachers held negative attitudes towards botany and botany teaching. Although this study did not aim to solve any problems as mentioned, the impact of the problems regarding lack of botany and botany teaching in science classes could have a major effect on children's foundation years of learning. If this foundation is not laid appropriately by the teacher it will be changed with difficulty.

These primary school teachers' PCK seemed insufficient to teach botany in the Natural Sciences classroom. Teachers who were not trained to teach Natural Sciences were placed in these teaching positions. Teachers' attitudes towards botany and botany teaching influences the PCK, and PCK in turn can influence teachers' attitudes towards botany. A teacher's PCK can therefore influence the way in which botany is taught.

Limitations of the study:

This study focused on a small number of teachers in the Gauteng province where a multiple case study approach was used. The results can therefore not be generalised to apply to the entire population of South African Natural Science teachers. This study also focused on the Learning Area of Natural Sciences, in particular botany teachers' attitudes towards botany and botany teaching, and botany PCK in Natural Sciences. Therefore results obtained on teacher attitudes and PCK can only be applied to the specific field of botany in Natural Sciences and no other Learning Area. Another limitation in the course of this study was the lack of South African literature on botany teaching. It was a difficult task to find South African literature that could inform the research on attitudes and PCK in the field of botany.

Suggestions for further studies could include the following;

- The effects of integration of technology in the botany classroom.
- The study of textbooks in comparing animal and plant images and content knowledge and also useful botany images in these textbooks.
- The effects of employing teachers who are not trained in the Learning Area that they teach.
- The quality of PCK development as related to botanical content.

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Appendix A **The teacher interview protocol**

The relationship between Natural Sxcience teacher attitudes and Pedagogical Content Knowledge for teaching botany

Time of interview: _____ Duration: _____

Date: _____

Place: _____

Interviewer: _____

Interviewee: _____ Pseudonym: _____

Male / Female: _____

Plants play a critical role in our society in all aspects. The purpose of this study is to contribute to the research of primary school science teachers PCK in the learning area of natural science of the Intermediate phase, with emphasis related to botany. PCK (Pedagogical Content Knowledge refers to the manner in which the teacher successfully carries his/her content knowledge across by means of instructional methods, and teaching strategies. Pseudonyms will be utilized in the interviews, data analysis and the findings. The data collected in this study will serve in research purposes only and treated as confidential. Access to the data will be granted to the researcher and the supervisor only. Please sign the consent form at the back of this document. Thank you for your participation.

Questions:

1. Which parts of the Natural Science curriculum are of less preference in teaching?
2. Which parts of the Natural Science curriculum do you prefer to teach?
3. Do you think the National Curriculum Statement (2003) place the correct amount of emphasis on the different disciplines such as zoology, micro biology, human sciences and botany related concepts?
4. How did you experience botany in your past teacher training?
5. Describe how botany was part of your past teacher training.
6. Describe our attitude toward botany teaching in the Natural Science classroom.
7. Describe the teaching strategies that you use when teaching botany.
8. To what extent is the use of different teaching strategies in your class considered as important to you as a Natural Science teacher?
9. What techniques or teaching strategies do you use to keep learners interested in the classroom when teaching Botany?
10. How do you ensure that learners will understand topics that you are teaching in botany?
11. How do you assess learners' learning and understanding of a specific topic in botany with reference to assessment strategies?
12. Do you integrate technology, for example Power Point presentations, in the botany teaching in the classroom, explain?
13. Do you think a teacher's attitude toward botany can show a relationship with their PCK? How?

Appendix B

15. Observational protocol

Topic of study: Ferns and Pinetrees (Gymnosperms)

Classroom number: - Pseudonym: Teacher B school A

Name of observer:

D. Lombaard

Role of observer:

Non participant

Time of observation:

08:30

Length of observation:

30 minutes

Plants play a critical role in our society in all aspects. The purpose of this study is to contribute to the research of primary school science teachers' PCK in the learning area of Natural Science of the Intermediate phase, with emphasis related to botany. Pseudonyms will be utilized in the observations, data analysis and the findings. The data collected in this study will serve in research purposes only and treated as confidential. Access to the data will be granted to the researcher and the supervisor only. Please sign the consent form at the back of this document. Thank you for your participation.

Not a planned lesson.

Descriptive fieldnotes	Reflexive fieldnotes
Classroom checklist: • Botany posters ✓ • Live plants ✓ • Plant experiments ✓	• Laboratory class (unutilized at back) • One flower poster at back, more animal & energy posters • Examples of dried pines, more animal examples (crabs, spiders) pictures of bugs on walls • No examples
Participants Teacher	• A lot of teaching experience, comfortable with teaching. • Teacher's cellphone rings in class, answers (in connection with function held at school)
Class lesson Topic. Pinetrees	• Teacher goes through homework questions • Learners cooperate by answering • Teacher gives interesting facts on uses of amber (gymnasts) • Tells learners about othe examples of pine trees • Writes on board • Questions + answering • Learners take notes • Teacher shows pines + leaves, doesn't send through class.

PCK Strategies:	Questioning + answering.
Plants as examples:	Use practical examples
Misconceptions:	Learners struggle with terms like rhizomes
Knowledge of plants:	Well defined, when learners ask about spelling of Welwitchia mirabilis, told to look in their textbooks. Relates human activities (repair) to function of amber.
Activities	• Learnes take notes in their observation books • Worksheet provided on topic.
Concluding comments or remarks:	• Colourful class • Learners ask a lot of questions, teacher tries to answer at best. • If learner gives incorrect answer, teacher just says no and goes on to the next learner.

Appendix C

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NATUURWETENSKAP : GR. 7

Inhoud: Plante: kiëldraend Datum begin: 30 Julie. Voltooi: 6 Aug. 2012

Leeruitkomste en Assesseringstandaarde
(Wetenskap ondersoek: LO1; Konstruksie van Wetenskapondersoek: LO2; Wetenskap, Samelewing & Omgewing: LO3

	LO1 : Die leerder is in staat om met selfvertroue en weetgierigheid oor natuurlike verskynsels te reageer en om binne konteks van wetenskap, tegnologie en die omgewing verbande te ondersoek en probleme op te los.	
	1.1	Beplan ondersoek: Beplan eenvoudige toetse en vergelykings, en dink na oor hoe om dit billik te maak.
	1.2	Voer ondersoek uit en versamel data. Organiseer en gebruik toerusting of bronne om inligting te versamel en aan te teken.
	1.3	Evalueer data en kommunikeer bevindings. Veralgemeen t.o.v. 'n relevante aspek en beskryf hoe die data die veralgemening steun.
	LO2 :	
	2.1	Onthou betekenisvolle inligting. Ten minste definisies en komplekse inligting.
✓	2.2	Kategoriseer inligting. Vergelyk kenmerke van verskillende kategorieë van voorwerpe, organismes en gebeurtenisse.
✓	2.3	Interpreteer inligting: Interpreteer inligting deur kernidees in die teks te identifiseer, patrone in aangetekende data te vind en gevolgtrekkings te maak uit inligting in verskeie vorme (bv. prente, diagramme en geskrewe tekste).
	2.4	Pas kennis toe; pas konseptuele kennis toe deur begrip wat onderrig is met 'n variasie van 'n soortgelyke situasie in verband te bring.
	LO3 :	
	3.1	Verstaan wetenskap as menslike aktiwiteit. Vergelyk verskillende interpretasies van gebeurtenisse.
	3.2	Verstaan volhoubare gebruik van die aarde se hulpbronne. Ontleed inligting oor volhoubare en onvolhoubare gebruik van hulpbronne.

Bande		**Planeet Aarde & Ruimte**		**Lewe & Lewendige dinge**		**Energie & Verandering**		**Materie**
Tema/ Konteks		1. Ons plek in die ruimte.	✓	1. Lewensprosesse & gesonde lewe.		1. Energie oordrag & sisteme.		1. Eienskappe & gebruike van materie.
		2. Atmosfeer & weer.	✓	2. Interaksie in omgewing.		2. Energie & ontwikkeling in S.A.		2. Struktuur, reaksie & verandering van materie.
		3. Veranderde aarde.	✓	3. Biodiversiteit, verandering & kontinuïteit.				

Dui aan die proses – vaardighede, uit die assesseringstandaarde wat gebruik is.			
✓	Waarneming & vergelyking		Hipotese
	Meting		Bevraagteken 'n situasie
✓	Aanteken van inligting		Beplan wetenskap ondersoek
✓	Sorteer & klassifiseer		Voer ondersoek uit
✓	Interpreteer inligting	✓	Oordra van wetenskaplike inligting
	Voorspel		

Leerarea Integrasie:	Tale LO/AS	MSW LO/AS	EBW LO/AS	WISK LO/AS	TEGN LO/AS	KK LO/AS	LO LO/AS
	✓	✓					

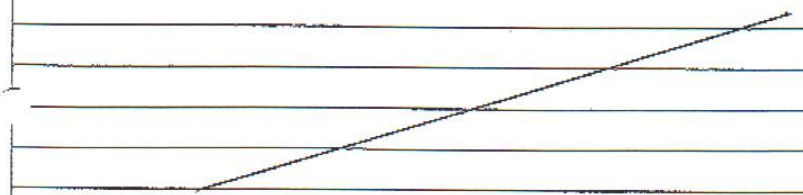
Verband met vorige en toekomstige lesse/leerinhoud.

Vorige	Toekomstige
Varing:- Plant, maar saadloos (spore)	Plante met blomme wat sade dra.

Kern inligting

Voorbeelde: Den, geelhout, broodboom & apies.
Plante dra keëls i.p.v. blomme.
Manlike keëls - stuifmeel, vroulike keëls sade.
Skurwe las:- beskerm @ druk, uitdroging & siekte.
Boom gee gom af:- - insekwerend.
- gee skerp reuk af.
- seël wonde.
Saad:- naaksadig (onbedek)
- het in vliesvlerkie - gevleuelde saad.

Verrykende geleenthede (Vinnige & stadige leerders – tekortkominge)



Onderwyser opmerking

Deur vir leerders fisiese voorbeelde en dele van plante te wys, verstaan en onthou hul beter.

Datum begin & voltooi	Onderwyser aktiwiteite	Leerderaktiwiteite	Assessering (Wat, Hoe, Wanneer)	Bronne
30 Julie ↓ 6 Aug.	Bied les aan aan mb.v. fisiese voorbeelde b. plant. Dui belangrike eienskappe aan, sekere funksies ens.	Leerders neem aantekeninge tydens les. Voorbeelde van plante en dele word deur lle. bestudeer	Leerders doen 'n werkkaart wat inhoud sowel as toepassing toets. (25)	Gr. 7 Handboeke
		Daarna word daar 'n werkkaart voltooi asook sketse v.d. manlike en vroulike kelke.		