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A design-based study of the perceived impact of the South African National Biodiversity Institute (SANBI) Teacher Professional Development Programme in Environmental Education on teacher practice

By

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Supervisor: Prof J.J.J. de Beer

February 2016
DECLARATION

I declare that: “A design-based study of the perceived influence of the South African National Biodiversity Institute (SANBI) teacher development programme in environmental education on teacher practice” is my own work; that all sources used or quoted have been indicated and acknowledged by means of complete references, and that this dissertation was not previously submitted by me or any other person for degree purposes at this or any other university.

1 September 2016

_______________________________ ___________________
SIGNATURE DATE
This work would not have been completed without the contribution of the following individuals:

- My supervisor, Prof. Josef De Beer: I deeply thank him for his patience in guiding me throughout the research journey.
- Editor Dr Xenia Kyriacou for her help in editing this document.
- My wife, Nolundi and my children, Yamkela, Manelisi and Mihle. I truly thank them for their sacrifice, support and encouragement.
ABSTRACT

Teacher professional development is an important priority in a country which underperforms in science education. In this study the role of the South African National Biodiversity Institute (SANBI) in assisting teachers in their pedagogical content knowledge development is explored. The assumption is that such institutions should work with Higher Education Institutions in better equipping our teachers for the demands they face in the 21st Century classroom. One such demand is that teachers are expected to incorporate Environmental Education principles in their teaching, yet most teachers were never trained to do so.

This study concerns an evaluation of a South African National Biodiversity Institute (SANBI) Teacher Professional Development Programme in Environmental Education. It is argued that such a programme could lead to the transfer of skills to the teachers if it is conducted in a participatory way, as in the case of this SANBI’s Teacher Professional Development Programme.

The effect of such an approach is that the programme can be cascaded down to almost all the teachers in schools, and thus leading to the development of communities of practice (CoP). Communities of practice provide an opportunity for teachers to share experiences thus leading to professional relationships and improved pedagogical content knowledge (PCK). This study followed design-based research principles, to assess the influence of SANBI’s programme on teachers’ professional development. The dissertation also describes how the research was conducted and makes some recommendations on what needs to be done to further improve this programme. In the research, discursive interviews, observations and focus group interview methods were used. The use of these tools highlighted the creativity that manifested among teachers who were involved in the programme.
Eight themes emerged from the data in this study:

1. The SANBI professional development programme resulted in improved teacher’s knowledge (Pedagogical Content Knowledge).
2. Integration of environmental education principles took place in various subjects (epistemological border-crossing).
3. Teachers adopted pedagogies that address environmental issues, thus moving towards Mode 2 context-sensitive science (Gibbons, 2000).
4. Enhanced environmental awareness, and appropriate affective development, was displayed by teachers.
5. Synergy/ linkages between schools and communities (and environmental agencies) took place, thus illustrating a systemic approach to environmental education.
6. Some transfer of knowledge and skills could be seen in classrooms, after the intervention.
7. Despite the programme, not all the teachers realize the importance of fostering self-directed learning among learners.
8. Although the SANBI programme is beneficial, a lack of continued support leads to an erosion of the envisaged outcomes.

The major recommendations for this study are as follows:

- There is a need to revise the SANBI Teacher Professional Development programme in order to assist Life Sciences and Natural Sciences teachers in their professional development, and to develop appropriate skills that would enhance environmental education in their classrooms.
- Teachers need further help in closing the gap between Environmental Education principles and infusing such Environmental Education in subject teaching.
- School principals should also be educated in Environmental Education principles as they are ultimately responsible for the overall curriculum delivery.
management at the school. Environmental education will only come to its right if a systemic approach is followed.

- Environmental Education must be mainstreamed into the curriculum, through text book revision and training of teachers because it is currently still in the periphery.
- The Department of Education needs to strengthen the curriculum management by subject advisors so as to ensure that the curriculum is delivered as planned for the year.
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CHAPTER 1: OVERVIEW OF THE STUDY (THE ROLE OF INSTITUTIONS LIKE SANBI IN TEACHER PROFESSIONAL DEVELOPMENT)

1.1 Introduction

Since becoming a true democracy in 1994, the Government of South Africa embarked on restructuring the education system to achieve an equitable socio-economic and political society (DOE, 2003:1; Wanyama, 2008). The changes in education also aimed to streamline the previously skewed education system that disadvantaged some communities and provided opportunities for others. Among the changes implemented were the introduction of Environmental Education (EE) in the national curriculum (Wanyama, 2008). In addition, the White Paper on education and training (1995) expressed the need for Environmental Education processes to involve interdisciplinary and integrated approaches that embrace an active learning approach to promote a sustainable development culture and lifestyle among South Africans (Lotz-Sistka & Raven, 2001:3).

Consequently, the National Curriculum Statement (NCS) provides for the inclusion of Environmental Education (EE) themes in the curriculum across all levels of learning. The inclusion of EE in the education system is achieved through the integration of environmental themes into the various subjects. For instance, environmental themes such as biodiversity and ecosystems are addressed in the strand “Life and Living”, and aspects of the lithosphere and atmosphere in the strand “Planet Earth and Beyond” in the Natural Sciences at the General Education and Training (GET) level (Saunders & Nduna, 2007:15). In Life Sciences at the Further Education and Training (FET) level, Change and Continuity; Environment and Society; Ecology and Biodiversity form some of the main environmental themes (DOE, 2007:36). In the Physical Sciences, Environment and Society; Technology; Impact of Pollution (e.g. mining) on the Physical Environment and Human Life are covered (DOE: 2007). The researcher
has summarised the links between the environmental themes in the CAPS curricula for Natural Sciences, Life Sciences, Physical Sciences and Geography in Table 1.1.

**Table 1.1: CAPS curricula links for environmental themes in Natural Sciences, Life Sciences, Physical Sciences and Geography**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Ecosystems</th>
<th>Abiotic and Biotic</th>
<th>Biodiversity</th>
<th>Biomes</th>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>2. Natural Sciences</td>
<td>Strand 1 (Grade 7)</td>
<td>Strand 1: Life and living Photosynthesis and respiration. Interactions and interdependence within the environment.</td>
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<td>-----------------------------------------</td>
<td>--------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Biosphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Biodiversity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sexual reproduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Physical sciences</td>
<td>1. Environment Society, technology 2. Impact of pollution on the physical environment</td>
<td></td>
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</table>
1.2 Challenges in the implementation of the National Curriculum Statement and CAPS: Is environmental education the elephant in the room?

The implication of this integration of Environmental Education into different subjects is enormous. First of all, the question can be raised whether universities adequately prepare teachers for teaching such an integrated approach, during initial pre-service teacher education (PRESET). Anecdotal evidence shows that many teachers do not adhere to these Environmental Education principles in their teaching of the abovementioned subjects. Whereas the policy documents do make provision for the inclusion of Environmental Education, many South African teachers do not have the necessary pedagogical content knowledge (PCK) to teach Environmental Education. This results in the lofty ideas underpinning the CAPS not being implemented. This raises the question about what type of in-service training (INSET) is provided for such integrated approach? How are Natural- and Life Sciences teachers assisted in incorporating Environmental Education in their teaching?

The National Curriculum Statement (NCS) and refined Curriculum and Assessment Policy Statement (CAPS) envisage a teacher who manifests a number of positive educational qualities. For instance, such teacher needs to show leadership qualities, be a counsellor, a mentor, a conflict mediator, a community builder, an examiner, a researcher, a lifelong learner and an expert in an array of teaching competencies, amongst many other qualities (DOE, 2007). Designing a professional development programme that offers opportunities for a teacher to develop most of the above listed qualities will remain a challenge.

In response to all that is required of a teacher to cope with, as well as all the changes introduced in the CAPS, teachers find themselves participating in many professional development programmes or activities planned and implemented by the Department of Education and other key role players. This also includes cluster meetings (and professional development support groups) that are
organised by the Department of Education. One of the reasons for ongoing professional development is to promote change or improve the dismal state of science education in a country that performs poorly in benchmark tests such as TIMSS (Rogan J, 2004: 55). But are teacher professional development programmes achieving its goals of improving science education in the country? The answer to this question may lie in reviewing and evaluating some of the current professional teacher development programmes. The evaluation activities done so far indicate that little has been achieved in terms of excellence (Lotz-Sistka & Raven, 2001). This situation could be linked to the fact that the CAPS implementation focuses on the “what”, and neglects the “how” of the curriculum (Walker & Schnack, 2003; O’ Donoghue, 2003, Rogan (2004). The “how” of a curriculum focuses on how teachers implement the principles and teach the content outlined in the CAPS. One of the reasons why teachers often find it difficult to implement the principles of the CAPS is a lack of Pedagogical Content Knowledge (PCK). This will be discussed in Chapter 2, but for the moment, this notion of Shulman (1986) refers to teachers’ subject knowledge, their knowledge of pedagogy, and how to best teach a particular concept for maximum learner understanding, and then contextual knowledge (e.g. profile of the learners). Also of crucial importance is what Bruner, cited in Gravett (2004:27), described as “mastering the process of inquiry”. He argued that people need to learn “to be” and “to do”, meaning that one needs to focus on learning for self-identity (ibid). The realisation and emphasis of learning for identity through inquiry processes enables an education which lasts (Gravett, 2004:27).

In this study, the researcher contextualised teachers’ professional and pedagogical content knowledge development in terms of the Zone of Proximal Teacher Development (Warford, 2011) – a construct that will be discussed in more detail in Chapter 2. Warford’s concept builds on Vygotsky’s notion of the Zone of Proximal Development, and the former author contextualised scaffolding and mentoring practices for teachers, to move from their actual development to
potential development. The researcher will indicate in how far SANBI’s programme achieves this in Chapter 4.

1.3 Teachers’ professional development and associated issues

In Chapter 2, the researcher draws on the arguments presented by Rogan (2004) in explaining issues related to professional development. The researcher will also refer to Freire (2005), Taylor (1998) and a wide range of other authors in reference to the concept of transformative learning as an important aspect of teacher professional development and adult learning.

Perhaps the most powerful statement about professional development and the issues pertaining to it was that postulated by Rogan (2004). He noted the poor implementation strategies and processes as problems related to education (Rogan, 2004:156). The fact that South Africa has a good national curriculum does not mean that the country has effective teaching and learning taking place in its schools. The problem is the actual implementation of the CAPS, and assisting teachers in their professional growth to achieve the outcomes identified in the CAPS. Verspoor (1998) argued that poor implementation of professional development programmes leads to low output, which in turn leads to a waste of time, efforts and money. The Centre for Development and Enterprise (2011) makes it clear that our teachers are often poorly trained. The 2007 McKinsey study clearly highlighted that no schooling system can rise above the limits imposed by the quality of its teachers. This illustrates the important gap that this study addresses. Where institutions like SANBI join forces with Higher Education Institutions, we might see improved quality in teacher education.

1.4 The South African National Biodiversity Institute (SANBI)

A number of organisations have developed teacher professional development programmes to meet the challenges presented by the CAPS. For the last six years, SANBI has been working with schools in five Environmental Education centres, located in Nelspruit, Cape Town, Pretoria, Bloemfontein and
Roodepoort, to implement the Teacher Professional Development Programme (PDP). The motivation for this is that SANBI’s interventions are informed by the constitutional as well as the CAPS requirements for teachers. The programmes operate in such a way that teachers participate without having to undergo formal examinations.

Furthermore, the programme is conducted informally, meaning it is not an accredited training programme. A group of teachers are identified, based on their interest and the interest of their schools and voluntarily trained over a period of two years. The aim is to train teachers to acquire the skills that can assist them to identify and develop resources that in turn can be used for teaching and learning. In other words, there is a strong focus on developing teachers’ Pedagogical Content Knowledge (PCK). An example of these resources that teachers can tap into is indigenous gardens. The programme also helps teachers to develop skills to identify environmental problems in local settings and consequently mobilise for response to the issues through facilitated learning processes as required by the CAPS. Wanyama (2008) observed that there is no useful, relevant and appropriate “ready-made” knowledge to be copied. He argued that authentic knowledge needs to be constructed by those wanting to use it in the context they plan to do so, informed by the past, present and future aspirations, risks and challenges at hand.

Teachers and facilitators of learning processes in South Africa tend to engage in abstracted Environmental Education practices, often using resources out of context or using the materials they find “simple” and easy to use. Teachers need to teach Environmental Education from an action point of view; they must be able to demonstrate what they teach to their students (O’Donoghue & Russo, 2004; Lotz-Sistka, 2007). Abstracted practices deprive learners of the opportunities of engaging with local socio-cultural, political and economic issues that pertain to local challenges and environmental risks (Wanyama, 2008). These weaknesses, in terms of how teachers deal with the CAPS, have largely informed the design and implementation of the Professional Teacher Development Programme of
SANBI. The intervention was informed by the realisation that teachers needed support to integrate Environmental Education into the learning areas and subjects they taught, as required by the CAPS.

1.5 Aims, objectives and research questions

The aim of this study was to conduct research on the South African National Biodiversity Institute’s (SANBI’s) Teacher Professional Development Programme in Environmental Education, during the different cycles of assessment and implementation of new innovations, to determine its short-term and sustainable impact on teachers’ practices.

The following overarching research question guided this study:

What role does the SANBI Professional Teacher Development Programme play in teachers’ pedagogical content knowledge development?

The following sub-questions were identified:

1. Which professional competencies are developed by teachers attending the SANBI Professional Teacher Development Programme, and how do these competencies manifest in their professional practices?

2. What are the salient strengths and weaknesses of the SANBI Teacher Professional Development Programme?

3. Which design principles can guide the curriculum of such Teacher Professional Development courses or programmes?

The objectives of the study were:

- To determine what professional skills teachers acquire through the SANBI Teacher Professional Development Programme
- To assess the strengths and weaknesses of the SANBI Environmental Education Teacher Professional Development Programme
- To provide feedback for the programme developers and implementers on how to improve the programme
To identify “keystone species” in the ecologies of practice around which the institute could anchor support for infrastructure development of the micro-group professional development and lifelong learning communities. A keystone species could assist teachers in maintaining the momentum achieved during the intervention, when they are back in “the teeming world of the classroom” (Darling-Hammond 2000).

To determine whether teachers achieve the recursion or de-automatisation phase (in Warford’s model, that is explained in Chapter 2) in striving for potential development within the zone of proximal teacher development, by having individual interviews with selected teachers two years after the programme.

To contribute to the literature on Teacher Professional Development in Environmental Education.

To develop design principles for such teacher professional development programmes.

1.6 Research design and methodology

In this research, the researcher has chosen to use both Design-based research (DBR) and interventionist research, as the researcher was a participant (trainer and observer of the SANBI courses) and an interviewer/analyst.

Design-based research methodology was chosen for this inquiry because it allowed me to distil design principles for refining the intervention. Within the DBR design, the researcher selected a qualitative design due to the social nature of the phenomena to be investigated. As a guiding principle, Loubser (2005:180) recommended that if the data sought is “verbal and explanatory or descriptive”, then qualitative methods are most appropriate. This qualitative research design was suitable to ascertain how the teachers experienced the SANBI intervention. The researcher will expand on the research design further in Chapter 3 and integrate the methods with the research design.
Teachers involved in SANBI’s programme were asked to assess the programme. However, for school observations, the researcher had to sample a number of schools. In sampling the participant schools, the researcher used a convenience sampling technique (schools in proximity to place of work or home). The convenience could, amongst other reasons, be based on distance to the participants, financial considerations or personal reasons. In this case, the researcher needed to work with teachers in schools closer to his place of work so that he could reach them either during or earlier after work every day during the data collection period (e.g. to conduct interviews). It also enabled the researcher to have enough time to observe some of the activities in the schools. After about three years, the researcher returned to some of the teachers he had interviewed and observed, using the Reformed Teaching Observation Protocol (RTOP), to see if they were still implementing any aspects of the SANBI programme. He also wanted to assess whether the level of enthusiasm of teaching EE was still high and, if not, what could have affected its potential success.

Ultimately, the preliminary findings were further analysed using third generation Cultural Historical Activity Theory (CHAT) (Engeström, 2001) as an analytical lens. By using CHAT as a research lens I was able to identify tensions and opportunities that could either inhibit or enhance Environmental Education in the classroom.

1.7 Conclusion

This study is divided into five chapters. Chapter 1 provides an overview of the study. This includes a brief analysis of the ‘gaps’ in teacher professional development in general, and some of the challenges in the implementation of the CAPS, especially with regard to the implementation of EE in the Natural Sciences. The aims, objectives and research questions guiding this research are explicated; and a brief description of the research design and methods is provided. Chapter 2 provides a review of literature pertaining to teacher professional development and emerging issues associated with this theme. In
Chapter 2 I provide the theoretical and conceptual framework used in the study, as well as a comprehensive literature overview. Chapter 3 deals with the research design and methodology, focussing on design-based and interventionist research. Chapter 4 gives a discussion of the data analysis; and a summary of the emerging themes emanating from the research. Chapter 5 provides conclusions and recommendations.
CHAPTER 2: TEACHER PROFESSIONAL DEVELOPMENT IN SOUTH AFRICA: TOWARDS A MORE SYSTEMIC APPROACH

2.1 Introduction

In my study I look at the role of SANBI in addressing two problems facing us in South Africa: the problem to effectively incorporate Environmental Education (EE) in CAPS subjects in the classroom, and secondly a factor that further complicate the EE agenda, namely the under-developed pedagogical content knowledge of many teachers. This research explores the affordances of programmes such as that by SANBI, in working with Higher Education Institutions (HEI’s) in assisting teachers in their professional development.

Over the past few decades, South Africa has struggled to mainstream Environmental Education into the core of the school curriculum due to the history of a disjointed education system and poorly coordinated teacher professional development programmes. This has constrained teachers in their attempt to effectively facilitate Environmental Education in their schools. However, far more pertinent is the fact that SA teachers in general need significant further and on-going development and training to meet the demands of an ever-changing and evolving world around them. To be able to capacitate and prepare their learners for a highly competitive environment, teachers themselves have to be capacitated in the first place.

Another aspect that is explored in this study, is that of transfer. Do teachers implement what they are taught during professional development programmes in the classroom? Kinsella and Pitman (2012) note that the teaching profession is plagued with claims of the theory-practice gap – that education is too theoretical, and not sufficiently practice focused. Do teachers simply attend such professional learning programmes to obtain professional development points (or certificates), or do they actually change their pedagogy/ practice, and apply the new theoretical knowledge in practice? In order to answer this question, I waited for
two years after the intervention, to interview teachers on whether they have implemented what they were taught during the intervention.

The above problems should also be seen against a general background of poor performance in science education by South African schools. The most powerful statement about teacher professional development and the issues pertaining to it was arguably that postulated by Rogan (2004: 156) when he noted that problems related to education are the poor implementation strategies and processes. The fact that there is a good national curriculum (Curriculum and Assessment Policy Statement) does not mean that there is effective teaching and learning taking place in South Africa’s schools. The problem lies with the implementation of the CAPS, and teachers who are not investing in their professional growth, to achieve the outcomes identified in the CAPS. The type of teacher envisaged in the NCS, and teachers working in the field, are often two different groups of people. Verspoor (1998) argued that poor implementation of professional development programmes leads to low outcomes which in turn leads to a waste of time, effort and money. However, according to the Trends in Mathematics and Science Study (TIMSS, 2003), South African teachers attended a higher number of professional development activities than the international average for activities related to Mathematics content, curriculum, improving critical thinking, and Mathematics assessment.

According to the TIMSS study, South Africa’s teachers’ high attendance of professional development activities may be due to the fact that the new OBE curriculum was introduced to Grade 8 classes for the first time in 2001. However, there is little obvious change in the quality of teaching or learning since then. Bertram (2011) argued that it is truism to say that professional development efforts should bring about teacher learning. Simply because a teacher attends a workshop, does not necessarily mean that he/she has learnt new knowledge or that practice has been changed. Bertram further argued that the impact of teacher development initiatives on improving the overall quality of education in South Africa is not encouraging. Welsch (2002) cited in Bertram 2011, noted that
despite a huge effort put into teacher upgrading in the 1970s and early 1980s, there were very few noticeable differences in learner achievement nor the overall quality of education. The post-apartheid Department of Education sponsored teachers to improve their formal qualifications such as the National Professional Diploma in Education (NPDE) and Advanced Certificate in Education (ACE) and invested a huge budget into workshops for the new curriculum reform, but Bertram argued that despite all this huge investment in education, there remained a number of reasons why most SA learners perform poorly on international and national tests. These can be summarised as follows:

- Poverty
- Malnutrition
- Parent unemployment and impact of HIV and AIDS in many communities
- Legacy of apartheid on effective management of the schools.

Bertram (2011) argued further that there are different reasons why teacher professional development initiatives do not always translate into better classroom practice. She identified the following reasons:

- The nature of new pedagogy required by curriculum reforms makes it impossible to implement in under-resourced schools
- It becomes too difficult for individual teachers to change their practice without the support of colleagues and those in management positions
- Teachers do not see the need to change their practice. One needs to recognise the effect of what Lortie (1975) calls “the apprenticeship of observation”. When teaching (after their initial teacher education) many teachers fall back to what they observed as pupils themselves. It is therefore difficult to change teachers’ professional behaviour through formal programmes (Gravett et al, 2016). In the context of my study, it is therefore important to determine what the influence is of SANBI’s programme on teachers’ pedagogy, and what transfer takes place in the classroom.
2.2 The theoretical and conceptual frameworks guiding this study

In order to guide and give meaning to my research, I had to identify a suitable analytical lens for my study. I make use of the distinction drawn between theoretical and conceptual frameworks by Petersen (2010) in this discussion. Petersen describes a theoretical framework as a theory which already exists in literature, and that can be described as “higher theory”. I base my approach to professional development of teachers in this study on Vygotskyan notions of the “zone of proximal development” (Vygotsky, 1978), and utilise third-generation Cultural-Historical Activity Theory (CHAT) as my research lens. Petersen (2010) sees a conceptual framework as a lower level of conceptual organisation. This is where a researcher decides upon concepts and theory that would form the route map of the study. In my study such concepts include pedagogical content knowledge (PCK), communities of practice (CoP’s), Japanese lesson study, and Environmental Education. I illustrate this distinction in Figure 2.1 on the next page.

2.3 Teacher professional development

In this chapter, the researcher draws on the arguments presented by a number of authors; among them, Warford (2011), Gravett (2004) and Rogan (2004), in explaining issues related to the professional development of teachers. The researcher will also refer to a number of other authors in this field, among them Freire (2005) and Taylor (1998) regarding the concept of transformative learning as an important aspect of Teacher Professional Development (TPD) and adult learning.
Theoretical Framework

Social constructivism (Vygotsky’s notion of scaffolding professional development across the Zone of Proximal Development)

Using third-generation Cultural-Historical Activity Theory (CHAT) as a research lens.

Conceptual Framework

- Teacher’s PCK (in terms of Environmental Education)
- Teacher Professional Development
- Learning within Communities of Practice

DATA

Teachers’ experiences of the SANBI programme
Transfer taking place in the classroom

Figure 2.1: Distinction between the theoretical framework and conceptual framework
The literature on professional development of teachers suggests various theories and approaches to be followed. This study views professional development through the following lenses:

- **Gravett’s (2004)** take on deep learning in teacher professional development, and the role of critical reflection on one’s practice.
- **Hoban** (2002), who believed that professional development of teachers, and the subsequent change in teaching and learning, is a complex on-going process and not a once-off event.
- **Vygotsky** (1978), who believed that a learner (in this case the teacher) will learn and develop professionally when he/she is collaboratively involved with a more knowledgeable other. This might imply professional development within a community of practice, and notably the influence of a more senior colleague or mentor.
- **Rogan and Grayson** (2003), who suggested a professional development plan focusing on three aspects: profile of implementation, capacity to support this implementation and support from outside agencies. Their notion of the ‘Zone of feasible innovation’ draws on Vygotsky’s “Zone of proximal development”.
- **Maslow’s (1987) hierarchy of needs**: If people’s needs are addressed, their motivation will improve. Addressing their needs will have an influence on their personal growth, development and identity.
- **Teacher professional identity and agency** affected by curriculum reform, building on the work of Anthony Giddens (1984).

### 2.3.1 Gravett on surface and deep learning

Gravett (2004) argued that many complex issues encountered in teaching and learning require that a teacher and a learner be constantly conscious of the differences between tradition and high standards. The context of her argument was that while engaged in a practice (classroom teaching in this case) that one is used to, it is important to be aware of the fact that what one is used to doing every day may not necessarily reflect the reality of the day. Many teachers
studied at colleges or university without ever having had the privilege of good teacher role models while they were in school. It is therefore easy for a teacher to adopt a well-known pedagogy such as ‘chalk-and-talk’, without any critical reflection on whether this pedagogy is mediating effective learning. Indeed, it is that reality that needs to inform one’s practice. Thus, for teachers to excel in their practice, it becomes critical that they have to constantly review their own teaching method, attitudes towards learners and resources used to keep up with the reality in the world of super complexity (Gravett, 2004:23). Teacher professional development programmes (such as this programme by SANBI) needs to ensure that teachers are assisted in metacognition, and be assisted to become more critical reflective practitioners.

In contrasting surface and deep learning, Gravett seemed to imply that whereas general learning can use surface learning approaches and achieve its goals, Teacher Professional Development needs to use both surface and deep learning approaches which encourage teachers to acquire knowledge, skills and attitudes as they develop their identity in whichever field they may be involved (Gravett, 2004).

**Surface learning** refers to learning where there is no emphasis on actual acquisition of skills and attitude. **Deep learning** refers to learning where there is acquisition of skills and attitude, and an element of critical reflection. For developing a professional identity, it is essential for a teacher – and a learner – to be critical and reflective. Developing identity means teachers redefining their own roles as teachers, and possessing a constant strive to develop their own PCK. This has some permanence attributed to it. **Transformative learning** takes time, involves radical approaches to learning such as dialogical processes, experiential processes and uses methods such as dialogue, debates, critical and self-reflection. Authors such as Freire (2005), Wals and Heyman (2004) also shared this view. Wals and Heyman (2004), for instance, referred to it as a process of learning to change. By inference, Gravett’s (2004) notion of deep learning and Taylor’s (1998) concept of transformative learning, as well as Wals and
Heyman’s (2004) description of the process of learning to change, all shared a number of attributes that pertain to how professional development ought to be implemented.

For the context of this study it is therefore of crucial importance that the SANBI programme supports deep learning, and assist teachers to become critical reflective practitioners.

2.3.2 New perspective on teacher development, according to Leu

There is almost consensus that teacher professional development programmes should be centred on learners, knowledge, assessment and the community to optimise teacher learning.

Villegas-Reimers (2003) cited in Yumiko and Ferreira (2010), suggested that a new perspective of professional development should be,

- Based on constructivism
- Perceived as a long-term process
- Perceived as a process that takes place within a particular context
- Intimately linked to school reform
- Conceived as a collaborative process
- Very different in diverse settings.

These tenets are similar to the guidelines for professional development programmes identified by Bernstein in the CDE Report (2011). In Chapter 5 I will reflect upon these principles again, in the context of the SANBI programme offered to teachers.
Table 2.1: Teacher Learning (Leu, 2004:6)

<table>
<thead>
<tr>
<th>Previous approach</th>
<th>Alternative approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>The goal is to have teachers who are</td>
<td>The goal is to have teachers who are reflective</td>
</tr>
<tr>
<td>competent in following rigid and prescribed</td>
<td>practitioners who can make informed</td>
</tr>
<tr>
<td>classroom routines</td>
<td>professional choices</td>
</tr>
<tr>
<td>Teachers are trained to follow patterns</td>
<td>Teachers are prepared to be empowered</td>
</tr>
<tr>
<td></td>
<td>professionals</td>
</tr>
<tr>
<td>Results in passive learning</td>
<td>Results in active and participatory learning</td>
</tr>
<tr>
<td>Cascade model run as centralised workshops or programmes</td>
<td>School-based model in which all teachers participate</td>
</tr>
<tr>
<td>“Expert” driven</td>
<td>Teacher facilitated with support materials</td>
</tr>
<tr>
<td>Little inclusion of teacher knowledge and realities of</td>
<td>Central importance of “teacher knowledge” and</td>
</tr>
<tr>
<td>classrooms</td>
<td>realities of classrooms</td>
</tr>
<tr>
<td><strong>Positivist base</strong></td>
<td><strong>Constructivist base</strong></td>
</tr>
</tbody>
</table>

This research points to the fact that professional development by itself does not automatically lead to tangible results. Professional development is a long-term investment. It also takes time for teachers to become competent in what they have been trained on.

2.3.3 A Vygotskyan perspective on teacher professional development

2.3.3.1 Social constructivism as theoretical framework in this study

It is important to state, at this stage, that both constructivism and pragmatic worldviews inform this study. One of the current influential theories on how knowledge is constructed, and the idea postulated by this theory is that learners learn by making meanings using their own life experiences. In terms of this view, learners actively engage in the making of meaning during interactions with fellow learners, as well as their teachers or even parents. This process of engagement leads them to jointly construct knowledge (co-construction of knowledge) by relating it to what they already know (Olivitt & Rosenberg, 2006: 10).

Constructivist ideas have thus largely influenced the development and application of new educational methods and processes that require teachers to facilitate
learning as opposed to transmitting knowledge to learners as commonly practised in the positivistic education processes. This thinking has enabled a shift from teaching by imposition to teaching by negotiation. Constructivism was favoured as a methodology by the progressive education movement because it promoted learner-centred education, by acknowledging the right of the individual to construct meaning in the educational setting (Olivitt & Rosenberg, 2006). In the SANBI intervention, such social-constructivist pedagogies should be emphasized, in order to convince teachers of the affordances of such approaches in the classroom.

2.3.3.2 Vygotsky and the Zone of Proximal Development

Lev Vygotsky was a Russian developmental psychologist and educator. He believed firmly that historical, cultural and social factors play an important role in the development of cognition and that all knowledge is socially constructed. This theory is known as the social constructivism theory. He also believed that past experiences had an influence on new learning experiences. Vygotsky believed that children learn by following the example of an adult or more knowledgeable other, until they gradually develop the ability to perform certain skills independently (Vygotsky, 1978).

Vygotsky developed a theory of zone of proximal development (ZPD). The ZPD is the gap between the actual development level of a student and the potential level the student can reach. The way in which this zone or gap can be crossed is through mediation by a more competent peer. Teachers have prior knowledge while they are operating in their community of practice which they apply when confronted with new situations. A teacher gains knowledge as he/she develops by way of social interaction with peers. The more experienced teachers, subject heads or heads of department can act as the more competent peer. Vygotsky used the term **scaffolding** to describe the facilitation offered by the more competent peer. This scaffolding entails mediation, provided by the “more competent other”, to achieve the learning goals.
This theory emphasizes the collaborative nature of learning and can be applied to the professional development of teachers. It suggests that the learner (in this case the teacher) must be actively involved in the learning process. Such learning can take place within a community of practice. In this regard, Welk (2006) and Jamieson (2004) emphasised that contextually-based learning takes place when it occurs in a community of practice. In such a community of practice novice as well as experienced teachers are found and both can learn from each other.

Vygotsky defined the peer with more knowledge as the “more knowledgeable other” (MKO). The MKO in a community of practice will be the **keystone species**. The role of the keystone species as mediator is that of providing collaborative dialogue and scaffolding to assist other teachers in their development. Motivation according to this theory is seen as extrinsic as well as intrinsic. Teachers learn through teamwork and gain knowledge as they develop by way of social interaction with peers when operating in a community of practice (Dahms, 2008).

### 2.3.3.3 First, second and third generation activity theories, and CHAT as a research lens in this study

According to Johnson, Dempster and Hugo (2011), knowledge undergoes several re-contextualisation as it passes from its origins as an academic discipline to its form in the school curriculum, to the classroom where it is taught and assessed. Jita and Ndlalane argued that teachers acquire knowledge through their formal training (knowledge of practice). The knowledge they acquire during their teaching experiences is called knowledge in practice; and they argue that although there is consensus on these types of knowledge, there is still no consensus on the minimum required knowledge for teachers to become effective teachers in the classroom. This process leads to tension – Vygotsky’s framework is used to remove this tension.
Vygotsky (1978) believed that learning takes place during social and cultural interactions between children and knowledgeable adults. This assumes that since people come from different backgrounds, they would have learnt something from their community or peers and it is that knowledge that would guide them in their decision making as adults. Following these deductions, Vygotsky (1978) formulated a new theory, known today as first generation activity theory. According to this theory, a human being will never react directly to his environment, but his/her actions are always mediated by an artefact (cultural means, tools and signs). Social interaction acts as the basis of cognition formation. This artefact-mediated and object-orientated human action can be visualised as a triangle, demonstrated in Figure 2.2 (Vygotsky, 1978:40).

![First generation activity theory diagram](image)

**Figure 2.2: First generation activity theory**
Adapted from Vygotsky, 1978:40

The subject in Figure 2.2 can be used for an individual or a group. The *subject* uses mediating tools, for example language, in order to act on the *object* of activity. An important concept that Vygotsky included in the mediation is that the learner can accomplish more with guided assistance (mediation or scaffolding) than on his/her own.

The first generation activity theory hinted at social activity, but did not include mediation by other human beings. Leontiev (1981) expanded on the idea of mediation and included the concept of collective activity as well as individual action from which the second generation of activity theory evolved. This theory
also linked on to the concept of division of labour (who does what, when and how). The division of labour is seen as a fundamental historical process assisting in the development of cognitive functions. The two level diagram was expanded to a three level model of activity. Figure 2.3 explains Leontiev’s (1981) second generation activity theory:

![Figure 2.3: Second-generation Activity Theory](source: Hardman, 2008:70)

The top level of collective activity still includes the tools of mediation and is driven by an object-related motive. The middle level includes the subject (individual) which is driven by a conscious goal or outcome, while the bottom level is driven by the conditions and tools at hand and explains automatic operations. Leontiev’s model explains how individual actions work in conjunction with social activities.

However, Leontiev’s model does not explain how individual actions are transferred into collective objects within a community (Hardman, 2008). During the 1980s, Griffin and Cole (cited in Cole, 1988) pointed out that the second generation activity theory was insensitive towards cultural diversity and, through their efforts, the third generation of activity theory was developed with the help of Engeström. Engeström (1987) built on both Vygotsky and Leontiev’s models and
generated the third generation activity theory. Figure 2.4 illustrates the activity system as the basic unit of analysis (Engeström, 1987:78):

![Figure 2.4: The third-generation activity theory](image)

In this study I will be utilising the above third-generation activity theory as my research lens. Activity theory corresponds with social constructivism as it also links cognition and behaviour to social interaction (Russel, 1997). An activity system is used as the basic unit to research human interaction and behaviour. The activity system is usually a group of people, be it a family, an organisation, people working together, a school, a classroom, etc. I will be using CHAT in two ways in my study: firstly, CHAT as research lens looking at the SANBI course (with the teachers as subjects), and secondly using CHAT as a lens in a teacher’s classroom, to see what transfer takes place.

People in the activity system are continuously shaping each other while they interact socially with each other (Roth & Lee, 2007). The two-way arrows indicate the dynamic nature of the nodes of the triangle. The individual action mediated by tools is represented at the top part of the triangle. The individual action is embedded within the social realm at the bottom part of the triangle. The power
relations, rules and division of labour all impact on the subject’s actions (Hardman, 2008).

2.3.3.4 CHAT as applicable to this study: Unpacking the different nodes in the activity system

Next I will show how CHAT is used as a research lens in this particular study.

(a) The Subject: The Science (Life-, Natural and Physical Sciences) teacher

![CHAT Diagram]

Figure 2.5 The subject in CHAT

The subject in the CHAT diagram represents the Physical- Life- and Natural Sciences teacher. Teachers are seen as key contributors to the transformation of education in South Africa. The types of teachers envisaged by the CAPS are those who are qualified, competent, dedicated and caring. They should be able to fulfil various roles including being mediators of learning, interpreters and designers of learning programmes and materials, leaders, administrators and managers, scholars, researchers and lifelong learners, community members, citizens and pastors, assessors and subject specialists (Department of Education, 2002:5).
While teachers are responsible for the development of learning programmes, teacher education programmes should build the capacity of teachers, school management teams and departmental support personnel to implement, manage and support the development of learning programmes (Department of Education, 2002:7-8).

Teaching as envisaged by the CAPS is a complex activity that is very broadly defined. The conventional role of a teacher as ‘only’ a transmitter of knowledge or lecturer now changes to include many different roles. Harden and Crosby (2000) categorised the many teaching roles teachers have into two main categories: subject expertise and educational expertise. Since this study focuses on teachers’ professional development, a third role is added to these two; namely, that of facilitator of investigations. Thus, the three roles of the Science teacher will be: critical mediator of knowledge, pedagogical content knowledge expert and facilitator of scientific investigation. In the context of this study, the teacher is not only expected to be a Science (subject) teacher, but also to address Environmental Education in a cross-curricular fashion. These roles will now be discussed in more detail.

The teacher’s role as critical mediator of knowledge

Both Dewey (1963) and Vygotsky (1978) viewed the teacher as a mediator standing in the middle between the learner and the knowledge to be learnt. Mason (2000) supported the view of a teacher as mediator and identified three types of mediation:

- When the teacher acts as a facilitator of learning, the importance of procedural knowledge is stressed. The development of skills, competencies and abilities is important.
- When the teacher is concerned with transmission of knowledge, the focus is on propositional knowledge. The drilling of content knowledge is important.
When the teacher is busy with *dispositional knowledge*, the focus is on social and cultural values and knowledge.

Bernstein (2000: 70) used the terms visible (transmitter of knowledge) and invisible (teacher as facilitator) pedagogies for the first two teaching styles.

With the implementation of OBE, the role of the teacher changed from the traditional role of *transmitter of knowledge* to that of *facilitator of learning*. In South Africa, rote learning and propositional knowledge were very popular teaching strategies prior to the first democratic election in 1994. Rote learning was easier to use to cope with problems like large classes, not teaching in the mother tongue, lack of equipment and having many under-qualified teachers (Mason, 2000:3). Since the implementation of OBE, education planners and teachers in South Africa are inclined to over-emphasise the role of teachers as facilitators. When over-emphasising the facilitation role, teachers often lapse into a very passive role, causing the accent to be on propositional knowledge. Mason (2002) argued that teachers tend to over-emphasise either propositional, procedural or dispositional knowledge. The researcher believes that scientific inquiry and problem-solving skills (specific aim 2) are best achieved via *procedural knowledge* facilitation. Participation by students and student expression are important to achieve this outcome. The achievement of specific aim one (the construction and application of Science knowledge) requires that learners be able to recall meaningful knowledge and therefore *propositional knowledge* is necessary. The achievement of outcome three requires that appropriate attitudes and values be developed to help learners become informed and responsible citizens in their community and in South African society. *Dispositional knowledge* will be applicable to understanding and application of Science knowledge. Bernstein (2000) also adopted the view that pedagogies are mixed to suit specific circumstances. Taylor (2008:12) mentioned that the US Department of Education recommended that instruction should not be entirely student-centred or teacher-directed. It does not support the exclusive use of
either one of these approaches. Based on the views of these authors, it is believed that teachers should try to find a balance between propositional, dispositional and procedural knowledge. Mason (2000) used the collective term *critical mediator of knowledge* for a teacher who applies a fine balance between these three types of knowledge.

The word mediator (when referring to a teacher) is sometimes used in the policy documents of the Department of Education, but is seen by many educationists as a synonym for facilitator. In this research report, the role of teacher will be seen as that of critical mediator of knowledge.

*The teacher and pedagogical content knowledge (PCK)*

A teacher should have a good in-depth knowledge of the *Science content* to be taught. This knowledge should stretch far beyond the knowledge found in school textbooks. A teacher should also have generic knowledge on general *pedagogic approaches* and which pedagogical methods are suitable for which topics. This will include understanding and anticipating misconceptions that learners might encounter on specific topics (Shulman, 1986; Van Rooyen & De Beer, et al., 2007). A third important aspect is knowledge of the *context* in which the knowledge is mediated (Grossman, 1990). Context will include knowledge of the school setting as well as the needs of the learners. This integrated scientific knowledge, pedagogical knowledge and context knowledge is known as pedagogical content knowledge or PCK (Van Rooyen & De Beer, et al., 2007).

The diagram below can be compared to the three primary colours of light: green, blue and red. When these three colours are projected and mixed on a screen, they form bright white light. In the same way, the *content knowledge, pedagogical knowledge and context knowledge* are the primary elements of a teacher’s pedagogical knowledge. When these three are mixed, they light up the lives of their learners.
Figure 2.6. Teacher pedagogical content knowledge (PCK)

Shulman (1986) introduced the term PCK in 1985 after research in America revealed that there was a poor correlation between learner needs, teaching methodology and the content to be taught. According to Shulman (1986:9), PCK includes:

“The most useful forms of representation of topics, the most powerful analogies, illustrations, examples and demonstrations – in a word the ways of representing and formulating the subject that make it comprehensible to others”.

_Pedagogical knowledge_ in this model is seen as knowledge concerning learning and learners, principles of instruction, classroom management, aims and purposes of education. Koehler and Mishra (2009) viewed this pedagogical knowledge as the knowledge that helps a teacher understand how students construct knowledge and acquire certain skills. In order to do this, a teacher should understand how learners apply cognitive, social and developmental theories of learning in the classroom.

_Content knowledge_ refers to the subject matter to be taught. In the context of this study it will refer to the Environmental Education concepts introduced during the SANBI programme, as well as the scientific knowledge to be taught as described in the CAPS. According to Shulman (1986), content knowledge should include knowledge of concepts, theories and ideas. It also includes established practices
and approaches toward developing such knowledge. If teachers do not have sufficient content knowledge, it results in learners developing misconceptions or receiving incorrect information (Koehler & Misha, 2009). Shulman (1986) stressed that understanding content is much more than just memorising the facts. It is about interpreting concepts, ideas and relationships in Science and the environment. The lack of content knowledge amongst many teachers results in poor understanding of concepts by learners.

**Knowledge of context** includes knowledge of the school setting, the culture of the school and individual learners. It also includes the social circumstances and abilities of the learner.

If the three have to be properly integrated and the nine basic requirements for teachers implementing the NCS have to be met, PCK is a very important aspect that has to be acquired by all teachers. Although PCK is such an important device for teachers to have, Loughran, Mulhall and Berry (2008) mentioned that there is very little literature on how teachers can develop and acquire PCK. These authors stated that PCK can be learnt through access to experienced teachers’ teaching. In this case, teachers would also acquire pedagogical content knowledge.

Loughran, Mulhall and Berry (2006) offered a way in which PCK is presented to student teachers in order to acquire PCK and reflect on their teaching practice. This method is known as the CoRes and PaP-eRs method. The method uses the concept of content representations (CoRes) and pedagogical and professional-experience repertoires (PaP-eRs) to address both the science content as well as specific ways to teach it. CoRes and PaP-eRs were developed by using a resource portfolio of expert science teachers’ PCK around a specific environmental topic. A CoRe focuses on a specific environmental topic and includes the main content ideas (‘big ideas’) to focus on possible misconceptions and areas that students will find difficult. It includes creative ways to determine if learners understand concepts and to scaffold their understanding. A PaP-eR
focuses on the *teaching and learning* aspect of the specific topic. The specific content will determine which pedagogical approach will be used. A PaP-eR helps to determine why the teacher follows a specific teaching method.

The student-teachers in Loughran, Mulhall and Berry’s (2008) study had to discuss and reflect on the CoRes and PaP-eRs found in the PCK portfolio of expert teachers given to them. They then had to choose a topic and develop their own examples. The CoRes and PaP-eRs approach gives teachers and student teachers the opportunity to reflect on how they understand the Science content knowledge to be taught, as well as how to apply these understandings in classroom practice. When the PaP-eRs and CoRes method was used in training student teachers, one of the results was that they developed the confidence to experiment with alternative teaching methods and ideas. It also helped students to shift from a teacher-centred to a student-centred teaching approach.

This method, as proposed by Loughran, Mulhall and Berry (2008), could be used as a framework in a community of practice to help teachers understand and apply PCK. The CoRes and PaP-eRs concept is a method that can help teachers to reflect on their own teaching practice, acquire the necessary PCK and develop as Environmental Education teachers when confronted with a new policy or curriculum. Loughran, *et al.* (2008) confirmed that the benefits of acquiring PCK leads to teachers being more “knowledgeable, flexible and capable.” Adopting PCK also allows a teacher to cater for the individual needs of each student. Without PCK, teachers are likely to focus on covering a certain amount of study material in a certain time (sticking to the pace setter) instead of focusing on deep conceptual understanding.

*The Science teacher as facilitator of scientific investigations.*

All three specific aims in the CAPS for Sciences imply that practical investigation be done, but specific aim two specifically focuses on explorative and investigative skills which are best developed within a context of experimental and data-handling skills. Teachers need to be well trained on how to conduct these
investigations and practicals with their students. They also need to be helped to develop skills for doing hands-on activities with their students; these activities need to be learner-centred and provide opportunities for learners to experience the external world and assimilate it into their internal world themselves. When teachers have little understanding of these activities, it limits the transfer of knowledge to learners.

The old Science syllabus (before CAPS) included laboratory work, but it was a very traditional (cookbook) approach. According to Hattingh, Aldous and Rogan (2007:75), students were provided with a hand-out containing the aim of the experiment and detailed instructions on how to execute the experiment. The learners were not required to plan, analyse or conduct the data evaluation of investigations. In the traditional approach, some of the cognitive work was done by the teacher and if they did not understand the aim of the experiment, they gained very little understanding. When a learner performs an experiment by following mere step-by-step instructions, he/she is cognitively very passive (Saunders, 1992:138).

Investigative Science – as implied by the CAPS – calls for an investigative or inquiry-based approach and places a strong emphasis on “doing Science” (Hattingh, Aldous & Rogan, 2007:75). When using this approach, the student is allowed to formulate his/her own expectation about observations and is also involved in planning the investigation. This involvement helps the student to understand the situation internally and the active cognitive involvement then helps the student to assimilate the external world (Saunders, 1992:139). This links to the first outcome in the CAPS which states that: “Learners act confidently on their curiosity about natural phenomena; they investigate relationships and solve problems in Science, technology and environment contexts” (Department of Education, 2002:7).

Hattingh, Aldous and Rogan (2007:75) summarised the three major ideas to be covered in the CAPS as follows:
Planning investigations;
Conducting investigations and collecting data;
Evaluating data and communicating findings.

For a Science teacher to accomplish the above-mentioned ideas, he/she has to be able to manage a Science laboratory. South Africa is a developing country and not all schools have a Science laboratory. Thus, a Science laboratory has to refer to laboratory in a broader sense for the purposes of this study and can include a normal Science classroom, a Science corner or even the schoolyard.

According to Van Rooyen & De Beer, et al. (2007), Gray (2008b), as well as Jones and Eick (2007), a Science teacher will need the following skills to manage a Science laboratory and facilitate scientific investigations effectively:

- Managing certain laboratory techniques and execute demonstrations
- Designing projects for students based on driving questions from the students
- Manage students when working in groups in the laboratory
- Management and control of chemical and physical stock
- Care, organisation and storage of materials
- Preparation of certain solutions
- Ordering scientific equipment and chemicals
- Applying safety rules
- Developing an appreciation for living organisms
- Recognise local resources to topics that they can use
- Be able to improvise and develop own materials if lack of resources appears (i.e. practising Science on a shoestring).
(b) The object – the professional development of the science teacher

Both Hardman (2008:72) and Engeström (1987:79) referred to the object in an activity system as the “raw material or problem space” at which the activity is directed. The object can be transformed into outcomes with the help of the other components of the activity system, namely the tools, rules, community and division of labour. The object in this study refers to the professional development of teachers through participating in a SANBI Teacher Professional Development Programme, to achieve the outcome, namely the successful integration of environmental aspects of the CAPS (by increased PCK development).

Whenever policy and curriculum changes are implemented, professional development of teachers is essential to ensure that effective teaching and learning takes place (Duschi, Shouse & Schweingruber, 2008). Taylor (2008) stated that the last 15 years demonstrated that it is very difficult to transform the schooling system, despite thorough structural change. He argued that the most important factor to improve the performance of schools is to foster a culture of professional responsibility across all levels. This can be done through focused professional development programmes. Taylor’s comments are in line with the
2007 McKinsey study that highlights that no schooling system can rise above the limits imposed by the quality of its teachers.

In terms of this study, the object is the professional (and PCK) development of teachers to incorporate environmental education in their teaching.

(c) Tools in the activity system

Tools in activity theory refer to all structures or pedagogies assisting the subject to achieve the object.

Outcomes-based education (OBE) as a tool

OBE strives to enable all learners to achieve to their maximum ability. It does this by setting outcomes to be achieved at the end of a process. OBE encourages a learner-centred and activity-based approach to education (Department of Education, 2002:1). Spady (1992) explained the outcomes as the actual demonstration of knowledge, competence and orientation.

Assessment is a very important component of OBE because it provides an indication of learner achievement. Assessment also helps students to make judgements about their own performance, set goals for progress and provoke further learning (Department of Education, 2002:10). In the OBE framework, teachers are seen as facilitators of learning in opposition to transmitters of knowledge as in the previous schooling system. According to Mason (2000:2), the emphasis in OBE is on procedural knowledge rather than propositional knowledge.

Implications of using the CAPS and OBE, and inquiry pedagogies, as tools of mediation

The tools of mediation have changed. Historically, teachers adopted a traditional teaching approach that was theoretical, exams-driven and content based. Many Science teachers were trained in using the old curriculum and the traditional way of teaching. Applying the "old tools", the subject acted as a transmitter of knowledge, exams were content-based and practical skills were required but not
examined. Very little or no practical work was done and learners were very passive in this teaching approach (Van Rooyen & De Beer, et al., 2007:19). When the Science teacher uses the new tools of mediation as stipulated in the CAPS, the implication is that the teacher's view of teaching also has to change. According to Van Rooyen and De Beer, et al. (2007:19), the nine basic requirements of implementing the CAPS for Science teachers are:

- Education should be outcomes-based
- Teachers should be facilitators of learning
- Learning should be learner-centred
- Learning should be activity-based
- The Science curriculum should be relevant
- Skills development should be a focal part of the curriculum
- Group work should be promoted
- Continuous assessment should be used to foster learning
- Learning should be integrated across learning areas/subjects.

All of the above requirements are incorporated by the inquiry-based learning (investigative Science) approach. The theoretical framework of inquiry-based learning finds its antecedents in the work of Vygotsky's (1978) learning theory. The core focus is that learning is based around students’ questions and also requires that students work together to solve problems instead of receiving direct instructions from the teacher on what to do (Kirschner, Sweller & Clark, 2006). Inquiry-based approaches to Science education are student-constructed as opposed to teacher-transmitted approaches of the traditional type. Science learning in this approach is not rote memorisation of information, but rather an acquisition of meaning, linking the student’s internal world (world of the mind) with empirical data in the external world (world of natural objects and phenomena). Restructuring then implies that learners experience a lot of sensory experience of what they have learnt from the outside world (Saunders, 1992:138-139). Inquiry learning could be seen as an example of problem-based learning, that could enhance self-directed learning (De Beer & Gravett, 2016). Problem-
based learning aims to assist students to (a) construct an extensive and flexible knowledge base, (b) become effective collaborators, (c) develop effective problem-solving skills, (d) become intrinsically motivated to learn, and (e) develop self-directed learning skills (Loyens et al, 2008).

Inquiry-based teaching can be done in different ways. The most learner-centred approach is known as *open-ended inquiry*. This type of inquiry requires that teacher-planned instruction is suspended and that learners explore content by themselves. This type of inquiry is very time-consuming. *Project-based inquiry* involves teachers designing projects based on questions from class discussions. This type of inquiry is more practical and effective as it focuses on specific content. Most curricula (like the CAPS) are also designed for project-based inquiry. *Guided inquiry* is more teacher-centred and the teacher decides on the questions that guide the concepts to be learnt (Jones & Eick, 2007:493-494). It is thus clear that the new curriculum also asks a new pedagogy (as a tool) from teachers. “Chalk and talk” transmission-mode pedagogies have to make way for inquiry-based, learner-centred approaches. The change of tools brings about many changes to be made with the result that it can bring about stress in the activity system.

**Language as a tool**

Language is an important tool, and in this study, two types of language are distinguished: English as the medium of instruction, and secondly science as an abstract language (with terminology often unknown to learners). English is the language used in prescribed textbooks and the language most teachers use when asking questions, explaining concepts and in assessment tasks. Hardman (2008:72) referred to the use of language as a linguistic tool. Using English as a tool can pose problems as many of the learners in South African schools use English as a second language and are not always proficient in English (Paxton, 2009:345). Despite the problems, teachers’ experience with these two types of languages is an important tool of mediation in implementing the CAPS.
(d) The rules as applicable in this activity system

![Diagram of activity system]

**Figure 2.8 Rules in the activity system**

The rules refer to the guidelines of the CAPS, rules of the SANBI Teacher Professional Development Programme, but also the rules of the school in which they operate. This will include the norms, values and social interactions around the school and in the classroom. The norms and values will include cultural norms and values as well as beliefs and traditional values that exist in the school. Rules refer to the school rules in relation to how a staff member should behave, but also how students should behave. Rules can also include rules of social order governing communication between teachers and management (Hardman, 2008).

In order for transfer to take place in the classroom, one would expect a classroom climate conducive for learning. Part of this research, is to establish whether such learning climates are produced.
(e) The community in which the teacher operates

**Figure 2.9: The community in CHAT**

The community refers to the school community in which the teachers work and ecology of practice, i.e. the SANBI programme, where teachers from different schools meet at the Walter Sisulu Botanical Gardens, to engage in curriculum activities. The school community includes the symbiosis between teachers, school management, learners and parents. The cluster as ecology of practice includes teachers from schools in a specific district as well as the subject facilitator (advisor). When referring to a ‘community of practice’ in this study, it includes the ecology of practice as found in the cluster meetings.

Cluster meetings were introduced by the Department of Education to assist teachers with the implementation of the new curriculum. A few schools in a certain district meet at least twice a term to discuss common problems and issues. The teachers of each learning area have their own cluster meeting. The district co-coordinators appoint cluster leaders based on certain criteria. A cluster leader is usually a senior teacher with at least 5 years’ experience and a good track record with regard to the pass rate of learners. The cluster leaders form an
important link between the head office/districts and schools as well as between schools. Moderation of learners’ portfolios, exam papers and other assessment tasks are also done at cluster meetings (Gauteng Department of Education, 2003).

(f) Division of labour as applicable in this activity system

![Diagram of division of labour in CHAT]

**Figure 2.10: Division of labour in CHAT**

Teachers may experience conflict as they are drawn away from what they regard as the most important part of their profession, namely interaction with their students (Day, *et al.*, 2005). Day, *et al.* (2005) mentioned that despite the increased burden of extra responsibility due to policy changes, many teachers stay committed to their profession. Woods (1981) found that the key to teachers’ commitment was a sense of identity. Some teachers may experience a sense of satisfaction and pride while taking up the new responsibilities, while other teachers find it too hard to cope with, feeling that teaching takes over their lives (Day, *et al.*, 2005). Teacher commitment and identity are all about motivation, self-esteem, values and self-actualisation.
In this study I will shed light on the different roles of the teacher, namely (a) the teacher as a mediator of learning, (b) the teacher as a life-long learner, and (c) the teacher as an agent of change. It is hoped that the SANBI programme would contribute to teachers growing in all three these aspects.

2.3.4 Rogan’s construct of the Zone of Feasible Innovation

I will first discuss Rogan and Grayson’s theory of curriculum implementation, and will then provide detail on their profile of implementation, and how it is applicable to this study. As mentioned earlier, the construct of the Zone of Feasible Innovation builds on the Vygotskian concept of the Zone of Proximal Development.

2.3.4.1 Rogan and Grayson’s theory of curriculum implementation

Rogan and Grayson built on the work of Vygotsky, and their notion of the Zone of Feasible Innovation can be traced back to the Zone of Proximal Development. Osaki, Hosea and Ottevanger (2004) were of the opinion that professional development of teachers cannot be implemented in isolation. They stated that the purpose of the professional development as well as the context of the school in which it will be implemented should be considered.

When considering the context of a school, Rogan and Grayson (2003) contended that schools in South Africa differ enormously. Some schools have beautiful buildings and excellent resources that can compete with the best in the world, while others have dilapidated mud buildings with broken or no windows, no water or electricity and few or no resources. In order to implement the CAPS, all schools ideally should be well-resourced and consist of small classes.

Another problem is the “enormous range in the knowledge and skills of the teachers. The problem is particularly acute when it comes to Mathematics and Science teachers” (Rogan & Grayson, 2003:1174). Rogan and Grayson (2003) argued that some schools in South Africa are so dysfunctional that they may need the help of external consultants, professionals or agencies to get the
process of professional development started. As these schools develop, the external help must be adjusted accordingly. The SANBI Teacher Professional Development Programme has been developed with this background in mind. SANBI over the years has been working with teachers from disadvantaged schools to address this gap.

Rogan and Grayson (2003) emphasised that issuing the decree on an educational policy like the CAPS is an event, but the process of change is context-specific and the outcome will differ from school to school. Due to the large diversity of schools, pupils and teachers in developing countries like South Africa, Rogan and Grayson (2003:1173) suggested the following during implementation and professional development:

- Implementation of the new curriculum cannot be done in one huge step, but should rather consist of a *series of smaller steps*. This corresponds with Hoban’s theory
- The *context of the particular school* must be taken into account – i.e. the teachers, pupils, leadership and environment
- The *level of the teachers’* subject knowledge and teaching experience must be considered

In order to implement these, Rogan and Grayson (2003) developed a *theory of implementation* which identifies the strengths of a school. Progress is then made in steps by building on these strengths. This theory is focused on Science education, but can easily be adapted for any learning area. The model of professional development suggested by Rogan and Grayson (2003) is based on three main constructs, namely:

- Profile of implementation
- Capacity to support innovation and
- Support from outside agencies.
A framework for this model is depicted in figure 2.11, and its three main constructs are briefly discussed below:

Figure 2.11: Rogan and Grayson's framework for implementation model
Source: Rogan (2007b:99)

2.3.4.2 Profile of implementation

The profile of implementation is about how the new curriculum or policy is put into practice. It will also include the values and expected outcomes from learners. It is not an all-or-nothing approach, but the implementation of a new curriculum or
policy is done in different steps or degrees. With such a profile, the implementation of a new curriculum like the CAPS becomes a long-term process and not a quick fix.

The profile of implementation is explained with the aid of Table 2.2. It focuses on four areas, namely: the teaching and learning aspect (what teachers and learners do), the Science practical work, the role of Science in community, and assessment practices. These four areas form the column headings of Table 2.2. Rogan and Grayson identified four different levels of progress for each of these areas (first column of Table 2.2). The levels develop from teacher-centred practices (as in the old curriculum) to more learner-centred practices (as required by the CAPS). Rogan and Grayson (2004:317) argued that there is no progress from the lower to the higher levels, but the lower levels are included in the higher levels.

Once the current level of the teacher is determined, a plan of action can be constructed by the school management team of how the teacher can reach the required level. The teacher now has a goal to work towards. This plan will include small steps phased in over a number of years. The context and capacity of the school will also be taken into consideration. Rogan (2007:114) suggested that subject advisors in cluster groups or agents form other outside support organisations can apply the same strategy. Rogan and Grayson (2003:1183-1185), and Petersen (2010:117) outlined the profile of implementation as illustrated in Table 1. It is adapted to fit the requirements of the CAPS:
Table 2.2: Profile for implementation (Source: Rogan & Grayson, 2003:1185)

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>CLASSROOM PRACTICE</th>
<th>SCIENCE PRACTICAL WORK</th>
<th>SCIENCE IN SOCIETY</th>
<th>ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
</tr>
<tr>
<td></td>
<td>• Presents content using chalk and talk method</td>
<td>• Does no practical work</td>
<td>• Uses examples and application of science in everyday life very seldom</td>
<td>• Uses written tests</td>
</tr>
<tr>
<td></td>
<td>• Has a lesson plan</td>
<td>• Some teachers use poorly planned demonstrations or group work</td>
<td>• Most recall type questions</td>
<td>• Mostly recall type questions</td>
</tr>
<tr>
<td></td>
<td>• Lesson not well organised</td>
<td>• Uses no local specimens</td>
<td>• Tests marked and sometimes discussed with learners</td>
<td>• Tests marked and sometimes discussed with learners</td>
</tr>
<tr>
<td></td>
<td>• Textbook bound – sometimes reading from textbook as lesson presentation</td>
<td>• Uses models or visual media to substitute practical work</td>
<td></td>
<td>Learners:</td>
</tr>
<tr>
<td></td>
<td>• No use of other media – blackboard only resource</td>
<td></td>
<td></td>
<td>• Write test</td>
</tr>
<tr>
<td></td>
<td>• Learner engagement mainly by means of questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learners:</td>
<td>Learners:</td>
<td>Learners:</td>
<td>Learners:</td>
</tr>
<tr>
<td></td>
<td>• Passive, inattentive and busy with own things. Some learners follow in textbook</td>
<td>• Learners observe but not very attentive.</td>
<td>• Ask questions concerning science in everyday life</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
</tr>
<tr>
<td></td>
<td>• Presents content in a well organised way</td>
<td>• Uses demonstration to develop concepts</td>
<td>• Uses examples and applications from everyday life – apply to Science content</td>
<td>• Uses written tests</td>
</tr>
<tr>
<td></td>
<td>• Has a lesson plan</td>
<td>• Uses specimens found in local environment for illustration</td>
<td></td>
<td>• Mostly recall type questions</td>
</tr>
<tr>
<td></td>
<td>• Provides adequate notes</td>
<td></td>
<td>• Some questions are higher order thinking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Uses textbook effectively</td>
<td></td>
<td>• Tests marked and returned promptly</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Engages learners with questions</td>
<td>Learners:</td>
<td>Learners:</td>
<td>Learners:</td>
</tr>
<tr>
<td></td>
<td>Stay attentive and engaged</td>
<td>Learners observe</td>
<td>Stay attentive and engaged</td>
<td>Mostly apply rote learning</td>
</tr>
<tr>
<td></td>
<td>Respond to and ask questions</td>
<td>Ask and answer questions</td>
<td>Ask and answer questions</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
</tr>
<tr>
<td></td>
<td>Textbooks used in conjunction with other resources</td>
<td>Uses demonstration to promote a limited form of inquiry</td>
<td>Uses specific problem or issue faced by local community</td>
<td>Uses written tests</td>
</tr>
<tr>
<td></td>
<td>Engages learners with questions to encourage in depth thinking</td>
<td>Learners assist in planning and performing demonstration</td>
<td>Learners assist learners to explore the explanations of scientific phenomena by different cultural groups</td>
<td>50% of questions require higher order thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learners participate in cookbook practical work</td>
<td></td>
<td>Some of the questions are based on practical work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learners communicate data using graphs and tables</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learners:</td>
<td>Learners:</td>
<td>Learners:</td>
<td>Learners:</td>
</tr>
<tr>
<td></td>
<td>Use additional resources to compile own notes</td>
<td>Some learners assist in planning and performing demonstration</td>
<td>Teacher assists learners to explore the explanations of scientific phenomena by different cultural groups</td>
<td>Apply practical knowledge</td>
</tr>
<tr>
<td></td>
<td>Engage in meaningful group work</td>
<td>Learners participate in cookbook practical work</td>
<td></td>
<td>Apply higher order thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learners communicate data using graphs and tables</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ask and answer questions</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
<td>Teacher:</td>
</tr>
<tr>
<td></td>
<td>Probes learners’ prior knowledge</td>
<td>Designs practical work to encourage learner discovery of information</td>
<td>Teacher facilitates investigation</td>
<td>Uses written tests</td>
</tr>
<tr>
<td></td>
<td>Structures learning activities on relevant knowledge and</td>
<td></td>
<td></td>
<td>Tests include seen or unseen guided discovery type activities</td>
</tr>
<tr>
<td><strong>problem solving techniques</strong></td>
<td><strong>Learners:</strong></td>
<td><strong>Learners:</strong></td>
<td><strong>Learners:</strong></td>
<td><strong>Learners:</strong></td>
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<td>-------------------------------</td>
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<tr>
<td>Introduces learners to the evolving nature of scientific knowledge</td>
<td>Engage in minds-on learning activities</td>
<td>Perform guided discovery type practical work in small groups – hands on</td>
<td>Learners actively investigates science application in own environment</td>
<td>Apply practical knowledge</td>
</tr>
<tr>
<td></td>
<td>Make own notes on the concepts learned from doing these activities</td>
<td>Write a scientific report</td>
<td>Gathers data e.g. surveys</td>
<td>Apply higher order thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can justify conclusions in terms of data collected</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learners:</strong></td>
<td><strong>Teacher:</strong></td>
<td><strong>Teacher:</strong></td>
<td><strong>Teacher:</strong></td>
<td><strong>Teacher:</strong></td>
</tr>
<tr>
<td></td>
<td>Facilitates learners as they design and undertake long term investigations and projects</td>
<td>Facilitates learners with design and data collection strategies</td>
<td>Facilitates learners on data interpretation and conclusions</td>
<td>Creates opportunity for different types of assessment</td>
</tr>
<tr>
<td></td>
<td>Assist learners to weigh theories that attempt to explain the same phenomena</td>
<td>Facilitates learners with the community project and identifying the need</td>
<td></td>
<td>Facilitates in compilation of portfolio</td>
</tr>
<tr>
<td></td>
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<tr>
<td><strong>Learners:</strong></td>
<td><strong>Learners:</strong></td>
<td><strong>Learners:</strong></td>
<td><strong>Learners:</strong></td>
<td><strong>Learner:</strong></td>
</tr>
<tr>
<td></td>
<td>Take major responsibility for own learning; partake in planning and assessment of own learning</td>
<td>Design and do own open investigations</td>
<td>Undertake long term community-based investigation</td>
<td>Includes open investigation of community project in assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reflect on design and collected data</td>
<td>Apply science to specific need in community</td>
<td>Create portfolio to present best work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interpret data</td>
<td></td>
<td></td>
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</tbody>
</table>
There is a gap between the current level where the teacher is and the higher level that the teacher strives towards or has the potential to reach. Vygotsky (1978) called this gap the zone of proximal development (ZPD). Vygotsky suggested that learning only takes place when instruction proceeds just ahead of the learner's current level of development. Rogan and Aldous (2004: 160) referred to this gap as the zone of feasible innovation (ZFI) in analogy to Vygotsky’s ZPD. Rogan and Aldous argued that during curriculum implementation, strategies will be effective if they proceed within the ZFI, i.e. just ahead of the level where the teacher currently is (Rogan & Aldous, 2004:160). Rogan and Aldous argued that, to be effective in the planning of new curriculum or policy implementation strategies, both the current level of the teaching and learning environment as well as the current capacity to support innovation should be taken into account.

2.3.4.3 Capacity to support innovation

The capacity to implement new policy differs from school to school. Jansen (1999) stated that well-resourced schools will benefit more from the NCS than underprivileged schools. According to Rogan and Grayson (2003), capacity to support can be divided into four groups: physical resources, teacher factors, learner factors and school ecology and management.

2.3.4.4 Physical resources

Physical resources in South Africa are a real problem as many schools do not have the necessary infrastructure or even basic things like electricity. Many schools have a lack of basic Science equipment (Muwanga-Zaka, 2001 & Rollnick, 2007). According to Rogan and Grayson (2003), poor resources and infrastructure can prevent even good teachers from performing well.

2.3.4.5 Teacher factors

In South Africa, many teachers lack the necessary motivation (Taylor, 2008b), teaching practice (Horak & Fricke, 2004), skills and content knowledge (Gouws &
Dicker, 2007; Kriek, 2005). A teacher’s attitude, commitment, confidence and willingness are very important when innovation is introduced (Rogan & Grayson, 2003).

2.3.4.6 Learner factors

There are many factors that can contribute to poor implementation. These include poverty and HIV/Aids, huge problems in South Africa. Learners may come from backgrounds where they have no support, books or a place to study. Many learners in South Africa come from child-headed families. Another major challenge in South Africa is that the language of instruction is mainly English which is not the home language of many learners.

According to Rogan (2004), the profile of implementation, that is, the extent to which the ideals of a curriculum are implemented, determines the competence or quality of the professionals graduating through such programmes. He argued that an effective professional development programme must take cognisance of the level of current classroom interaction and the current capacity of the teacher to support innovation. Innovation refers to the change occasioned by the capacity of a teacher, which is achieved by the educator’s experience, creativity, knowledge, skills and associated attributes (ibid). Drawing from Vygotsky’s notion of “Zones of Proximal Development”, he proposed the concept of the “Zones of Feasible Innovation” or ZFI (Rogan, 2004: 160). His proposition was that there could be a co-relation between the profile of implementation of a professional programme for teachers and the capacity to support it. Capacity, in his view, depends on the role of a teacher in implementing the curriculum. The implication is that Professional Development Programmes may not be viewed as good or bad, but rather in terms of varying degrees of appropriateness. His profile of implementation has four stages as listed in the table below:
Table 2.3: Levels of Professional Development Programmes (Rogan, 2004: 164).

<table>
<thead>
<tr>
<th>Level</th>
<th>Design of Professional Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Information on policy and expected changes are presented to school-based personnel. Typical mode is short, one shot workshops.</td>
</tr>
<tr>
<td>2.</td>
<td>Examples of 'new' practices as suggested by the policies are presented to school-based personnel, who are given an opportunity to engage in these practices in a simulated situation. Typical mode is a series of short workshops lasting for one year.</td>
</tr>
<tr>
<td>3.</td>
<td>Professional development is designed by school-based personnel depending on which new practices they wish to implement, and implemented using both inside and outside support. Typical mode consists of both external and school-based INSET for two to three years.</td>
</tr>
<tr>
<td>4.</td>
<td>Communities of practice take full responsibility for their own continued professional growth, and for school governance and curriculum implementation, calling on outside support as appropriate. Typical mode consists of ongoing school-based and directed professional INSET.</td>
</tr>
</tbody>
</table>

Warford (2011) further refined the Vygotskian concept of 'Zone of Proximal Development' (ZPD), and talked of the Zone of Proximal Teacher Development (ZPTD). Warford argued that the ZPTD sees teaching and learning as a holistic and authentic approach.

2.3.5 Warford’s construct of the Zone of Proximal Teacher Development (ZPTD)

Warford (2011), also building on the Vygotskyan construct of the zone of proximal development, coined the term zone of proximal teacher development (ZPTD). Warford states that the ZPTD represents the distance between what teachers can do on their own without assistance, and a proximal level they might attain through structured mediated assistance from more capable others (2011:253), and, in the context of this study, through the SANBI intervention and scaffolding within a resulting community of practice. Warford suggested a number of stages for this scaffolding within the ZPD:
Phase 1: Teachers are required to reflect on prior experiences and assumptions – in this case about incorporating Environmental Education principles in their teaching.

Phase 2: The next phase is the expert-other assistance. This SANBI programme follows the Japanese lesson study model, and teachers plan lessons in small groups. The researcher shares the view of Van Lier (2004) that in an expanded ZPTD, scaffolding happens on four levels:

- Inner resources (resourcefulness, self-access)
- Interaction with less capable peers (“we learn by teaching”)
- Assistance from more capable peers (scaffolding; mediation)
- Interaction with equal peers (If one member of a dyad undergoes developmental change, the other is also likely to do so).

Phase 3: The third phase is that of internalisation. Teachers need to individually reflect on their professional growth. Through critical reflection and journaling, the teachers start to develop an own footing and voice regarding environmental education, and incorporating EE principles in their teaching.

Phase 4: Warford also distinguished a fourth stage – the recursion or de-automatisation phase. This can be described as the ‘theory into practice’ stage, as the teachers have to teach what they experienced during the programme (Warford, 2011:255). A Vygotskian approach values conflict as a catalyst for developmental change. Teachers had to accommodate new concepts in their conceptual understanding, and this equilibration might entail discomfort and stress.

2.3.6 Scaffolding teacher professional development within communities of practice

2.3.6.1 The learning community

A learning community can be defined as a community of learners who decide to come together for the purpose of learning jointly; and in the process learning from
each other. Lave and Wenger (1991) introduced the idea that situated learning can take place whilst being part of a community. This model proposes that learning takes place within a so called ‘community of practice’. Wenger (2006:1) defined a community of practice as a group of people who share a concern or passion for something they do and learn how to do it better through regular interaction. In this case, SANBI teachers can be referred to as communities of practice as they share the passion for professional development. The SANBI programme can be referred to as ecology of practice and the SANBI teachers, in their individual schools can be classified as communities of practice if they meet the following requirements as defined by Wenger (2006:1):

(i) **A domain**: Members should have a shared domain of interest and to be become a member of the community of practice, members should be committed to the domain.

(ii) **A community**: Members must interact, share information and learn together. Members should engage in joint activities, have discussions, help each other and share information.

(iii) **A practice**: Members of the community are practitioners and must develop a shared repertoire of resources and ideas. To develop this takes time and sustained interaction. In the SANBI programme, this is done through planned workshops, group work during workshops and teachers trying out new activities in their schools with the help of their colleagues. SANBI teachers are professionals who used the SANBI Teacher Professional Development workshops as a platform to develop a shared vision and common goals.

The learning community involves implementing meaningful and stimulating processes that take into account the individual and collective needs and interests of the participants and that are adapted to the characteristics of each specific context (Sauve & Orellana, 2004). This approach promotes the development of a capacity for critical reflection and leads to a new reading of reality in all its complexity in order to rethink ways of being and acting.
The learning community is an appropriate pedagogical strategy in any situation in which people want to learn together in order to carry out a common project that aims at transforming realities they want to change (Sauve & Orellana, 2004). Because it leads to dialogue and involvement among various parties who are attempting to address socio-environmental issues in their living space, the learning community provides a context within which to educate towards a culture of peace and environmental responsibility. Wals and Heymann (2004) asserted that social learning, understood as a collaborative reframing process involving multiple interest groups or stakeholders, is located in the multitude of actions, experiences, interactions and social situations of everyday life. However, Wood (2007: 701) contended that there is a need to replace current traditional professional development approaches, which usually seat expertise outside the teaching field itself, with a learning community structure designed to foreground, critique, build and enhance practitioner expertise. This approach argues that learning communities create space for teachers to learn from one another without having to rely on experts from outside. Bertram argued that the literature advocating teacher learning in communities of practice and within their own school context emerges from industrialised countries such as United States and United Kingdom. He further argued that there are South African examples of programmes often linked to universities which have been located within situate perspective of teacher learning and which focus on creating teacher communities of practice (Graven, 2002; Maistry, 2008). Both studies suggested that it is important that there should be an expert to lead the community initially, which the Wenger model does not include. Instead of encouraging teachers to depend solely on external expertise to improve their practices, the learning-communities approach seeks to imbue in teachers a sense of efficacy and to seat professional expertise, responsibility and judgment in communities of reflection, critique and inquiry (Harding, 1991 cited in Wood, 2007). Professional development should therefore not be approached as an opportunity to master technical skills, but rather as an attempt to encourage participation of teachers to engage in a dialogue about systematic strategies that they could use to empower themselves
and also to collectively build their own knowledge. This calls on teachers to take responsibility for their professional development. This resonates with the view that “the best teacher for other teachers is another teacher”. A learning-communities approach ensures that teachers accept responsibility for growing in expertise so that they could effectively respond to the student needs.

The idea of learning communities is often built on the assumption that teachers working in professional learning communities who share expertise are more likely to improve student learning than teachers working alone (Wood, 2007). Built into this notion is the idea that practitioner expertise and collaboration matter, and that school cultures need to be re-imagined and re-configured so that both can flourish (Wood, 2007). The idea of learning communities also ensures that teachers do not work in isolation, making teachers’ work more visible and public. Wenger (1998) pointed out that for the professional community to be strong, it must push the work of improving classroom practice and student learning forward; and for the work to progress, the community must bond around common commitments, values and achievements.

2.3.6.2 Defining a community of practice

Humans are by nature social beings and interaction and connection with each other are natural results when people come together. However, merely being together does not make people a community. Lee and Newby (1983:57) explained that the nature of the relationships between people and the social networks in which they operate are aspects that will turn such interaction into a community. Cohen (1985:118) stated that:

“People construct community symbolically, making it a resource and repository of meaning and a referent of their identity”.

Teachers participating in SANBI Teacher Professional Development have the potential to become a community of practice as they share the domain of professional development, as a community they can engage in professional development activities, share best practices and resources or ideas. It is
important to note that every member of the community knows everything about professional development. They should also know something about professional development.

2.3.6.3 Advantages of a community of practice

To be able to learn, a person has to actively participate in a community. Learning in a community of practice is not so much about acquiring knowledge from other members as a process of social participation (Smith, 2003). Lave and Wenger (1991) used the term ‘legitimate peripheral participation’ (LPP) when referring to people standing on the outside of the community of practice. According to them, people start to learn once they are accepted by the group and become an insider in the specific community of practice. Hodges (1998) used the term ‘marginalisation from a community of practice’ when referring to members of the community not involved in the production of the practices.

Some authors (Jarzabkowski, 2002; Wenger & Snyder, 2000) suggested that communities of practice can be important tools for any organisation as they can help drive strategy, solve problems quickly, transfer best practices and develop professional skills. Communities of practice can be very effective in fostering professional development and are valuable tools for the professional development of Science teachers in a school. Such communities can be very useful in helping teachers to acquire PCK. Social interaction between teachers in schools can improve the quality of teaching and learning and also the emotional health of the teachers. It can reduce emotional stress and burnout. Communities of practice can add value to organisations by helping drive strategy, start new initiatives (like the implementation the CAPS), solve problems, transfer best practices (PCK in this case), develop professional skills and help recruit and retain talented individuals. All of these attributes can be very helpful in a school situation.

White (2012) has shown that communities of practice provide a social setting wherein learning can take place, and in which specific developmental needs of
individual teachers can be addressed. She also highlights the crucial role played by the keystone species within such a community of practice.

2.3.6.4 Keystone species

Davic (2003, p.2) provides the following definition of a keystone species:

“...a strongly interacting species whose top-down effect on species diversity and competition is largely relative to its biomass dominance within a functional group.”

This operational definition links the community importance of a keystone species to a specific ecosystem process. If one would use this concept in an educational setting, a keystone species would refer to teachers who can support their peers and share good practices, especially those who are enthusiastic to adopt changes in their practice but need some support in doing so (White, 2012).

2.3.6.5 Sustainability of a community of practice

Wenger (1998:6) emphasised that despite communities of practice arising naturally, it is important for an organisation to develop and nurture such communities. To be effective, this assistance must work from the inside rather than to manipulate it from the outside. Jarzabkowski (2002) identified the importance of creating a variety of opportunities for teachers to come together in an informal matter in order for community building to take place. In her research, she found that when staff members are given the opportunity to come together in an informal manner, community building takes place. These informal gatherings include interaction in the staffroom before and after school and during lunch breaks. Social rituals such as celebration of birthdays, Friday afternoon drinks and social outings also play an important role in developing a sense of community and enhancing stronger collaboration in the work place.

Community building cannot develop overnight and it requires the support of school management and the body of teachers. Wenger and Snyder (2000) compared the cultivation of communities of practice with a garden that needs
attention. A garden that is watered, weeded and nourished regularly will flourish and bring about new growth. In the same way, communities of practice need to be nurtured by leadership. The leadership should identify potential communities of practice, provide the infrastructure and support such communities, and assess the value of the communities of practice.

2.3.6.6 Potential problems in communities of practice

Whitelaw, De Beer and Henning (2008:36) found what they call a *pseudo-community of practice* in a school where they conducted research. In the specific community of practice, they observed that there was no opportunity for open discussion, reflection and learning as the members of the community were merely “playing” community. Lave and Wenger’s theory of LPP can also become a problem if certain staff members stay on the outside boundary of the community of practice, or when they are marginalised. These teachers will not have the opportunity to learn from and share with their colleagues. In this study, the researcher will flag tensions within the activity system (amongst the various role players in the community) that may result in such a “pseudo-community”.

The professional development of teachers can be assisted by communities of practice and especially PCK can be acquired by teachers in this way. The problem might be that in many schools such communities do not exist or do not function as such because they are not nurtured or recognised as important by school managers.

2.3.7 Japanese lesson study, and implications for teacher professional development

In the SANBI training aspects of the Japanese Lesson Study was used. In this section I provide an overview on lesson study, and how it is applicable to this study.
2.3.7.1 The Japanese Lesson Study: An overview

Lesson study has been practised in Japan for a long time. This form of teacher professional development evoked the interest of many researchers in the US. Ono and Ferreira (2010) defined the lesson study as a type of classroom research in which a few teachers investigate teaching and learning in the context of a single class lesson. When the teachers complete the study, they document their work in a report that describes the lesson they designed, explains how the lesson worked and what they learnt about teaching and learning from the lesson study experience.

The most noticeable feature of the lesson study is that teachers are jointly involved in an action research. The Japanese curriculum sets up the curriculum guidelines, which form the foundation of writing textbooks. The most noticeable contribution of this approach is that teachers get an opportunity to contribute to textbook writing and this bridges any possible gap between the course of study as intended by the curriculum and the actual lessons as interpreted and implemented. Lesson study became popular in Japan in the 1960s, according to Ono and Ferreira (2010); the origin of the lesson study was the Tokyo Normal School and its attached school, both of which were established in the early 1870s. The authors argued that a school lab was used for student teaching as well as for studying and experimenting with new teaching methods. Teachers in this school produced reference materials to disseminate these new methods, which were originally introduced from the USA. Baba and Kojima (2004), Hashimoto et al. (2003) argued that these methods were subsequently introduced to ordinary classrooms via a normal school.

Almost all Japanese schools earmark a school-based professional development period within regular working hours during which various issues and challenges are discussed by teachers and administrators. A priority in school-based professional development has been the improvement of the quality of lessons. The workshops or conferences are held in districts and municipalities on a
regular basis and newly appointed teachers are observed regularly by the assigned mentors.

Japanese lesson study is divided into three sections:
1. Plan;
2. do and
3. see.

The planning phase begins with the selection of the topic and involves the study of the teaching materials and mapping out lesson plans. The process of lesson study is initiated by setting a goal. The teachers will work together towards achieving the particular goal. Teachers jointly study the teaching materials; this helps teachers to clarify certain points. This also helps teachers strengthen their content knowledge of the subject. Mapping out lesson plans requires teachers to have a good understanding of their learners’ needs, pre-knowledge and misconceptions. Teachers are encouraged to anticipate the challenges learners may encounter in the lessons and be prepared with appropriate strategies to assist them.

After the planning phase, a teacher conducts the study lesson based on the plan. A lesson plan is usually photocopied and distributed to each observer. A number of colleagues get assigned to observe the lessons. The number of observers is usually smaller (Ono & Ferreira, 2010). These observation sessions are usually also attended by experts and curriculum advisers. In each case, the observers will carefully watch what the teacher and learners do. The observers listen attentively to all contributions made by learners and make a note on the lesson plan; they also look at the behaviour of the teachers and learners in relation to the achievement of the lesson outcomes. The observational notes on a lesson plan serve as evidence for later discussions in a post-lesson conference.

After the lesson, all the participants meet to discuss various aspects of the lesson. The presenting teacher is expected to lead the discussions; all observers
are expected to contribute in refining the lesson, they recognise the strengths and they also point out challenges. Observers are always encouraged to come up with suggestions and alternatives.

Lesson study has been credited with much success in Japanese schools. It is mostly characterised by the fact that it is classroom situated, context based, learner focused, improvement oriented and teacher owned.

### 2.3.7.2 The Mpumalanga Secondary Science initiative (lesson study 1999-2006)

The dawning of C2005 and subsequent CAPS in 2010 challenged many South African teachers’ content knowledge of the subjects they had been teaching. Researchers observed that teachers’ content knowledge was not adequate. The case was more serious with Maths and Science, due to inadequate training of the older teachers in the previous political dispensation. This shortcoming resulted in fewer teachers qualifying to teach Maths, Science and Technology. This in turn led to poor quality of teaching in rural and poorer area schools. In response to a request for assistance by former President Nelson Mandela, the Japan-International Cooperation Agency conducted studies for project formulation, which led to the official inception of the Mpumalanga Secondary School Initiative (MSSI) in 1999.

This initiative saw the Mpumalanga Department of Education, Japanese International Cooperation Agency (JICA) and University of Pretoria participating in an MSSI project as equal partners. It was agreed that the three entities would mobilise their own resources to implement this programme. The project included establishing a school-based in-service system in the Mpumalanga province to improve the quality of teaching in Mathematics and Science in the province by enhancing teachers’ skills and subject knowledge. Although this was not mentioned in the project documents, it aimed at institutionalising lesson study,
the form of school-based continuing professional development commonly practiced in Japanese schools (Ono & Ferreira, 2010).

MSSI was implemented in two phases. Phase 1 (1999-2003) adopted a staggered implementation. Four districts closest to Tshwane joined the MSSI in the first year; four more districts in the following year; and the remaining two districts joined in the third year. One curriculum implementer was involved for each subject in each district; consequently, a total of 20 covering both the general (GET) and Further Education and Training (FET) phases. The intention was to involve 540 schools with Grade 8 and 9 in the 10 districts. 313 Schools were involved by the end of 2002.

In phases 1 and 2, curriculum implementers assumed the role of key players. The CIs were subject advisors appointed by MDOE. The CIs were sent to Japan to study content and to prepare materials for three MSSI workshops scheduled for the following year. The partnership approach was realised in two phases. The MDOE was expected to take the initiative in the planning, implementation and monitoring of the training workshops in the province at three different levels (Ono & Ferreira, 2010).

JICA, supported by Hiroshima University and Naruto University of Education provided CIs and cluster leaders with the opportunity to get involved in study-cum-training in Japan and with technical support to lead the workshops on their return. The University of Pretoria assumed the role of an interpreter of the Japanese subject and educational expertise in the of C2005 and the provision of a certification process for training opportunities that could be accredited as recognised annual training hours or towards an optional further diploma (MDOE, UP & JICA, 2006:42)

Mokhele and Jita (2010:1762) reflect on the outcomes of the MSSI intervention by stating that “…the more there is alignment between the personal circumstances and motivations of the teachers and the CPD intervention, the
more likely it is that the outcomes will be meaningful for the participating teachers”. This is therefore an important element that SANBI should consider in its professional development programme.

2.3.8 Hoban’s systematic approach to teacher professional development

Hoban (2002) suggested a systematic approach of professional development. During the 1960s and 1970s, many educational innovations in countries like the USA, the United Kingdom and Australia were presented to teachers using a top-down or workshop model. Teaching material was delivered to schools, in-service workshops were offered and it was perceived that educational change would be a natural consequence of this action. This linear process of educational change can be explained by the following diagram (Hoban, 2002:13). However, Garret and Colleagues (Fullan, 2012) found some evidence that teachers retained knowledge from professional development experience, but they also discovered that this knowledge did not result in change in practice and that consequently there was no impact on student achievement. After two years, even the knowledge that teachers had initially acquired no longer remained. According to Garret and Colleagues, this could be interpreted to mean that professional development is simply a wasted investment that could justifiably be cut when resources are scarce. Yet professional development has little or no impact when it relies on “individual learning” and does not focus on follow-through support for teams of teachers to learn together. They further argued that not all, or even most professional development, until now has been good professional development.

These authors argued that what is crucial is what happens between workshops: “Who tries things out? Who supports you? Who gives you feedback? Who picks you up when you make a mistake the first time? Who else can you learn from? How can you take responsibility for change together?” They believed the key variable that determines success in any innovation is the degree of social capital.
in the culture of one’s own school. They argued that learning is the work and social capital is the fuel. If social capital is weak, everything else is destined for failure.

Hargreaves & Fullan (2012) defined social capital as referring to the quantity and quality of social interactions and social relationships among people, as this affects their access to knowledge and information, their sense of expectations, obligation and trusts and how far they are likely to adhere to the same norms or codes of behaviour. Social capital increases knowledge, it gives one access to other people’s human capital. It expands one’s network of influence, gives one resilience when one knows that there are people to go to, who can give advice. Therefore, success of professional development has more to do with not just interaction with other teachers, but more with the quality of those interactions.

Figure 2.12: A top-down approach to professional development
Source: Hoban, 2002:13

According to Hoban (2002:13), the major pitfall of a linear process was that although teachers learn in this approach, they stay in their zone of comfort and see the innovations as new ideas that they can fit into their existing practice. This type of approach promotes a sense of control over teachers. These teachers seldom think outside the box. However, there are some advantages of the linear top-down model:

- New content about practice and theory that is beyond teachers’ current experiences can be delivered in this way
- It is convenient and economical.

During the last three decades of the 20th century, new curriculum materials were introduced in US schools which were very similar to the South African CAPS.
These curricula had a common philosophy that encouraged learners to explore, invent and discover for themselves. Teachers were supposed to be facilitators of student learning rather than merely distributors of knowledge. Although there was no problem with the quality of the innovations, many of these programmes actually did not achieve their objectives. The reason for this was the mechanistic linear way in which the innovations were introduced to the teachers (Hoban, 2002:15-16).

Both Verspoor (1989) and Hoban (2002) referred to the fact that many educational change programmes focused on adoption of the programmes and neglected the implementation process. The consequence is that the outcomes are disappointing even though initially the policy or idea was good.

Hoban (2002:35) viewed educational change as a complex system consisting of different elements that are in a relationship with each other. These elements can be compared with a spider web, with each frame of the web representing a system. The different frames or systems are interconnected and change in one frame will affect the other frames. Figure 2.15 explains the complex system graphically (Hoban, 2002:37):

![Figure 2.13: Hoban’s complex system spider web](Source: Hoban (2002:37))
When a new curriculum is introduced, the relationships of the system also change. The interrelationships may strengthen each other to support the change (unbroken lines) or they may undermine each other and break down relationships. Hoban (2002:36) mentioned that the most influential element of professional learning is when teachers share their own experiences in a group or learning community. This viewpoint corresponds with the community of practice approach to teacher development discussed earlier. In such a community, teachers manage their own growth – unlike the top-down approach which advocates that someone from outside controls teacher learning. A limitation of such a learning community is that they are not often exposed to new ideas and thus might stagnate. It is important that conditions in such a complex system should be conducive to support teacher learning. The conducive conditions can be managed and orchestrated by school management. Examples of such conditions are positive working conditions, autonomy to change practice, motivation to change and collegiality among staff (Hoban, 2002:36).

When considering teachers as part of a complex system, conditions that are conducive for teacher learning, according to Hoban (2002:56), are:

- Teachers should be treated as active learners who construct their own knowledge
- Teachers should be empowered and treated as professionals
- Teacher education should be situated in classroom practice
- Teacher educators should treat teachers as they expect teachers to treat their learners
- Teachers need to consider what ideas or content is essential in their learning and gain different expertise
- Teachers need to use a range of tools to keep track of the vast information available

The top-down mechanistic approach was followed with the implementation of the CAPS, resulting in the same problem referred to by Hoban. Although the CAPS
contains educationally sound ideas, its implementation in South Africa was much slower and more difficult than anticipated due to teachers staying in their zone of comfort (Rogan & Grayson, 2003). Research done by Khuluma Management Services (1999) suggested that implementation of the new curriculum was underestimated, inadequately resourced and not supported enough. Most Provincial Education Departments followed a cascade model, consisting of one or two-day workshops. The model of professional development used was a “one size fits all” approach and the content and time-span used was the same for all schools (Rogan & Grayson, 2003).

2.4 Framework for environmental education

The SANBI programme specifically focuses on teachers’ PCK development in incorporating indigenous knowledge in the school curriculum. It is therefore necessary to briefly look at the tenets of environmental education.

2.4.1 What is meant by Environmental Education?

Environmental education is the process of recognising values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among people, their culture and their biophysical surroundings. Environmental education also entails practice in decision making and self-formulation of a code of behaviour about issues concerning environmental quality (Irwin & Lotz-Sisitka, 2014:42).

2.4.2 Open process framework for environmental learning

The best example for this kind of intervention is provided for by Lotz-Sistka and Raven (2001, cited in Roux & Maila, 2004). These authors made the point that for teachers to contribute meaningfully to the improvement of the quality of environmental learning, an open process framework to guide the Environmental Education process is imperative. Such an open-process framework should be based on the Tirisano campaign, anchored on explaining and providing detail that aims to encourage active learning through outcomes-based education (OBE),
school-community links and professional development of teachers. Tirisano is a government-led campaign that encourages a school community to be part of the school activities in the best interest of school development, and includes aspects such as parents’ involvement at the school, involvement of local business, and so on. Unless teachers are equipped with the necessary skills and knowledge to do so, learners will not be provided with meaningful learning experiences that benefit the environment and the process towards sustainable development.

**Key transformation factors**

The training and development of teachers is recognised as one of the key factors in the transformation of the South African education system. The committee for the review of Curriculum 2005 identified “inadequate orientation, training and development of teachers” as one of the seven confounding factors in the hitherto largely unsuccessful realisation of the government’s educational reform initiatives (Van Rensburg & Lotz-Sistka, 2000). Teachers who participated in training programmes as part of their professional development stood a better chance of growing professionally. For example, teachers who participated in the Project Grow as discussed by Lewis (2004), benefitted most from staff development training activities that were hands-on experiences (practical) in group dynamics, team building, outward bound outdoor leadership activities, lessons in horticulture, sustainability education, GIS mapping and research methodology (Lewis, 2004:93). They also learnt about design as a way of learning (pedagogical paradigm), participatory action research (PAR) pedagogy, conflict resolution, fundraising, public speaking and web page development among other skills (Lewis, 2004:93).

Teacher Professional Development programmes in South Africa highlight the tensions of transformation. Teachers, administrators and teacher support staff want to realise a different system, one that is well supported and appeals to the majority. They are, however, constrained by their context and capacities. Van Rensburg and Lotz-Sistka (2000) stated that these contexts and capacities of
teachers bear the weaknesses of past training that most teachers were exposed to, and therefore Teacher Professional Development programmes in South Africa were designed with this aspect in consideration. The Teacher Professional Development programmes in South Africa thus assume a unique history that may not be modelled anywhere else in the world.

In the pre-1994 period in South Africa, most teacher education imposed a political ideology through the use of the national curriculum. Van Rensburg and Lotz-Sistka (2000: 43) stated that,

“The overarching policy of segregation and separate development was established at great financial and administrative cost to cater for multiple education departments and a large number of segregated teacher education institutions, including colleges of education for homeland teachers”.

Often, this segregation disadvantaged homeland-based teachers who were responsible for the teaching of disadvantaged communities, mostly in rural areas. Homeland refers to a system of segregation where areas were treated as independent states, although they did not have any powers and were not recognised outside the Republic as independent states, so the education system in those reserves was of poor quality. This legacy still manifests itself among those teachers who underwent training at that time and who did not benefit from other professional development programmes.

The committee for the review of Curriculum 2005 recommended the cascade model of training as the primary means of preparing the majority of educators to implement Curriculum 2005 (Van Rensburg & Lotz-Sistka, 2000:44). To realise this goal, the National Department of Education commissioned a non-governmental organisation (NGO) to train a core team, consisting of 20 officials from each province, who would in turn cascade the knowledge and the understanding that they had gained to the district officials; the district officials
then conducted training workshops for the classroom teachers and other educators, using the experiences and knowledge gained in the training that they had undergone (Van Rensburg & Lotz-Sistka, 2000).

The SANBI’s Teacher Professional Development Programme follows this model. The organisation has a Teacher Professional Development Programme division which supports the programme in respective teachers’ working environment. This model has, however, been criticised for several reasons. First, it is argued that its emphasis was mainly on terminology and structure and that the educational processes were dealt with through a simplistic dichotomising that seemed to endorse the “out with the old, in with the new” call (Van Rensburg & Lotz-Sistka, 2000:45). Others argued that the sessions (training workshops) were not well supported by good quality materials and that there were obvious gaps in areas such as the assessment strategies (ibid). It was also argued that the duration of the training was too short, to the extent that there was virtually no on-going support and development when teachers went back to their respective schools. This made it difficult for teachers to implement what they had been taught. The district trainers, for instance, were said to be unable to effectively conduct workshops for teachers because they also were unable to interpret and apply the knowledge and skills learnt in the pilot training in the model (Van Rensburg & Lotz-Sistka, 2000: 45).

Van Rensburg and Lotz-Sistka (2000) further made the point that the cascade model may water down information as it gets passed on. They observed that it may also cause the misunderstandings introduced into the system to escalate. The cascade model is also in itself limited as it is based on a limited understanding of what teacher development requires. The idea that one can cascade down or transfer information intact from one person to the next is in conflict with the constructivist epistemology said to underpin outcomes-based education (OBE) in South Africa. Furthermore, this model incorrectly assumes that the kind of information that can be passed on in such a way is adequate to
bring about the fundamental changes in teaching, learning and education that transformative outcomes-based education necessitates.

There are many other authors who do not favour the model. For instance, some argued that cascade models share several features with technicist approaches to teacher development which focus on information mainly in the form of terminology for highly structured processes. This focus on information transfer and a separation between the information, classroom practice and teachers’ theories about that practice does not develop teachers in professional competences to facilitate learning/teaching processes that require learners to become transformers (Yumiko & Ferreira, 2010). They argued that although the cascade model can be an effective strategy to transmit messages about aspect of educational reforms, the intended message does not cascade down to lower levels without the proper mechanisms and support to ensure multiplication. Other authors argued that when transmitted, chances are high that crucial information may be watered down or misinterpreted (Fiske & Ladd, 2004, cited in Yumiko & Ferreira, 2010). They argued that the cascade model of TPD was designed and operated in the same manner as that criticised in developed countries where learners were passive receivers of information.

It is in this respect that the models seem inappropriate for developing teachers’ critical skills and insights, and reflexive competencies in the new policies, which was intended to enable them to actualise an education framework different from that in which they themselves had been schooled (Van Rensburg & Lotz-Sistka, 2000).

2.4.3 Guiding principles for EE

Since the SANBI intervention focuses on developing teachers’ PCK related to Environmental Education, it is necessary to focus on some of the important principles underpinning EE. Robottom (1987) developed a list of guiding
principles for Environmental Education educators. These principles suggest that professional development for Environmental Education should strive to be:

- **Enquiry based:** All participants should adopt a research-stance to their work and regard current educational practices as problematic, having the potential for improvement through participant research.

- **Participatory and practice-based:** Environmental Education should address the gap between what practitioners think they want to do and what they actually do; and between what they want to do and what they are actually able to do in their particular setting. The author suggested solutions to these gaps could only be developed in the context of practice, in a process of working through the relationship between theory and practice.

- **Critical:** it should involve a critique of the values and assumptions that inform and justify environmental and educational policies and practices. He noted that becoming conscious of these values and assumptions through critical enquiry, allows practitioners to formulate their own theories.

- **Community-based:** both environmental and educational issues are context-specific in time and space and seldom amenable to universal solutions. Educators needed to keep this in mind all the time during their involvement in the facilitation of Environmental Education activities.

- **Collaborative:** colleagues needed to help one another to recognise false consciousness or institutional pressure. This was due to the belief that collective action was more likely to successfully address the forces which work against the improvement of environmental education which are often political in character (Robottom, 1987:114-115).

### 2.5 Other models for teacher professional development: the spiral model

As an alternative to the cascade model, some critics suggest the “learning-for-sustainability spiral model” to facilitate the professional development of teachers.
The most distinguishing feature of the spiral model as compared to the cascade model is its extended training duration which, in some cases, lasts up to three years or more (Van Rensburg & Lotz-Sistka, 2000). The extended period available for professional development was seen as important given the fundamental or radical learning which environmental education and teacher development for a transforming system seem to require.

As with other professional development programmes (Lotz & Robottom, 1998; Van Rensburg & Le Roux, 1998), the spiral model assumes that the teacher development curriculum has to be flexible in order to be able to respond to the context of the teachers and their particular needs. Furthermore, if one is to encourage teachers to become curriculum developers, they should have an opportunity to contribute to the development of their own professional development curriculum (Van Rensburg & Lotz-Sistka, 2000). This is another key distinction between the spiral model and the more conventional teacher development programmes such as the pre-determined delivery of pre-packed curricula described by Wade (1996, cited in Van Rensburg & Lotz-Sistka, 2000).

The spiral model also focuses on reflection-in-action. According to Hargreaves and Fullan (2012 98), reflective practice has two aspects reflecting in action and reflecting on action. Reflecting in action is the capacity to walk around a problem while one is right in the middle of it, to think about what one is doing even as one is improvising it. When one has considered whether to speed up or slow down a presentation, to stop and ask a question or tell a joke, to move to the back of the classroom or stay at the front, or to explain an idea another way with other example, one is reflecting in action.

Reflection on action is reflection after the fact, once the practice has finished. Both of these kinds of reflection are central to professional practice and both of them benefit from practice. But in the main they benefit from having a mentor or coach who can pull one back, slow one down, give feedback and cause one to reflect on what one has been doing, why one has done it that way and how one
might do it differently (Hargreaves & Fullan, 2012:98). The recursive nature of the spiralling process makes such reflection on practice both possible and necessary. According to Van Rensburg and Lotz-Sistka (2000), project staff members are required to take an action research approach to their work. An action research can be described as essentially an “on-the-spot” procedure, designed to deal with concrete problems located in an immediate situation. Its origin lies in a strongly-felt need, usually associated with a difficulty or dissatisfaction, in a particular situation and is carried out with the aim of resolving the dilemma (Loubser, 2005). In comparison with teachers, project staff’s reflections are usually more focused, more rigorously documented and followed up, and shared with a broader audience, including colleagues outside a project. Hargreaves and Fullan (2012:92) argued that what is crucial is what happens between workshops, who tries things out? Who supports you? Who gives you feedback? Who picks you up? When you make a mistake the first time? Who else can you learn from? How can you take responsibility for change together? The key variable that determines success in any innovation, in other words, is the degree of social capital in the culture of one’s own school. They further argued that learning is work and social capital is the fuel. If social capital is weak, everything else is destined for failure.

2.6 A Holistic and systemic approach to teaching, learning and professional development of teachers

Commenting on teacher professional development, Rollnick and Brodie (2011) argued that one should consider a number of possible strategies, including whole school reform, the provision materials and resources, a focus on initial teacher education, support for new teachers, using the assessment to leverage the system, extra support for learners, teacher retention and teacher professional development.

These authors argued that all of the above listed strategies are necessary and there is no single strategy on its own that can achieve the desired objectives.
They further argued that professional development lies at the centre of all the other interventions, primarily because it is not possible to improve Maths and Science education without better teachers. They acknowledged that not all forms of professional development are equally successful and that it should build on initial teacher education, support new teachers, help teachers to engage with curriculum change, evaluate and use materials, learn from assessing their learners and contribute to and be supported by, school leadership. They further argued that for these to make a meaningful impact on teacher performance would require ‘deep and targeted interventions’. Jita and Ndlalane (2009) argued that many of the approaches used to develop teachers have had minimal results in influencing and changing teachers’ knowledge and classroom practice (Fullan, 2001; Gottesman, 2002; Jansen, 1999). They further argued that unfortunately, much of the evaluation of staff development programmes begins and ends with the assessment of individuals’ reactions to workshops and courses. They argued that in such cases, little is revealed about the acquisition of new knowledge and skills and how that learning affects teachers’ daily practice (Guskey, 2000, sited in Jita & Ndlalane, 2009).

Jita and Ndlalane further argued that collaboration and sharing of knowledge among peers helps teachers to reflect on their practices as equals, through meaningful social interactions. Prawat (1992) used the term “negotiation” to describe this social interaction because it involves learning and unlearning new information. They argued that cluster approach to teacher development seems to promote collaboration, construction and sharing of content knowledge and pedagogical content knowledge in a meaningful way (Guskey, 1986, cited from Jita & Ndlalane, 2009).

**School ecology and management**

South African schools are also diverse (Taylor, 2008). In order to maintain rules and order, the role of the school principal is very important. An environment that is conducive to change has to be nurtured and school management carefully has
to plan any innovations that are to be implemented, as well as the necessary support given to the teaching staff (Rogan & Grayson, 2003).

When these four factors are taken into consideration, the profile of the capacity of a school to implement innovation can be demonstrated in Table 2 as adapted from Rogan and Grayson (2003:1188) and utilising Taylor’s presentation at a conference: “What’s wrong in South African schools?” (2008). It is clear that the capacity of some SA schools do not meet the requirement for level 1. To make provision for such circumstances, a level 0 was added to Rogan and Grayson’s model, following the same approach as Petersen (2010) for Table 2.4.

Table 2.4: Adapted Profile of the capacity to support innovation (Source: Rogan & Grayson, 2003:1188)

<table>
<thead>
<tr>
<th>Level</th>
<th>Physical resources</th>
<th>Teacher factors</th>
<th>Learner factors</th>
<th>School ecology and management</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Buildings in poor condition</td>
<td>Teacher is under-qualified</td>
<td>Learners have very little proficiency in language of instruction</td>
<td>Management:</td>
</tr>
<tr>
<td></td>
<td>Not enough classrooms</td>
<td>Teacher has no professional qualification</td>
<td>Learners are malnourished.</td>
<td>Time table not followed, class lists not updated</td>
</tr>
<tr>
<td></td>
<td>No or inadequate running water</td>
<td>Teacher absenteeism is large</td>
<td>Learners come late for school</td>
<td>No attendance register for teachers</td>
</tr>
<tr>
<td></td>
<td>Some outside toilets available</td>
<td>Teacher spends less than half the time teaching</td>
<td>Learners have other responsibilities and don’t have enough time for schoolwork</td>
<td>Principal does not exercise control or take up responsibility</td>
</tr>
<tr>
<td></td>
<td>The teacher has a textbook.</td>
<td></td>
<td>Learners do not have facilities to study at home</td>
<td>Ecology</td>
</tr>
<tr>
<td></td>
<td>The few textbooks available in class do not go home with learners</td>
<td></td>
<td>Learners receive no academic support at home</td>
<td>School often starts late</td>
</tr>
<tr>
<td></td>
<td>No science laboratory or science apparatus</td>
<td></td>
<td></td>
<td>Learners and teachers do not return on time after break</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>School is not secure and learners and strangers come and</td>
</tr>
</tbody>
</table>


| 1 | Basic buildings – adequate classrooms and one office, but in poor condition. Toilets and running water available. Electricity in some rooms. Some textbooks but not enough for all. Some basic science apparatus. No science laboratory or if laboratory is present it is not in working condition. | Teacher is under qualified for the position. Teacher does have a professional qualification. Teacher absenteeism is low. Teacher spends more than half the time teaching. | Learners have some proficiency in language of instruction, but several grades below grade level. Some learners do not receive enough food at home – school has feeding scheme. Learners have socio-economic problems. Learners receive very little academic support at home. |
| Management | A timetable, class lists and other routines are in evidence. The presence of the principal is felt in the school at least half the time. Staff – and subject meetings are held at times. Attendance register for teachers exists. |

| 2 | Adequate basic buildings in good condition. Suitable furniture – adequate and in good condition. Electricity in most of the rooms. | Teacher has minimum qualification for position. Teacher is motivated and diligent – enjoys his/her work. Teacher participates. | Learners are reasonably proficient in language of instruction. Learners attend school on a regular basis. |
| Management | Teacher attends school/classes regularly. Principal is present at school most of the time and is in regular contact with his/her. |

Ecology
School functions i.e. teaching and learning occur most of the time. Teachers and learners return on time after break. School Governing Body exists. School is secure and access is denied to unauthorised personnel.
<table>
<thead>
<tr>
<th></th>
<th>Textbooks for all</th>
<th>Reasonable amount of apparatus for science</th>
<th>in professional development activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teacher has good relationship with and treatment of learners</td>
<td>Learners are well nourished</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Teacher</strong> is active participant in professional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learners are proficient in language of instruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learners have access to quiet safe place to study</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learners come</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Principal takes strong leadership role, is very visible during school hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teachers and learners play an active part in school management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ecology**
- Responsibility for making the school function is shared by management, teachers and learners to a limited extent
- School Governing Body operates well
- School functions all the time i.e. learning and teaching always take place as scheduled

**3**
- Good buildings, with enough classrooms and science laboratories
- Running water and electricity in all the rooms
- **Teacher** is qualified for position and has a sound understanding of subject matter
- **Teacher** is an active participant in professional
- Learners are well nourished
- Learners are given adequate time away from home responsibilities to do school work
- Timetable properly implemented
- Extramural activities are organised in such a way that they rarely interfere with scheduled classes
- Teachers/learners who shirk their duties or display deviant behaviour are held accountable

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| Textbooks for all pupils and teachers | Teacher is over-qualified for position and has an excellent knowledge of content matter. |
| Sufficient science apparatus | Teacher has an extraordinary commitment to teaching |
| Additional subject reference books for teachers | Teachers shows willingness to change, improvise and collaborate and has a vision of innovation |
| Reasonably equipped library | Teacher shows local and national leadership in professional development activities |
| Secure premises | Learners are fluent in the language of instruction |
| Well-kept grounds | Learners take responsibility for their own learning |
| | Learners are willing to try new kinds of learning |
| | Ecology |
| | Everyone in the school is committed to making it work |
| | Parents play active role in School Governing Body and in supporting the school in general |
| | Ecological |
| | There is a visionary, but participatory leadership at school |
| | There is a shared vision |
| | The school plans for, supports and monitors change |
| | Collaboration of all stakeholders is encouraged and practiced |
Support from outside organisations

The focus of interventions or “scaffolding” from outside agencies will be in line with the professional developmental needs of the teachers. Outside agencies are any organisations outside the school and can include the Provincial Department of Education, the District Office, NGOs, donors, unions and universities. In the context of this study, the focus was on the role of SANBI in supplementing the school curriculum, by introducing teachers to strategies to incorporate Environmental Education in their classrooms. The profile that Rogan and Grayson (2003) developed takes into account the type of support, the kinds of actions and ways the actions are undertaken as indicated in Table 2.3 below. The three main categories of support include the type of support, the force, evoking the support and the mechanism monitoring the support.

The first category, type of support, is divided into three subcategories, namely physical resources, professional development and support to learners. Note that there is no level 0 in the profile of outside support section.

Table 2.5: Profile of outside support (Source: Rogan & Grayson, 2003:1193)

<table>
<thead>
<tr>
<th>Level</th>
<th>Types of encouragement and support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physical Resources Categories: buildings, curriculum material, apparatus, books, computers, internet</td>
</tr>
<tr>
<td></td>
<td>Design of professional development</td>
</tr>
<tr>
<td></td>
<td>Direct support to learners</td>
</tr>
<tr>
<td></td>
<td>Dominant change force evoked by agency</td>
</tr>
<tr>
<td></td>
<td>Monitoring mechanism and accountability</td>
</tr>
<tr>
<td>1</td>
<td>• Provision supplements what exists, but not enough to support the</td>
</tr>
<tr>
<td></td>
<td>• Information on policy and expected changes are presented to</td>
</tr>
<tr>
<td></td>
<td>• Provision of basic needs such as lunches and places to study</td>
</tr>
<tr>
<td></td>
<td>• Bureaucratic: Change is brought about by top-down directives to</td>
</tr>
<tr>
<td></td>
<td>• Inspections undertaken by authorities</td>
</tr>
<tr>
<td><strong>intended changes.</strong></td>
<td><strong>school based personnel.</strong></td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>• Provision is in one category only</td>
<td>• Typical mode is short, one shot workshop</td>
</tr>
</tbody>
</table>

2 | • Provision completely covers what is required to effect the intended change in one category, or partly sufficient in two categories | • Examples of new practices are presented to staff | • Charismatic: Change is brought about by top-down inspiration and encouragemen | • Inspections undertaken in collaborations with school-based personnel |
| | | • Staff given opportunity to engage in these practices in simulated situation | | |
| | | • Series of short workshops lasting for one year | | |
| | | • Basic academic needs are catered for in the form of extra lessons | | |
| | | • Series of short workshops lasting for one year | | |

3 | • Provision completely covers what is required to effect the intended change in two categories, or partly sufficient in three categories. | • Professional development designed by school-based personnel | • Professional change brought about by encouraging role of players to embrace codes of conduct and standards of teaching and learning | • School based personnel monitor own progress, but report to authorities |
| | | • Staff decides which new practices they need | | |
| | | • Using both inside and outside support | | |
| | | • Both external and | | |
| | | • INSET for two to three years | | |
| 4 | • Provision completely covers what is required to effect the intended change in three categories | • Communities of practice take full responsibility for their own continued professional growth | • Complete academic and personal support is provided | • Learning community change is brought about by communities with shared values and commitment | • All monitoring is undertaken by school-based personnel |

It is believed that if teachers can be supported and scaffolded from within their own school communities to draw up a plan and set goals for their professional development using this model of Rogan and Grayson (2003), they will be more motivated to implement a new curriculum. SANBI and other institutions can also play a significant role in teacher development.

### 2.7 Teachers’ views of the nature of Science, as part of their PCK

A crucial factor to reflect on, is whether teacher professional development programmes focus sufficiently on the tenets of the nature of science. In a schooling system that is mainly characterised by transmission-mode teaching (“chalk and talk”), it is essential to focus in professional development programmes on the tenets of science, and the value of inquiry approaches in the science classroom (De Beer & Ramnarain, 2012). This is also important when assessing the SANBI programme. Does this programme focus on the tenets of the nature of science, and the affordances of inquiry learning in the science classroom?

#### 2.7.1 Scientific inquiry (investigation) and problem-solving skills

These skills will allow learners to solve problems, think critically, make decisions, find answers and satisfy their curiosity. They are seen as the focus of Science
learning and assessment activities in the classroom. Physical, Life and Natural Sciences focus on exploring and investigation skills. These skills are best developed within the context of an expanding framework of knowledge and involve the use of experimental and data-handling skills. Experimental skills include following instructions, making observations, measuring trends and recording information. Data-handling skills involve identifying, selecting, organising, presenting, translating and manipulating data as well as making inferences, deductions and conclusions from the data gathered. Learners present reasons for explanations of phenomena and identify relationships between experimental processes and results obtained. They make predictions and hypotheses regarding phenomena in order to solve bigger problems.

2.7.2 Construction and application of Science knowledge

Scientific, technological and environmental knowledge is constructed (interpreted) and applied within the prescribed knowledge areas. Learners should be able to recall meaningful information when needed and categorise information to reduce complexity and look for patterns. The knowledge areas for each of the Sciences are as follows:

Natural Sciences:
- Life and Living
- Energy and Change
- Planet Earth and beyond
- Matter and Materials

Physical Sciences:
- Matter and Materials
- Chemical Systems
- Chemical Change
- Mechanics
- Waves, Sound and Light
- Electricity and Magnetism
Life Sciences:
- Tissues and Molecular studies
- Structure and Control of Processes in Life Systems
- Environmental Studies
- Diversity, Change and Continuity

2.7.3 Understanding the interrelationship of Science, Technology and the Environment

Learners must develop an understanding of the relationships between Science, Technology, the Environment and Society. This understanding and the appropriate attitudes and values that are developed contribute to learners becoming informed and responsible citizens in their community and in South African society. It is important, therefore, for learners to understand:

- The scientific enterprise and, in particular, how scientific knowledge develops
- That scientific knowledge is in principle tentative and subject to change as new evidence becomes available
- That knowledge that is contested and accepted often depends on social, religious and political factors
- That other science understandings, such as African indigenous knowledge systems, should also be considered
- That the explanations and limitations of scientific models and different theories need to be evaluated
- How science relates to their everyday lives, to the environment and to a sustainable future
- The importance of scientific and technological advancements and their impact on human lives.

It is the teachers’ role to effectively communicate these to the learners. In teacher professional development programmes, such as the programme offered by SANBI, this should be highlighted.
2.8 Conclusion

This chapter reviewed relevant literature regarding teacher professional development and the need for continued teacher pedagogical content knowledge (PCK) development, and how SANBI could assist in this regard. The following chapter will present the research methodology followed, in assessing the interventions offered to teachers by SANBI.
CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

In this chapter, the preparation for field research, research design and methods applied in this study will be discussed. As the researcher was both a facilitator in the SANBI programme and also the investigator of this study, he had to be mindful of the potential conflicts of interests that may arise (see later in the Chapter). I used a design-based research approach, and qualitative data collection methods and instruments were used. Teachers’ experiences of the SANBI programme were recorded. I also conducted classroom, school and lesson observations, utilising appropriate instruments, to determine what transfer took place after the intervention.

During the course of his research, the researcher was confronted with a major challenge in that there was an ongoing teacher strike. This affected appointments made for personal face-to-face interviews; the timeous receiving of all requested consent forms and also the return of mailed-out questionnaires for potential data analysis. Consequently, the researcher had to adjust the methodology accordingly. Data was collected in the form of personal face-to-face in-depth interviews; SANBI intervention/workshop discussions and observations (part of an ongoing Teacher Professional Development programme); formal and informal school visits, school- and lesson observations and discussions; and school visits and interviews again at the end of 2013, nearly 3 years after stage one. (The reason was to determine whether such interventions are a “flash in the pan”, or whether there are long-term outcomes from such interventions).

The questionnaire schedule for the in-depth face-to-face interviews was semi-structured. The questionnaire is provided in Appendix E. The mailed self-completion questionnaire is provided in Appendix G. The transcribed interview data from the in-depth interviews is provided in Appendix F1-F7.
Initial findings from the analysis of the various data sources (in-depth interviews, informal discussions and observations during and after training, school visits, lesson and school observations) were further analysed using third-generation Cultural Historical Activity Theory (CHAT) as an analytical lens in order to identify tensions arising during the research process as an activity system.

Figure 3.1: Research lens and instruments in this design-based research
3.2 **Research questions, and the theoretical framework underpinning this research**

In this paragraph I would like to highlight the alignment between the theoretical framework used in this research, and the research questions.

### 3.2.1 Research questions guiding the study

As mentioned in Chapter 1, the following overarching research question guided this study:

What role does the SANBI Professional Teacher Development Programme play in teachers’ pedagogical content knowledge development?

The following sub-questions were identified:

1. Which professional competencies are developed by teachers attending the SANBI Professional Teacher Development Programme, and how do these competencies manifest in their professional practices?
2. What are the salient strengths and weaknesses of the SANBI Teacher Professional Development Programme?
3. Which design principles can guide the curriculum of such Teacher Professional Development courses or programmes?

### 3.2.2 The objectives of the study were:

- To determine what professional skills teachers acquire through the SANBI Teacher Professional Development Programme
- To assess the strengths and weaknesses of the SANBI Environmental Education Teacher Professional Development Programme
- To provide feedback to the programme developers and implementers on how to improve the programme
- To identify “keystone species” in the ecologies of practice around which the institute could anchor support for infrastructure development of the micro-group professional development and lifelong learning communities
To determine whether teachers achieve the recursion or de-automatisation phase (Warford, 2011) in striving for potential development within the zone of proximal teacher development, by having individual interviews with selected teachers two years after the programme.

To contribute to the literature on Teacher Professional Development in Environmental Education, by formulating design principles for such programmes.

This study has social constructivism as its theoretical framework.

3.2.3 Constructivist view of learning

In the case of the SANBI programme, teachers were shown how learners could collectively be involved in planting indigenous gardens at school. Project activities in the model emphasise the role of the construction of knowledge, as opposed to mere absorption of knowledge, as the basis for a constructivist epistemology and pedagogy. Examples of these activities included an exercise in which project participants were asked to look at, and interpret, a drawing which had multiple interpretations. Teachers were not told beforehand what it was or represented, they actively constructed different meanings making it clear that there was not just ‘one right answer’ to the question of what the drawing signified. This also emphasised varied perspectives that people held about the environment. This had the effect that to mobilise common understanding called for consensus building or co-construction of meaning (Van Rensburg & Lotz-Sistka, 2000). These activities reflected an emphasis on individual meaning-making, associated with tolerance, critical thinking and other aspects of democratic education. In some instances, there was an emphasis on meaning-making from a cultural perspective. Group dialogue played an important role in many of these activities. This model put more emphasis on the activity-based professional development. This feature of the spiral model is yet another way in which the project activities modelled a constructivist educational approach. During the workshops and study tours, the project staff involved teachers in
numerous learning activities to demonstrate conceptual ideas associated with constructivism or environmental education, and provide them with examples for the classroom (Van Rensburg & Lotz-Sistka, 2000). This was also done in the similar way by SANBI programme, teachers were provided with example lesson plans, they were encouraged to adopt these and make them fit into their school context. This tended to confirm Gough’s (1997) assertion that when the constructivist view of learning is adopted, knowledge is no longer seen as being extracted or induced from nature and independent of people; rather, it was constructed by each learner through the interaction between the learner’s present understanding of the world and the new information. Participating teachers were encouraged to reflect, in discussions and activities such as journal writing, on aspects of their practice. This also encouraged them to try new methods in the classroom work based on the assumptions underpinning this new approach, as compared to the traditional methods through the learning programmes which they were developing as part of the programme.

3.2.4 The CHAT lens emerging from the theoretical framework of social constructivism

Cultural Historical Activity Theory (CHAT) is chosen as the lens for this research. Its history can be traced back to Vygotskyan notions of social constructivism. The professional development of teachers will be looked at using CHAT as a lens. This framework is chosen to view the bigger picture, and to view the SANBI intervention as an activity system, where a myriad of tensions may develop.

The teachers involved in the SANBI intervention cannot be seen in isolation from other broader teacher reforms, since the life sciences curriculum has been further revised into curriculum and assessment policy statement (CAPS, 2010). CHAT looks at the teacher in a holistic fashion. During the SANBI intervention, social relationships can be seen as the first “cultural plane” of which Vygotsky (1978; 1983; 1986) spoke.
However, teachers are confronted with knowledge and didactical approaches that they are not necessarily accustomed to. It can be argued that this ‘tension’ or ‘discomfort’ can act as catalyst for internalisation, the second plane in Vygotsky’s writing.

The third generation CHAT is chosen as the conceptual framework in this study to view the bigger picture of teacher development within this specific community of practice—teachers who participate in SANBI Teacher Professional Development.

The activity system within the SANBI Teacher Professional Development Programme is discussed in more detail. For the purpose of this study, the different entities will have the following meaning:

The **subject** is the teacher participating in the SANBI intervention (teachers of Natural Sciences, Physical Sciences, Social Sciences, Geography and Life Sciences), and their professional development in a broader sense – the teacher envisaged by the CAPS. The teachers’ view on learning as well as their level of motivation will impact on how the available tools are utilised (Hardman, 2008).

The **object** (outcome) refers to the effective development of the teacher to implement Environmental Education in the classroom. Although many teachers are qualified to teach Science, they do not know how to incorporate Environmental Education in the teaching of Science (probably because this was never a focus in the initial teacher training). The object of an activity system represents the problem at which the activity is directed (Hardman, 2008). In this study, the object is the professional development of the teachers participating in SANBI teacher development to become the teacher envisaged by the NCS, as well as a self-actualised person as envisaged by Maslow. Using the analogue of Ribierio (2006) and Goffman (1981), Science teachers find a new secure “footing” and “voice” or professional identity.
**Tools** in this research include the SANBI training (learning) materials and intervention, CAPS prescribed outcomes (in Physical-, Life- and Natural Sciences curricula), policy documents and cluster meetings. The researcher also includes pedagogy under tools, and would like to see whether the teaching methods that the SANBI programme suggests, are used by teachers in their own teaching. Language is also an important tool.

**Rules** refer to the guidelines of SANBI and the CAPS, but also the rules of the school in which they operate. Rules also refer to norms, conventions and social interactions of the school which drive the subjects’ actions. Rules in this study refer to the guidelines of the CAPS, classroom rules and also the rules of the school and the Education Department in which they operate.

**Division of labour** in the context of this study refers to the two roles of the teachers who participate in this study: firstly, their role as learners, developing new skills and gaining new knowledge during their professional development (the SANBI programme). Secondly, the teachers’ role as facilitators and how they facilitate learning in the classroom. Division of labour also refers to responsibilities, tasks and power relations within the school and the school district.

The **outcome** refers to the successful implementation of the SANBI Professional Development as well as CAPS by a self-actualised and confident teacher who has found his/her footing and professional identity.

It is important to note that the teachers in this study are involved in two activity systems. In the one system they are part of a school community or a community of practice. When teachers are at the Walter Sisulu National Botanical Garden, they interact as part of an ecology of practice. In the second activity system, they are part of the cluster of Science teachers in their school district and as such they are part of an ecology of practice consisting of various communities of practice (Petersen, 2010: 58). Petersen (2010:58) explained this through a diagram (see figure 3.2 below).
Figure 3.2: Relationship between communities of practice and ecologies of practice

Source: Petersen, 2010:58

The small activity systems represent the different schools or communities of practice and the arrows show the interaction and secondary tensions between the schools. The big triangle represents the ecology of practice as the second activity system. The subject is still teachers participating in SANBI Teacher Professional Development Programme, the object is the professional development of the teacher and the outcome is the successful implementation of what teachers learnt during the SANBI workshops.

3.2.5 Elements of critical theory

This research also contains elements of critical theory. It is for this reason that the researcher also followed an intervention research which should be studied in the context of critical theory, because it appears to have the potential to underscore the values and ideals underpinning emancipation and the transformation of social reality. Critical theory necessitates that research participants and researchers become reflective practitioners. This means that
research participants should take real action in an attempt to liberate participants from disadvantaged social conditions (such as poor Science study). Teachers in the SANBI Teacher Professional Development Programme are always encouraged to take action or start action projects that would address environmental issues that have been identified in the school. In some cases, teachers are encouraged to close the gaps in their teaching methodologies that are identified during SANBI workshops; this they do when teaching after attending the workshops. To this end, all teachers participating in the SANBI Teacher Professional Development Programme developed indigenous gardens in their schools with a selected group of learners to improve the physical outlook of their school grounds and also to create an outdoor learning environment that will support the teaching of Environmental Education in their schools.

In the context of this study, teachers need to go beyond studying about new ways of innovative teaching, and move to the actual implementation of new things that were learnt in the programme and continuously review their newly acquired techniques and improve their teaching practice (Du Preez & Roux, 2008). When intervention research is used as a means of professional development, its aim should not only be to emancipate teachers, but also to provide them with an opportunity to critically reflect on their social realities and to question concerns they might have about these realities.

A participative process should include not only the target group for whom the intervention is intended, but also other stakeholders who could give valuable input regarding the intervention process.

The SANBI Teacher Professional Development Programme consequently promotes reflection and praxis as important principles guiding SANBI’s intervention. According to Le Grange (2002), cited in Du Preez and Roux (2008), principles of educational research, aimed at empowering participants through democratic processes, highlight participation, reflection and praxis. He identified the following principles: contextual (research processes are consistent with the
workplace issues of the participants), responsive (the research topic is of concern and importance to the participants), emergent (knowledge that emanates from an enquiry should contribute to the knowledge base of a particular field), participatory (participants are equally involved in different aspects of the research), critical (the research should not only focus on the obvious results, but also the hidden meanings of the results) and PR axiological (theoretical and practical considerations are consciously addressed and represented in the research). In support of this argument, Rogan (2004) asserted that if one wants to empower participants, one must use scaffolding as soon as teachers show signs of understanding the innovation or have mastered the new skills, then the scaffolding can be removed. He further argued that for new learning to be accepted by teachers it must be intelligible, plausible and fruitful. There will be little incentive to implement a new curriculum if there is no sense of dissatisfaction with the old one. Some authors call this situation a conflict. A sense of dissatisfaction must somehow be provoked, whether by peer pressure, by government edict or by developing a share vision of something better than what currently exists. In this case, it is a new Government policy, a new continuing professional teacher development system (CPTD) that seeks to achieve the following objectives:

• Ensure that current initiatives devoted to the professional development of teachers contribute more effectively and directly to the improvement of quality of teaching
• Emphasise and reinforce the professional status of teaching
• Provide teachers with clear guidance about which professional development activities will contribute to their professional growth.
• Protect teachers from fraudulent providers and
• Expand the range of activities that contribute to the Professional Development of teachers (Government Gazette, 2007).

The innovation also needs to be seen intelligible, plausible and fruitful by those whose responsibility is to implement it. In this case, teachers who are involved in
the SANBI Teacher Professional Development programme must see reasons why this intervention is needed and they must be dissatisfied with existing conditions in their schools. In other words, there must clearly be a need for this intervention. This is an important point to remember as the researcher was an SANBI trainer.

3.3 Research design: Intervention research and Design-based Research (DBR)

3.3.1 Intervention research

Compared to the research by design method, Comer, Meier and Galinsky (in Du Preez & Roux, 2008) described intervention research as a “developmental research method” that is more flexible than conventional experimental designs. It takes into account issues which are of importance to the target group and aims to promote an understanding of these issues (Rothmans & Thomas, 1994:25). However, Du Preez and Roux (2008) further argued that intervention research is based on elements of interpretivism and constructivism. Comer, Meier and Galinsky (2004: 251) described intervention research as typically conducted in a field setting where researchers and practitioners work together to design and assess interventions. They further made the point that these interventions should be useful for diverse conditions in different practice settings (2004:258).

Rothman and Thomas (1994:7) suggested that intervention research should be understood as consisting of three facets: knowledge development, knowledge utilisation, design and development. They argued that the paramount aim of intervention knowledge development was to contribute to basic knowledge of human conduct by using the methods of conventional social sciences research (Rothman & Thomas, 1994:14-18). According to Rothman and Thomas (1994), intervention knowledge utilisation aims at applying knowledge of human conduct by means of transformation and conversion of available knowledge into the application of concepts and theories relevant to the given target groups’ practices (1994:18-19). The aim of intervention design and development is to create new
methods, programmes, service systems, or policies by means of a process of problem analysis, intervention design, early development, advanced development and dissemination (Rothman & Thomas, 1994:8-14).

**Table 3.1: Summary of the facets of intervention research (adapted from Rothman & Thomas, 1994:7):**

<table>
<thead>
<tr>
<th>Areas of difference</th>
<th>Knowledge development</th>
<th>Knowledge Utilisation</th>
<th>Design and Development</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objectives</strong></td>
<td>To contribute knowledge of human behaviour</td>
<td>To apply knowledge of human behaviour</td>
<td>To evolve new human service technology, e.g. treatment methods, programmes, service systems or policies</td>
</tr>
<tr>
<td><strong>Methods</strong></td>
<td>Conventional social and behavioural science research methods</td>
<td>Transformation and conversion of available knowledge into application concepts and theories relevant to given target populations, problems and intervention methods</td>
<td>Emerging methods include the means of problem analysis, intervention design, development, evaluation and dissemination and related techniques</td>
</tr>
<tr>
<td><strong>Outcomes</strong></td>
<td>Information about human behaviour in the form of, for example concepts, hypotheses, theories and empirical generalisations</td>
<td>Such applications as changes in the understanding or practices relating to populations, problems or interventions in human service</td>
<td>Such technical means of achieving human service objectives as assessment and intervention methods, programmes, systems and policies</td>
</tr>
</tbody>
</table>
Table 3.1 shows how Rothman and Thomas (1994) envisaged intervention research as mainly a linear process; moving from knowledge development toward knowledge utilisation and design and development. They viewed the process of design and development as the actualisation process of intervention research in terms of Vygotsky’s theory of learning, this exercise is called “scaffolding”. It is thus this scaffolding that will ensure that teachers are able to implement what they have been trained on. Ball and Cohen, cited in Bertram (2011), argued that more effective professional development interventions are those that include clear examples of the new assessment and pedagogies to be learnt (using direct modelling or video footage and that give teachers the opportunity to practice these new processes with their learners under supportive supervision). They further argued that it is important that teachers observe good practice, produce their own teaching activities and then allow other colleagues or experts to observe critique them. (Shalem, 2003) cited in Bertram (2011), further argued that these kinds of meaningful learning opportunities are labour intensive, are thus expensive and also require learning and support over a sustained period of time, otherwise all resources that have been committed to Teacher Professional Development can be regarded as having been lost if there is no plan of how the teachers will be assisted to implement what they learnt from the programmes.

According to Denscombe (2007), pragmatism places great emphasis on the “practical” rather than the abstract when it comes to issues of knowledge and truth, and it operates on the premise that the value of any theory can only be gauged by how well it addresses real practical needs and how well it works in practice. Therefore, there is a school of thought that argues for a school-based professional development programme, where teachers are active through experimentation, inquiry, writing, dialogue and questioning that encourages collaboration and teachers working together, focuses on student learning, takes place over time and provides follow up support, mentoring and coaching in teachers’ classrooms (Lieberman & Pointer-Mace, 2008; Shulman & Shulman,
2004, cited in Bertram, 2011). Lieberman and Pointer-Mace (2010) suggested that teachers learn best when they are members of a learning community, provided there are supportive working relationships. They subscribed to Wenger’s (1998) theory that most people learn in communities of practice where learning happens through experience and practice.

**Professional development through participative intervention research**

Evans (2002) described different understandings, kinds and forms that professional development for teachers – as process, not procedure- could adopt. The author distinguished between the notion of restricted professionals and extended professionals. She explained that restricted professionals refer to teachers operating predominantly intuitively rather than rationally, who often view education theory as mostly irrelevant to their classroom practice. Extended professionals, the opposite of restricted professionals, refers to teachers who rely on their rationality just as much as on their intuition and who value theory as important to their practice (Evans, 2002:124). The notion of extended professionals also corresponds with what Waghid (2003: 65) referred to as reflexive praxis and Le Grange (2002: 39) referred to as the PR axiological principle.

One could argue that one of the aims of any professional development should be to assist teachers to become extended professionals. Teachers should thus be granted opportunities to enhance their own professional status so that they can become more rationally and intuitively balanced (Evans, 2002: 130).

Teachers often complain about their experience of professional development programmes (Du Preez, 2008: 178, 197-198). Empirical research has shown that teachers often feel that new ideas are being imposed on them without being offered an opportunity to contribute, even if only to share their experience of what works in their practice and what does not (reflection). This explains why some attempts at professional development simply go unnoticed (Du Preez, 2008:159). In addition, it might be argued that imposing programmes upon teachers
strengthens the notion of teachers as restricted professionals instead of extended professionals. This emphasises the importance of empowering teachers to become more actively involved in their own professional development.

Research designs are the plans and procedures used to construct the research process. The chosen design includes the entire spectrum from assumptions made to the methods of data collection and analysis (Creswell, 2009:3). Henning et al. (2004:1) referred to the whole research process as a home of knowledge or an epistemological home. In terms of this metaphor, the research design chosen for this study resembles the architectural plans for the custom-designed research home of the study. The selection of a research design depends on what the researcher is trying to find out, i.e. what the specific research questions are and which design offers the best way to obtain useful answers (Silverman, 2002:1). In this study, the research problem is best solved via a combination of a design-based study and interventionist steps taken.

Barab and Squire (2004) postulated that design-based research is concerned with using design in the service of developing broad models of how humans think, know, act and learn. Thus, a critical component of design-based research is that the design is conceived not just to meet local needs, but to advance a theoretical agenda, to uncover, explore and confirm theoretical relationships. Design-based research requires more than simply showing that a particular design works, and demands that the researcher generates evidence-based claims about learning that addresses contemporary theoretical issues and further knowledge of the field (Barab & Squire, 2004).

The study will seek to determine the perceived impact of the SANBI programme on the professional development of teachers. Ascertaining the impact of the programme will require involving the teachers who participated in the SANBI programme, to reflect on their experiences of the programme, and to study the transfer in the classroom (through observing teacher lessons). This research will focus on the aspects of identifying and development of “keystone species”
(master teachers) in “ecologies of practice” (this refers to various schools serviced by SANBI) as described by Henning, et al. (2004) and Sauvé and Orellana (2004).

The relevance of a pragmatic perspective in the study is in the evaluation of how innovative teachers are applying the knowledge, skills and other competencies that they acquire in the SANBI programme in their day-to-day practice. According to Denscombe (2007), pragmatism places great emphasis on the “practical” rather than the abstract when it comes to issues of knowledge and truth, and it operates on the premise that the value of any theory can only be gauged by how well it addresses real practical needs and how well it works in practice. The researcher has also used Cultural Historical Activity Theory (CHAT) as a lens; for instance, he examined whether the teachers were able to use tools that came from the SANBI Teacher Development Programme, in this case tools would have been resource booklets, activities done during the workshops, lesson plans, CAPS, etc.

3.3.2 Design-based research

Design-based research is not so much an approach as it is a series of approaches, with the intent of producing new theories, artefacts and practices that account for and potentially impact learning and teaching in natural settings. Figure 3.3 below exemplifies the stages of the DBR research cycle:

![Figure 3.3. Design-based research involves iterative cycles of research stages](image)

The aim of intervention design and development is to create new methods, programmes, service systems or policies by means of a process of problem analysis, intervention design, early development, advanced development and
dissemination (Rothman & Thomas, 1994:8-14). There is, therefore, a synergy between this approach and what the SANBI’s Teacher Professional Development Programme does. The programme is designed to assist teachers to implement knowledge and skills in a much more practical way. It also looks at how teachers who are not directly involved in EE benefit from this programme. This process assumes that teachers, after participating in this programme, would have gained new knowledge and competencies that they would try to implement. From this study, I have developed design principles that would inform future presentation of the SANBI short learning programme. In developing these design principles, I was not only guided by my data, but also by literature. Based on international literature, Rollnick and Brodie (cited in Bernstein, 2011) suggested seven principles that should guide effective professional development (see below). Most of these aspects eventually also emerged in the design principles that were distilled in the study.

- The piecemeal, workshop-type professional development currently prevalent in South Africa is not effective
- A focus on a few important instructional priorities over a long period of time is most effective
- Actual school and classroom data is an important source for teacher learning
- Teachers learn best through interactions with other teachers and with experts acting as ‘critical friends’ in professional learning communities, in an environment of mutual trust
- High-quality professional development should immerse participants in enquiry, questioning and experimentation and act as a model for enquiry forms of teaching
- There should be a focus on both subject matter-knowledge and pedagogical content knowledge.
Reform strategies must be linked to other aspects of school change, such as whole school development and curriculum change.

3.3.3 Research rigor in DBR

There are similarities between the design-based research and SANBI programme in that they follow similar logic in an action research evaluative cycle and philosophy. DBR also aims to contribute to theory building. One of the criticisms of DBR, which can also be levelled at any SANBI course evaluation, is the fact that it is characterised by flexible revision of educational designs in natural settings, with the designer, who can also implement and evaluate the design, making no efforts to control the variables that may affect the outcome of the inquiry (Barab & Squire, 2004). The variables in this case could be the cause of designer bias.

The following important concerns are raised about the state of design-based research in its evolution towards a rigorous research methodology, and which should also be kept in mind in this study:

- Lack of progress in the description of a standardised, coherent design methodology to guide design studies, for example when to abandon a design or when the design warrants further investigation (Dede, 2004; Kelly, 2004).
- Difficulty to distinguish a design from its conditions for success (Dede, 2004; Barab & Squire, 2004).
- Tentative generalisation of findings across contexts (Barab & Squire, 2004; Dede, 2004; Kelly, 2004; Hoadley, 2004).
- Close researcher involvement with high risks of researcher bias (Barab & Squire 2004; Brown, 1992; Dede, 2004; Hoadley, 2004).
- Excessive data collection necessitating data selection (Brown, 2002; Dede, 2004 in Greylingh, 2007).
- Lack of substantial theoretical basis for designs and disappointing contribution to design theory (Dede, 2004; Disessa & Cobb, 2004).
3.4 **Research methodology**

Before I continue discussing the DBR, I first need to highlight the nature of the SANBI intervention.

3.4.1 **The SANBI Teacher Professional Development Program**

The SANBI Teacher Professional Development programme follows a short learning cycle programme design, namely: curriculum development and design, implementation of the learning programme, analysis of data (feedback from teachers, and observation in schools) and revision by the SANBI programme developers based on the feedback. The teachers participating in the programme take part in the evaluation of the programme. Feedback from them is used to identify weaknesses or gaps for improvement, the programme is then improved based on the programme. So far, this is an informal process – there is no fixed process for recording or filing such information and for recording any “before and after” achievements. This is the gap that my study will address. From this study formal design principles are distilled, to improve the SANBI programme. Figure 3.4 below demonstrates an implementation cycle of the SANBI Teacher Professional Development Programme.
Through the SANBI Teacher Professional Development Programme, participants are encouraged and assisted to move beyond theoretical understanding of Environmental Science issues to trying out things practically in their schools. Furthermore, the programme developers seek to obtain feedback from the participants so that, where there are weaknesses, the learning programmes can be improved. This is often an ongoing process. It is conducted through collecting incidental evidence about improved teaching practice of the teachers that are involved in the programme. In other words, information about how the course is assisting teachers is always collected, but it has never been analysed or systematically stored to identify the true value of the course to the teachers. (This is the gap that this study addresses).

3.4.2 Participative intervention: Teachers actively engaging in cooperative learning

Using a contemporary, participative intervention research process to include teachers in the process of developing professional programmes not only allows
for more input during the design process, but also provides teachers with an opportunity to take ownership of their professional development and to become extended professionals. Participative intervention research can assist in extending teachers as professionals only if it is grounded on the basic principles of critical thought; that is, participation, reflection and praxis. So far, the SANBI programme is – among some other venues – based at the Walter Sisulu National Botanical Gardens in Roodepoort. This means that an artificial “gardening” environment is shown to teachers, considering that they may not have access to good soil, water or gardening implements in their own schools.

Figure 3.5: Subject advisors and Teachers attending a teacher workshop at SANBI’s Botanical Garden.

This project was sponsored by the South African National Biodiversity Institute in an attempt to support teachers to implement Environmental Education.
Views have been expressed by some that gardening programmes have not been explored as a vehicle that could be used as a tool to achieve Teacher Professional Development, especially when it comes to Environmental Education and the Natural Sciences. Mackenzie (2009) maintained that while gardening programmes have become progressively more common, empirical research into the impact of these programmes is limited. The same argument can therefore be used with regard to Teacher Professional Development. This is the gap that this study wants to address.

3.4.3 Community focus of the SANBI program

It is often stated that experiential and community-focused projects have also been identified as a significant benefit in that they potentially allow children to engage in meaningful experiences, with opportunities for transferring learning to their everyday lives having value beyond schools (Bell & Dyment, 2006, 2008; Corkery, 2004; Dyment, 2005; Miller, 2007). The same argument is relevant for Professional Teacher Development Programmes, because teachers need to be seen after attending a Teacher Professional Development workshop, transferring all that they learnt during the workshop into their daily teaching. The research included personal school visits and observations to examine whether the learnt material actually has been applied at the schools.

3.4.4 The spiral model in the SANBI TPD program

The Department of Education in the Gauteng Province selected clusters of schools, in relatively close proximity, to participate in the project and recruited at least two teachers from each school to participate. A cluster means a group of teachers that have been grouped together for the purposes of easy functionality of the workshops. Teachers in each cluster met on a regular basis with the SANBI environmental education programme staff members and curriculum implementers. While attendance to these cluster meetings fluctuated due to various factors, it was generally quite stable and in some cases exceptionally
good. The clusters thus consisted of a core group of teachers who met regularly and who, in many instances, created bonds with each other as team members.

Working in clusters and school-based pairs encouraged professional collaboration and collaborative learning. This promoted constructive strategies such as group work and dialogue. Relationships became a key feature of the professional development activities in the project, the assumption being that groups of people in respective schools and districts would be in a better position to sustain environmental education once the pilot project came to an end (Van Rensburg & Lotz-Sistka, 2000).

The spiral model involved cluster meetings and study tours in which the groups worked together, interspersed with periods in which pairs or individual teachers worked-away in the classroom context or on homework activities. As in SANBI’s Teacher Professional Development Programme, these activities encouraged participants to: (i) work through ideas introduced during the workshops such as preparing and presenting tasks to the entire group of teachers or designing their own learning programmes based on examples from the workshops; (ii) apply or extend the learning from the workshops such as by adapting a worksheet introduced during the meeting and trying it out with learners and (iii) engaged in enquiry activities in their own contexts; all of which represented the preparation for work to be done in the following meeting. Such a system encouraged reflection in action, as it interspersed meetings, during which concepts were introduced, with contextual activity. For instance, participants were expected to work on garden designs that will be appropriate for teaching and learning purposes. This was markedly different from many teacher development activities in which there were often distinct gaps between classroom activities and professional development training sessions.

The spiral model embodies the valuing of the process involved in an activity. The view that meaningful learning is a process that takes time, motivated the longer term duration of the project (Van Rensburg & Lotz-Sistka, 2000). It was
considered important to re-visit concepts which had been introduced earlier in the project with increased depth and sophistication. This gave rise to the spiral nature of the process, and characterised by advancing and recurring cycles.

The recurring nature of the spiral model’s teacher development curriculum also encouraged action-reflection activities. While it is often difficult for people to reflect critically on new ideas as they are introduced, an opportunity to re-visit these ideas, perhaps after discussing them with colleagues or tried them out in action proved useful.

### 3.5 Sampling and site collection

For the purpose of this study, the population comprised teachers who attended the SANBI Teacher Professional Development workshops. Defining the population is a two-step process: (i) the target population, which is the population to which one wishes to generalise, must be identified and (ii) the sampling frame must be constructed. The sampling frame refers to the set of all cases from which the sample will actually be selected (Conrad & Serlin, 2006). There are approximately 200 teachers who have undergone SANBI training since its inception in 2002. These teachers are mainly situated in the Gauteng province, and most of them teach in the General Education and Training band. They are mainly Life Sciences and Natural Sciences teachers.

The key concept in sampling is representativeness. Unless the sample from which we will generalise truthfully or faithfully represents the population from which it was drawn, we have no reason to believe that the population has the same properties as those of the sample (Conrad & Serlin, 2006). Sampling is thus far more than simply a way in which to collect data for a study. It is a much more integral part of the overall research design than many scholars consciously acknowledge.

Unwise sampling can create a problem of bias, as the sites or participants one has easy access to may not necessarily be representative of the population. Out
of approximately 200 teachers who were involved in SANBI’s Teacher Professional Development Programme, eight representative schools were selected. These schools were carefully selected to provide a range of different contexts: at least one suburban school and other schools were selected from the townships. However, these schools all had to be accessible to the researcher. The sample also had to include a well-resourced and a poorly-resourced school; and a school acknowledged for obtaining good academic results, as well as a school where academic performance needs to be improved. In each of the eight schools, two Natural-, Physical- or Life Sciences teachers were selected, thus resulting in a chosen convenience sample of 16 qualifying teachers who had participated in the SANBI programme. (For a qualitative study this is acceptable). Due to the fact that this study was an in-depth investigation, the size of the sample may not be that important (Henning, Van Rensburg & Smit, 2004). Permission was obtained from the principals of these selected schools that the qualifying teachers could be interviewed, that the school gardens and relevant classrooms and lessons could be observed. Teachers also gave their prior permission for such interviews.

Sampling refers to a process of selecting objects. It is carried out when it is impossible to have knowledge of a larger collection of these objects. The aim of sampling in social research is to produce representative selection of population elements. In this case objects are teachers.

Sampling refers to a selection, not scientific discourse, although we often work on the assumption that sampling in everyday life is reliable and represents the population from which it is selected. This is often not the case. Sampling, in most instances, is haphazard and unsystematic; hence often results in decisions being biased on inaccurate information (Mouton, 1996). In order to avoid the pitfall of bias convenience sampling was used in this study.
3.6 Data collection and instruments

The sources of data in qualitative research can vary widely, and might include historical documents, governmental records, in-depth interviews, questionnaires developed as part of research protocol for a particular study, observations, participant observation, and so on (Conrad & Serlin, 2006). In the case of this study, semi-structured questionnaires, observation schedules (using, among others, the RTOP instrument for classroom observations) and individual in-depth face-to-face interviews were used. The researcher also used his own observations during training and resulting discussions during the programme as input for this study.

Good research requires that the researcher understands the strengths and weaknesses of the data. As the researcher was programme facilitator/trainer, observer, inspector and researcher, he had to carefully guard against personal bias.

The personal in-depth interviews were conducted after school so as to avoid disruption of teaching and learning. Prior, post and during the time the researcher conducted the interviews, he also set aside separate time to observe some of the aspects of the SANBI programmes implemented within the school such as how teachers were using the school gardens for teaching and learning purposes, as well as lessons and lesson plans of teachers incorporating environmental education. The focus was to determine how teachers were interpreting the National Curriculum Statement to include Environmental Education. He also observed how environmental messages were being communicated to learners by teachers during classes.

The researcher had ample opportunity to interact with teachers during the actual SANBI programme, whilst training and immediately following such training at the training venue, providing “fresh” feedback and input. Such feedback and input is normally neither recorded nor followed up upon. Subsequent to such training, the identified convenience-sampling selected teachers were contacted and asked to
participate in the research. All these teachers showed interest in sharing their experiences of the SANBI programme with the researcher. Each of these teachers related their experiences. Following the observations and discussions during and after the SANBI programme, the researcher started the formal research process with the individual in-depth interviews with teachers.

3.6.1 Questionnaires

Historical data can reflect the biases and ideological preferences of those who recorded it. People who provide data can distort it intentionally to put themselves in a better light; for example, reporting that they had higher grades than they actually did (Clifton, Conrad & Serlin, 2006)

This study was approached with full awareness of potential bias. For instance, teachers can overstate or exaggerate the extent to which they gained skills and knowledge in this SANBI Teacher Professional Development programme. Teachers sampled might deliberately over-state how they were helped by the programme or hold back with criticism to impress the researcher or those who might want this information. In addressing this weakness, triangulation will be used in order to make sure that what is obtained through the questionnaire is verified by actually observing the sampled teachers in class teaching, their school gardens and application of material that was handed out.

Questions in a survey might be ambiguously written or a single item might contain two questions with different answers. For example: “How satisfied are you with your salary and fringe benefits?” A respondent might have no opinion on most of the items. Other respondents might not want to reveal personal information (Conrad & Serlin, 2006). Although the questionnaire might be comprehensive enough, respondents might not understand the questions, might not care about the answers given or might become fatigued while answering the questions. Questions should always be well written and unambiguous (Bean, 2005).
In this study, where questions were semi-structured, it gave respondents (teachers) the opportunity to supply additional information. It rests with the researcher to make sure that questions in the questionnaire schedule are well thought through and unambiguous.

In compiling the questionnaire, the researcher was guided by the following principles:

(a) Questions in the questionnaire are not ambiguous, are to the point and cover all aspects he wants to examine for the purposes of the survey.

(b) The sampling is not biased in favour of a certain group.

(c) Respondents are not forced into difficult choices that do not talk to their experiences.

During this study, a semi-structured and probed questionnaire was used. Teachers were asked a set of questions; they had to answer using their experiences. Teachers were not forced into awkward or pre-determined choices that they would have not wanted to make. Teachers were given the option whether they wanted to participate or not.

The questionnaires explored the teachers’ background, their level of qualification, whether they received any formal training in environmental education. The second part looked at the appropriate curriculum, whether the training provided by SANBI supported them to teach environmental content better, resource availability whether teachers received enough training on how to use resources, whether enough time or opportunity to participate in this programme was given and finally course organisation, what they found useful and how the course could be improved performance.

3.6.2 Interviews

Data gathered from face-to-face interviews for qualitative research has the potential to yield great insights into people’s lives and situations. There is no substitute for prolonged and focused conversations between trusted parties to
discover what is important to the interviewees and how respondents understand key elements in their own lives.

When badly handled, interview data can reflect what the interviewees think the interviewer wants to hear, normatively appropriate responses, as well as the fears and biases of the interviewers. Data flaws become the limitations of the study for which the only response is to caution the reader that the results are far from certain. Structured interviews are mostly used in quantitative surveys, where respondents are asked a consistent set of questions. Semi structured interviews, where a time schedule and set of concept questions may be followed, allow the interviewer to engage the respondent in relatively informal conversation, asking events or opinions. Focus group interviews are when respondents get together as a group and are asked questions as a group and individually, and fully probed as to meaning of the answers. (Conrad & Serlin, 2006)

This study made use of semi-structured interviews. By using interviews, the researcher hoped to reach areas of reality that would otherwise remain inaccessible such as people’s subjective experiences and attitudes. The interview is also a very convenient way of overcoming distances both in space and in time; past events or far away experiences can be studied by interviewing people who took part in them (Denzil & Lincoln, 2008). This aspect was particularly relevant to the interviews that were conducted nearly three years after the first set of interviews. All personal face-to-face in-depth interviews were conducted at the schools where the selected teachers were teaching. The training programme had taken place during the middle of 2010. During this phase, all spontaneous information was gleaned by observation and during discussion. The first phase of interviewing took place during August/September 2010. The second phase was conducted during December 2013.

When the first phase interviews with the selected 16 teachers were supposed to be conducted, a prolonged teachers' strike commenced. It therefore became impossible to interview all the teachers that were supposed to participate in the
study. The researcher then designed a structured self-completion questionnaire that was mailed to 200 teachers who had participated in the SANBI programme. Again, the teacher strike interfered with the returns of the questionnaires and subsequent analysis. It was then decided to restrict the current study to the qualitative research already conducted and to plan a quantitative stage for a later project (not part of this study).

The interview schedule and the analysis on the interview can be found in the Appendices E and F1-F7.

The interview started off by asking the teachers about their backgrounds, as well as their level of qualifications. The interview schedule tried to follow a particular logic but was open to include spontaneous input from the teachers. The teacher background also looked at whether the teacher concerned received any formal training in Environmental Education. The second part looked at the appropriate curriculum. This section looked at whether, from the teachers’ point of view, the training provided by SANBI supported teachers to teach environmental content better. The third aspect of the questions looked at resource availability: whether SANBI provided teachers with adequate and appropriate resources to implement this programme and also whether teachers received enough training on how to use resources that were provided by SANBI. The fourth part of the interview examined whether teachers were given enough time or an opportunity to participate in this programme, while the fifth part looked at course organisation. The sixth part of the interview looked at behavioural interaction, to establish whether teachers were engaged during the workshop and the topics or aspects they found to be most useful. The seventh aspect of the interview explored whether the programme improved performance, whether attending the workshop led to any new skills acquisition. The interviewing schedule/guideline and transcripts of the interviews can be found in the Appendices.

The interviews were transcribed, and the transcribed interviews were coded to identify emerging themes.
3.6.3 Observations

Teachers were observed during the SANBI programme training, discussions were held with them during and after the workshop. Following onto the actual course/workshop, selected teachers were contacted and asked if they were willing to participate in the survey. Upon acceptance, they were informed of the impending visit beforehand. The observations were conducted by looking at the lesson plans (and actual classes), materials that teachers were using, integration of environmental aspects into teaching and learning. This included observing the school’s grounds, consideration of the environment by the school, e.g. does the school have an environmental policy; is there documented evidence on how the school manages natural resources such as water; what do the school grounds look like; is material used in the classrooms; is there a special classroom for Science, what resources are available? In Appendix H I provided a completed Reformed Teaching Observation Protocol (RTOP) form, that was used during classroom visits to determine what transfer took place of new skills and knowledge in the classroom.

3.6.4 Studying artefacts (Documents)

Documents are written material relevant to the development of a qualitative study. They can provide an important indication of an organisation in action. The organisation’s culture leaves its imprint on most of the printed material that is produced. Relevant documents may include memos, letters, meeting agendas and minutes, written reports and evaluations as well as newspaper coverage-and of course teachers’ lesson plans. Getting access to documents, finding out where they are kept and verifying their authenticity and accuracy are important parts of the data collection process (Merriam, 1998). Since documents are typically not produced for research purposes, they might therefore be fragmentary, not fit the purposes of the research and/or might be difficult to authenticate (Merriam, 1998).
It is important to keep in mind that such items have a definite organisational slant to them; so the investigator should be aware that documents reflect the organisation or group as seen through its own eyes. For example, minutes of meetings are often edited to present them in a concise manner. It is important to seek clarification and corroboration of documentary evidence from other sources. For the purpose of this study, lesson plans of teachers and project file, a project file will normally have examples of activities taught in class, other resources that were used such as work sheets, communication letters between SANBI and the schools were used. The documents were scrutinised to see whether teachers used the strategies and resources they got during the SANBI course. For example, lesson plans will reflect examples of lessons that were taught by the concerned teacher. A project file for instance would reflect activities that were done during the workshops and in some cases it will also have teacher reflections. It is also hoped that in these documents evidence of environmental projects that the teacher would have given to the learners would be found. Unfortunately, the researcher was not allowed to take any such material with him from the sampled schools. However, he drew his conclusions from having studied the material at the schools and will report on them under the analysis part of this study.

**Document analysis**

Inside the classrooms, teachers make use of a variety of teaching and learning resources such as posters, preparation files, lesson plans and student assessment reports. Teachers’ files are periodically checked by their head of department. Teachers integrate teaching environmental topics into different subjects. Environmental teaching is supplemented by excursions to places such as heritage sites, Zoological Gardens, and Botanical Gardens.

There is one specific type of observation that is referred to as participant observation. This involves actually gaining access into a setting and getting close to the members of a group or an organisation such that one can observe and
interview them to determine how they participate in, and make meaning of, their social and cultural situations. It is against this background that in this study, the researcher was a participant observer in his role of trainer in SANBI’s Teacher Professional Development Programme, as well as a researcher. This implies that he had access to the teachers not as a researcher primarily, but as a trainer. This aspect made them enter into conversations with the trainer, while in the process he was able to get a deeper understanding of how they think about the course. Participant observation allows one to note participants’ behaviour in actual settings as opposed to what they might say in retrospect on a survey or what they might intend to do. The sum of these various participant observation techniques is sometimes referred to as ethnographic (or field) work.

During the data collection phase, the researcher used a personal journal to record his notes so that he could easily access them at any time. In addition, one should maintain a comprehensive and detailed audit trail. For example, a journal can be used to record daily research activities, including the location of material, the logistics of obtaining the data decisions regarding the selection of data, what piece of data led to other explorations, emergent themes, new research ideas, problems in data collection and analysis, and decisions that were made to resolve research and writing problems. This can be useful in terms of how one made decisions about the data, the trustworthiness of sources and the coding of the information. This provides an important check on one’s initial perspectives versus evolving perspectives and on the subjectivity of the research process, data and solutions (Conrad & Serlin, 2006).

### 3.7 Data analysis

**Process of analysis of qualitative data**

Evidence, analysis and interpretation tend to occur more simultaneously in interpretive types of analysis. Linking the data to propositions is the core of the data analysis. This step has to do with generating concepts that can form foundations of theory (Glaser & Straus, 1967). The coding of the data is integrally
related to their conceptualisation. Conceptual categories become more abstract and hence further from the data.

As the researcher was participant, observer and researcher, he had to continuously guard against reflecting his own content knowledge in the findings and interpretations. However, such knowledge helped him to observe very closely during and after the training process of the SANBI workshop how the teachers responded, what new knowledge and skills they transferred to their classrooms and where they indicated insecurity or lack of comprehension. This applied knowledge and experience also helped the researcher analyse the findings from the various interviews. In analysing the data, the researcher considered at all times what he had observed and noted during the SANBI Teacher Professional Development workshop.

From those observations and the transcripts of the in-depth interviews, he looked at themes that were emerging from the transcripts. Firstly, he transcribed the data. From the codes that were emerging, he then constructed categories that were relevant to the research questions. These categories were further scrutinised in terms of their meaning, and themes emerged. This yielded insightful information about the benefits and shortfalls of a SANBI Teacher Professional Development Programme.

The themes or concepts can eventually be shaped into theory (Saldana, 2009:11; Henning et al., 2007:105; Cresswell, 2007:151). Saldana (2009) explained it by using a diagram (see figure 3.6 below):
There are a number of ways in which to go about analysing the data. One way is to follow the theoretical propositions that led to the study. Linking data to proposition can occur in a variety of ways, including pattern matching (where the information in the case is compared with a theoretical proposition as a hypothesised chronological sequence; explanation building, where one attempts to develop casual links from the study to other known aspects of the phenomenon and emergent categories, where attempts to create new categories from the data as opposed to imposing existing categories from previous research are made. Having some of these propositions at hand helps to organise the analysis and focus on key aspects of the data. This helps in building an explanation. A second strategy, especially for descriptive case studies, is to organise the case around key descriptive aspects, such as key events, themes and patterns that emerge from the data. For the purpose of this study, descriptive aspects such as key events, themes and patterns to organise data will be used.
3.8 Ethical considerations, trustworthiness and validity

3.8.1 Ethics

The permission to conduct this research was received from the Gauteng Department of Education (GDE) provincial office (Appendix C). Permission was also received from the SANBI Biodiversity Education Director (Appendix D). School principals of participating teachers also granted permission for teachers to participate in the interviews. These permissions and consent forms are shown in the Appendix A and B. I was reminded by Cohen et al’s (2002:56) take on ethics in doing this research:

“Ethics is a matter of principled sensitivity to the right of others. Being ethical limits the choices we can make in the pursuit of truth. Ethics say that while truth is good, respect for human dignity is better”.

I provided a letter to all the teachers, explaining the purpose of the research, and also highlighting the following aspects related to their participation:

- Participants were told that they have the right to withdraw at any stage, without any consequences
- Their views will be treated with confidentiality.
- Their names will not be revealed- pseudonyms will be used throughout.

3.8.2 Validity and reliability in qualitative research

Internal validity refers to the technical soundness of an investigation. External validity, on the other hand, refers to the issue of generalisability an investigation is externally valid to the degree that the arrangements, procedures and subjects are representative of the outside setting, thus making results generalisable (Drew, 1976). In this study, the researcher will adopt the role of participant-observer-researcher. He will be a participant observer because, as a programme developer working at SANBI, he will also be responsible for that analysis. He therefore needed to be involved from the onset and throughout the programme. As a participant-observer, the researcher reports on the experiences of the
participants. This raises important issues concerning objectivity and reliability, since people are by nature subjective. The following validity and reliability concerns are relevant to this type of research (Merriam, 1998):

- **Triangulation**: Using different sources of data and/or data collection methods to confirm emerging findings. The word triangulation is used when a variety of data collection methods and sources (generally known as triangulation of methods) are used, but also in the use of different approaches to working the data or building the interpretive text, so that the strength of an enquiry is built (Henning, 2004). This study should produce questionnaire responses, interview transcripts, notes of conversations and observations in the duration of the training.

- **Member checks**: Checking data and tentative interpretation with participants.

- **Peer review**: On-going dialogue and critical reflection with colleagues on research process and tentative interpretations.

- **Reflexivity**: Critical self-reflection by the researcher regarding anything that may bias interpretation e.g. hidden assumptions, own worldview, theoretical orientation, and interrelationship with participants.

- **Audit trails**: A detailed account of methods, procedures and reasons for decisions.

According to Howe & Eisenhart (2014), a valid argument is one that is credible in a general as well as design-specific way – one kind of validity with different design-specific instances. They propose that there are five standards that can be used in educational research; these could prove that the research methods used has some validity.

- **Standard 1**: There must be a fit between research questions, data collection procedures and analysis techniques. Valid studies require a cogently developed design. In addressing this aspect in the research, the researcher used semi-structured questionnaires and classroom observations. The analysis techniques involved drawing codes, themes, merging themes as
they emerged from the data analysis. This led to drawing conclusions that talk to the research questions.

- **Standard 2**: There must be effective application of specific data collection and analysis techniques. Research studies qua arguments cannot be valid without credible reasons for a specific choice of subjects, data gathering procedures and analysis techniques. In this study, this was taken into consideration, the research topic chosen related to the Teacher Professional Development programme the researcher had been part of as trainer, in other words he had a first-hand experience of the programme. The data gathering procedures used was appropriate for a design-based study, the tools used could help to answer the research questions. He also used analysis techniques such as codes, themes, emerging themes, checking data and tentative interpretations with participants, on-going dialogue and critical reflection with colleagues on the research process and tentative interpretations, kept a detailed account of methods, procedures and reasons for decisions (final interpretations).

- **Standard 3**: refers to alertness to and coherence of prior knowledge, where arguments to satisfy this standard, the assumptions and goals embedded in the development and conduct of the study must be exposed and considered. Only if this is done can the arguments derived from a new study be exposed and considered, placed in their appropriate context and the arguments of one study appropriately compared to those of other studies. In this study, the teachers’ prior knowledge was taken into consideration, the study was conducted in an authentic environment (schools) where they are implementing the ideas they had been taught in the SANBI Teacher Professional Development workshops. Assumptions were made about teachers’ level of knowledge about environmental issues, given their exposure to SANBI training workshops and working closely with SANBI trainers.
• *Standard 4*: Value constraints, are where valid research studies qua arguments must include discussion of values that is of the worth in importance or usefulness of the study and of its risks. For this there must be an external value constraint, in other words is the research valuable for informing and improving educational practice? Valid studies must be worthwhile. Valid research studies qua arguments should explicitly address, in language that is generally accessible to the community of interested parties, the importance of the research and its (potential) usefulness. The research should have internal value constraints; there must be research ethics or concern the way research is conducted vis-à-vis research subjects. Although internal value constraints can be distinguished from more conventional issues or research credibility, they are nevertheless crucial to evaluating the legitimacy of research designs and procedures and thus to the validity of a research study. In this study, research participants participated at their own free will, they were never forced to participate in this research, and were informed that they are free to withdraw at any stage of the research; the researcher also used a language that is easy to understand. In addressing the educational practice, the research findings will be shared with research participants, so that teachers will be able to improve their practice where they need to. The research findings will also be made available to the Department of Education.

• *Standard 5*: demands a judgment about the overall clarity, coherence and competence – overall theoretical and technical quality”. Standard 5 also requires a balancing of the overall technical quality, the value and importance of the study and the risks involved in the study – thoughtfulness consideration and explanation of trade-offs.
3.9 Conclusion
This chapter discussed research design, methodology, and data collection techniques as well as how the data would be analysed in this study. The following chapter will provide an insight into the data analysis providing a summary of the research findings.
CHAPTER 4: DATA ANALYSIS AND FINDINGS: STUDYING THE SANBI PROGRAMME FROM A CULTURAL-HISTORICAL ACTIVITY THEORY PERSPECTIVE

4.1 Introduction

This chapter presents an analysis of the data obtained during the various stages of the research. The design-based research and methodology highlighted in the previous chapter provided data that needed to be 'cleaned' and analysed, in order to identify the emerging themes.

4.2 Analysis of the transcripts of the in-depth individual interviews

(The transcribed interviews are provided in Appendix F)

Much of social life in modern society is mediated by written texts of different kinds. For example, modern healthcare would not be possible without patient records, the legal system would not be possible without laws and other judicial texts, professional training would not be possible without manuals and professional journals, and leisure would not be possible without newspapers, magazines and advertisements. Texts of this kind have provided an abundance of material for qualitative researchers (Anssi Peräkylä, 2005).

In many cases, qualitative researchers who use written texts as their materials do not try to follow any predefined protocol in executing their analysis. By reading the empirical materials, they try to pin down their key themes and thereby draw a picture of the presupposition and meanings that constitute the cultural world of which the textual material is a specimen (Denzil & Lincoln, 2008). This perspective informs the researcher's approach to this data analysis. The material does not come as ready-made and packed-for-use by the researcher. This consequently creates an opportunity for the researcher to dig deep into the empirical data to identify what is not obvious and that which links with what is being researched (research questions).
An informal approach may in many cases be the best choice as a method in research focusing on written texts; especially in research designs where the qualitative text analysis is not at the core of the research, but instead in a subsidiary or complementary role. In this respect, no more sophisticated text analytical methods may be needed.

The analytical process started with the analysis of the verbatim transcripts from the in-depth interviews and identified phrases representative of the experiences of educators. The researcher wrote codes that were emerging from the transcripts. From the codes, he started grouping categories together, and then **identified the emerging themes**. These themes were identified on the basis of the responses made by educators in the in-depth face-to-face interviews. While conducting this analysis, there was also continuous reference back to observations made during the training of the SANBI workshop and discussion held with educators during and after the workshop.

A number of themes were identified on the basis of educators having responded with similar perceptions or experiences. The researcher will give quotes to substantiate the themes and categories identified. The transcripts of the in-depth interviews are provided in Appendix F1-F7.

As mentioned in Chapter 3, after the in-depth interviews were conducted, it was transcribed, and the Saldana coding method was used to arrive at five key themes. These themes will be used to provide answers to research question 1: Which professional competencies are developed by teachers attending the SANBI Professional Teacher Development Programme, and how do these competencies manifest in their professional practices?

The identified themes, as established during observation at the SANBI workshop and during the in-depth interview reflected answers to the first question.
Theme 1: The SANBI professional development program resulted in improved teacher knowledge

Knowledge refers to the information that teachers have on Environmental Education – both subject content, as well as pedagogical knowledge. This theme is based on the information received from teachers who completed the in-depth interview at the initial onset of the research process and at the follow-up stage as well as on results from the workshop discussions.

Teachers were asked to identify the most useful part of the workshop and most of these teachers pointed out that the workshop helped them to gain better knowledge of environmental issues and more theoretical knowledge on how to integrate these environmental themes into their teaching. Knowledge included a range of aspects, for instance,

“It supports teaching and learning, there were words a bit strange to learners such as indigenous, horticulturist or biofuels, and the workshop provided proper explanations, so we can give pupils a better understanding.”

“They gave out booklets, so we can use them for lesson preparation, they are curriculum-based.”

“Going through the park you gain knowledge, the history of the Botanical Garden, environmental issues.”

“It tells you about the environment and you get more passionate about it as an educator.”

“It made it very clear how to look at bio-diversity, how plants and animals are linked and all other parts of the environment.”

“It teaches us about alien plants and that they use too much water.”
In other words, the workshop helped teachers to improve their content knowledge in subjects related to Environmental Education. Some stated that EE had been taught to them only in the first year of their own studies and had not been revisited thereafter at college or university. This means that workshops and extra courses are essential for teachers to become up-to-date with EE issues. It does not yet mean, however, that such newly-gained knowledge is then always applied/implemented.

Research on environmental teaching shows that many teachers have limited past knowledge of environmental content and concepts, probably because the environmental subject matter is new in the South African education system and it is also changing rapidly. In many cases, teachers teach environmental content and concepts at levels that are too basic, depicting that they actually lack the relevant skills and prior content knowledge in this subject. Educators across the curriculum need to develop appropriate levels of understanding of the content. In many instances, teachers also do not make time to take part in teacher education programmes that seek to close this gap. As participation in the SANBI workshop was a) voluntary and b) limited to teachers who were interested in environmental education or already taught one of the natural sciences, it could be assumed that these teachers would have had some prior knowledge of EE. It speaks to the quality of the workshop that these teachers believe they gained further knowledge. (I will later in this chapter discuss issues of triangulation, and provide evidence of knowledge transfer during the lessons observed).

**Theme 2: Integration of environmental education in various subjects took place: Epistemological border-crossing**

Integration refers to the methods that teachers may use to assimilate Environmental Education into other learning areas. According to the teachers, they believed that the SANBI Teacher Professional Development workshops provided them with an opportunity to integrate Environmental Education firstly into their normal daily teaching, daily lives and also into other subjects. According
to the feedback received, teachers were introduced to practical ideas that they could use in their classrooms. Teachers who participated in the workshop stated: “This workshop helps us in the integration of environmental content into the Natural Science lesson.” “The garden serves as a resource for learning. We arrange school visits to Botanical Gardens and use case studies to create scenarios that are relevant to the content of Natural Science.” “I now realise I have to be involved in the environment. It showed us how to integrate it into the curriculum, do the lesson plan and deal with the environment as an educator.” “It gives input for the governing body.” The course was supportive as we saw how to deal with the outside environment.” “Group work make you see that your subject also fits into other teachers' work.”

In the past, teachers often struggled to identify areas of integration. Given the history of teacher education, teachers were trained on how to teach specialised subjects, become experts in them and in many cases these subjects were viewed as isolated from each other, such as History or Maths. It is therefore important to change the mind-set of many teachers in this regard. Some interviewed teachers stated that,

“This workshop will help me improve integration, clustering of concepts and conceptual progression.”

“The workshop will help the school to integrate and design activities relevant to Environmental Education, for example, the importance of looking after plants and beautification of schools and make schools attractive as learning centres.”

“We try to include all learning areas, not just Life Science, but also the Humanities, we even include languages.”

“There’s a cascading effect of what happens at school, we start and it goes to the other teachers.”
Integration of the EE topic into other lesson plans and other subjects will only be achieved if there is close cooperation between teachers, if there is an 'open' attitude among management towards such integration and a community has been created in the school, as discussed in Chapter 2 (Wood, 2007, Lave & Wenger, 1991).

**Theme 3: Adopting pedagogies that address environmental issues (problems), thus moving towards Mode 2 “context-sensitive science”**

Gibbons (2000) distinguishes between mode 1 and mode 2 knowledge production. In mode 1, problems are set and solved in a context governed by the academic interests of a specialised community (e.g. subject experts, or curriculum developers of the Department of Education). In mode 2, knowledge is produced in a context of application involving a much broader range of perspectives. Mode 2 is trans-disciplinary, as typically the case with environmental education. Gibbons (2000:161) states the following:

“...society can (and will with increasing frequency) ‘speak back’ to science. The idea of science communicating with society is familiar enough. Now, society is speaking back to science. Reverse communication is generating a new kind of science, let us call it context-sensitive. In epistemological terms, context-sensitive science is new in the sense that it produces socially robust knowledge that is, knowledge likely to be reliable not only inside but also outside the laboratory.”

And this is really what the SANBI programme envisages: utilising a border-crossing approach where environmental education sheds light on specific problems in society.

Environmental issues are harmful effects of human activity on the biophysical environment. Environmentalism on the other hand addresses environmental issues through advocacy, education and activism. Teachers said that the SANBI's Teacher Professional Development workshops assisted them in
identifying problematic environmental issues better. These are often complex and not easy to identify, sometimes being hidden to the uniformed.

“We often see problems in the environment too late.” “Children do not want to touch soil; they think it is poisonous.”

“Vandalism in schools and on school grounds makes the problems even more serious, where resources are destroyed or stolen and then we cannot work with the environment.”

“We could think it is a weed and it is not, or we think it is a useful plant, but it is exotic or even poisonous.”

Through participation in the Teacher Professional Development workshop, teachers were trained on how to identify environmental issues in their immediate environments. They should now be able to respond to environmental issues through a facilitated learning programme. Teachers are then able to use their school grounds for teaching and learning purposes. Commenting on the usefulness of the workshops, some teachers stated:

“The workshop made people aware about problematic environmental issues. One cannot separate the community from the school when it comes to environmental issues.”

“I’m now informed and will be able to advocate the environmental education issues.”

This suggests that although environmental issues are always present, they are not always easily or correctly identified. This therefore also suggests that teachers need help from facilitators to enable them to recognise and identify such issues and to learn how to address them appropriately. Having been exposed to examples of such environmental issues during the SANBI workshop, teachers believed they now had more theoretical knowledge and confidence after the workshop intervention. However, it became obvious that the previous two themes
were far clearer in respondents’ minds than being able to identify environmental problems or issues. This leads to another challenge: if too few people – be they leaders, teachers or learners – identify or describe problems in their environment, they will then also automatically not seek solutions to the problems or seek to avoid the problems from occurring. They will then also not take such issues seriously. This can be seen in allowing soil erosion to occur, littering, leaving broken pipes unattended to/not reporting them, and so forth. This would happen wherever there is a short-term vision.

**Theme 4: Enhanced environmental awareness, and appropriate affective development**

Environmental awareness goes beyond knowledge. It means to understand the fragility of our environment and the importance of its protection. Promoting environmental awareness is the first step towards becoming an environmental steward and participating in creating a brighter future for the next generation. Teachers felt that the SANBI Teacher Professional Development workshops helped to increase their awareness of the environment, and they said,

“…we hope that they would be able to mobilise the entire community so that their level of awareness about environmental issues was also raised.”

“I will be able to link the principles of the Earth Charter to lessons teachers deliver in class, and also encourage community awareness in environmental issues.”

“Schools will be able to raise environmental awareness with their different communities.”

In many cases, schools in the townships are suitably placed for Environmental Education, given the extent of environmental issues that are found in their vicinities, most of which the various communities are not even conscious of. Therefore, building a solid community of environmental educators in the township
schools, if done correctly, can have good results in terms of benefitting the wider community. Comments during the training workshop and the in-depth interviews were:

“There is a general lack of awareness about environmental issues in schools and communities.”

“This lack can be addressed if schools have a strong foundation in Environmental Education as they could start engaging the surrounding communities in matters such as being able to identify toxic or alien plants and also remove them from their yards.”

“Communities could be introduced to the indigenous plants and be taught their importance.”

“We can all become more aware how not to waste water and to plant the right plants.”

It will probably take vigorous training to move teachers to a point where they could start sustained programmes that raise community awareness on key environmental issues such as water wastage. The National Curriculum Statement and its environmental components, have the theoretical potential to greatly enhance the relevance of what is being taught, thus increasing learner participation, meaningful learning and application (NCS). The curriculum creates spaces for educators to bring in local content: (i) choose a local social or environmental issue for the learners to investigate in life orientation, or (ii) choose a positive case study of sustainability practices to explore in Social Studies or Geography (NCS).

Programmes like the SANBI’s outreach greening and SANBI Teacher Professional Development help to provide practical projects in and around the schools, which educators can then draw on for classroom-based teaching. Schools involved in these kinds of activities report closer school community
relations and a greater sense of relevance in the educational act. Therefore, teachers should look out for locally-based environmental learning opportunities. These can enable the epistemological access and participation in learning. This also has the potential to increase teacher motivation (Van Rensburg & Lotz-Sitka 2000).

From the teachers’ responses, it became clear that there was more than just cognitive development (enhanced knowledge), but that teachers also achieved much-needed affective outcomes. Krathwohl et al. (1964) developed a taxonomy for the affective domain, in which the following levels were identified:

Level 1: Receptive category
Level 2: Responding
Level 3: Valuing
Level 4: Organisation in a value-system
Level 5: Characterisation

All the teachers in the study reported that they became more aware on environmental issues. Some of the teachers indicated that they started to respond to issues (e.g. taking action), and several teachers also provided evidence of valuing environmental education. These affective gains are an important outcome of the SANBI programme.

**Theme 5: Synergy/linkages between schools and communities (a systemic approach to environmental education)**

Some of the teachers had the following to say:

“It is so exciting to be working with NGO’s that does environmental education. These organizations are valuable partners and resources for schools, and I feel energized by their involvement in our school”.

“SANBI provided us with so many links with organisations working in environmental education. I have realised that in EE we should be working together, to achieve more”.

Environmental Education and associated projects like the SANBI Teacher Professional Development Programme, and activities such as litter clean ups, soil erosion stabilisation, schools greening and garden-based programmes often help to foster stronger links between schools and their communities (Van Rensburg & Lotz-Sistka 2000). If appropriate, these projects can serve as extra-mural or community-based activities. They can also be linked to national curriculum–based classroom work in Life Orientation, Geography, Life Sciences, Technology and others (Van Rensburg & Lotz-Sistka 2000). There is a real opportunity to explore locally relevant issues such as poverty, access to resources like water and waste management facilities, food security and other environmental issues afforded by the National Curriculum Statement, and giving teachers a sense of meaning and satisfaction that they are indeed making an attempt to address the socio-economic challenges which they witness on a daily basis, and which affect many people almost every day (Van Rensburg & Lotz-Sistka). This will also ensure that the school-going youth in South Africa are afforded an opportunity to acquire the knowledge, skills and values that will help to ensure socio-economic and ecological sustainability and their wellbeing. The environmental focus in the curriculum also contributes to the educational development in the country by:

- Contextualising teaching and learning, thus addressing the need to base schooling on learners’ needs and experience
- Enhancing integration across the curriculum, since environmental issues are multi-disciplinary by nature
- Contributing to the development of critical thinking and problem solving skills
- Creating opportunities for mobilising indigenous knowledge; for example, in the management of natural resources like soil and water
- Forming a platform from which to improve the health of the learners and the school environment. For example, better managed school grounds, waste management, food gardens and greening of the school yard. The environmental focus in the curriculum also develops important life skills
necessary for solving the challenges of the 21st century such as poverty, environmental degradation, climate change, water scarcity, environmental health problems, and so forth. (Van Rensburg & Lotz-Sistka 2000).

4.3 Discussion of data resulting from the study of artefacts and observations

The visit to schools offered a very good opportunity in terms of observing how teachers were implementing Environmental Education in their schools. First-hand observation gave the researcher an insight that cannot be replaced by a distant study or correspondence. The researcher found that in general, the teachers who attended the SANBI workshop programme were passionate about Environmental Education. The same themes that were identified when analysing the interview transcripts, emerged here as well. For instance, teachers clearly developed relevant pedagogies to teach EE, such as developing resources such as school gardens.

During the observations of teachers in action, the researcher took notes for easy reference after each class. In this regard the RTOP instrument was used. In many of the schools visited, there was evidence that Environmental Education is taught, but not at the required depth or scale. During SANBI workshops, teachers struggled with terminology and academic jargon. This makes it difficult for teachers to understand some of the technical terms in EE. Many of the teachers who attended SANBI workshops use English as a second language and this makes learning of a new topic and many foreign words a real challenge.

In the various schools that were observed, most had started a school garden and were proud to show what they had achieved. In one school, the teacher provided examples of activities that were done with the learners. The teacher took the learners to the indigenous garden within the school yard to show them different parts of a plant or teach them about different ways of multiplying plants. One of the Life Sciences teachers indicated how he uses the school indigenous garden to teach the concept of photosynthesis. The researcher was privileged to observe
one of the teachers guiding learners to collect evidence of biodiversity in the school garden. Learners were asked to observe and record any form of biodiversity that they could find in the school garden. They were also given soil and compost organisms. They used this to identify organisms that they could find in the garden. This approach proved to be useful in terms of increasing learners' knowledge about soil and compost organisms, how they relate to growing plants and how everything relates to each other.

In another school the relevant teacher showed how they had set up a resource room. This resource room was a micro-library composed of a project file with pictures of workshops as well as pictures of the school garden as it was being developed by the project team. The pictures showed different stages of the project. The school did not have the space or facilities to have a proper Science room.

It was observed that in the schools visited, learners are not allowed to walk through the school gardens and they are not allowed to pick flowers from the school garden. They are informed why these rules are there and are taught to appreciate plants. Littering is also not allowed, school prefects are specifically instructed to look out for learners who throw litter on the grounds. Learners are encouraged to dispose of litter into the provided bins.

The researcher further observed in one school that there were many posters hanging on the classroom walls. These were posters about environmental subjects such as wild animals, biodiversity, water issues, and so on. However, he could not establish if and how these posters were being used in the teaching and learning context other than being visible on the wall.

In one school, the participating teacher showed how the school, after participating in the SANBI Teacher Professional Development Programme, got involved in a can recycling project. It would appear that when schools get introduced to an environmental project, they eventually also get involved in some other environment-related projects. In another school, it was observed that the
school had finished the project cycle from a SANBI project, and used knowledge that they derived from the SANBI Teacher Professional Development Programme to start a hydroponics organic farming project, where they were planting tomatoes, carrots and other vegetables using a “perma-culture principle”.

On the next few pages, I indicate what the nature of data was that emerged from the RTOP instrument that was used. RTOP proved to be a useful instrument to determine what the level of transfer was that occurred. More examples of RTOP instruments are found in Appendix H.

**Figure 4.1: An example of a completed RTOP instrument**

![RTOP Instrument Example](image-url)
Record here events which may help in documenting the ratings.

<table>
<thead>
<tr>
<th>Time</th>
<th>Description of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:02</td>
<td>The teacher greets the students; They discuss the homework assignment of the previous day. The class deals with plant diversity today. The teacher provides the learners with a one-page worksheet, and learners are asked to walk on the school grounds (there are a number of plants growing from various taxa), and to complete the table identifying:</td>
</tr>
<tr>
<td></td>
<td>Mass</td>
</tr>
<tr>
<td>09:07</td>
<td></td>
</tr>
<tr>
<td>09:24</td>
<td>The learners are back in the classroom, and learners are asked to provide examples in each of the plant groups. Communication was restricted between conversations between the teacher and learners and not between learners themselves:</td>
</tr>
</tbody>
</table>

I was disappointed that the teacher did not point...
III. LESSON DESIGN AND IMPLEMENTATION

<table>
<thead>
<tr>
<th></th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>The instructional strategies and activities respected students' prior knowledge and the prerequisites inherent therein.</td>
<td>0 1 2 4</td>
</tr>
<tr>
<td>2)</td>
<td>The lesson was designed to engage students as members of a learning community.</td>
<td>0 1 6 4</td>
</tr>
<tr>
<td>3)</td>
<td>In this lesson, student exploration preceded formal presentation.</td>
<td>0 1 2 4</td>
</tr>
<tr>
<td>4)</td>
<td>This lesson encouraged students to seek and value alternative models of investigation or of problem solving.</td>
<td>0 1 6 4</td>
</tr>
<tr>
<td>5)</td>
<td>The focus and direction of the lesson was often determined by ideas originating with students.</td>
<td>0 1 2 3 4</td>
</tr>
</tbody>
</table>

IV. CONTENT

Propositional Knowledge

<table>
<thead>
<tr>
<th></th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>6)</td>
<td>The lesson involved fundamental concepts of the subject.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>7)</td>
<td>The lesson promoted strongly coherent conceptual understanding.</td>
<td>0 1 6 3 4</td>
</tr>
<tr>
<td>8)</td>
<td>The teacher had a solid grasp of the subject matter content inherent in the lesson.</td>
<td>0 1 6 4</td>
</tr>
<tr>
<td>9)</td>
<td>Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>10)</td>
<td>Connections with other content disciplines and/or real-world phenomena were explored and valued.</td>
<td>0 1 2 3 4</td>
</tr>
</tbody>
</table>

Procedural Knowledge

<table>
<thead>
<tr>
<th></th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>11)</td>
<td>Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>12)</td>
<td>Students made predictions, estimations, and/or hypotheses and devised means for testing them.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>13)</td>
<td>Students actively engaged in problem-solving activity that often involved the critical assessment of procedures.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>14)</td>
<td>Students were reflective about their learning.</td>
<td>0 1 2 3 4</td>
</tr>
<tr>
<td>15)</td>
<td>Intellectual rigor, constructive criticism, and the challenging of ideas were valued.</td>
<td>0 1 2 3 4</td>
</tr>
</tbody>
</table>
### Classroom Culture

#### Communicative Interactions

<table>
<thead>
<tr>
<th></th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Students were involved in the communication of their ideas to others using a variety of means and media.</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>The teacher's questions triggered divergent modes of thinking.</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>There was a high proportion of student talk and a significant amount of it occurred between and among students.</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>Student questions and answers often determined the focus and direction of classroom discourse.</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>There was a climate of respect for what others had to say.</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Student/Teacher Relationships

<table>
<thead>
<tr>
<th></th>
<th>Never Occurred</th>
<th>Very Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Active participation of students was encouraged and valued.</td>
<td>0</td>
</tr>
<tr>
<td>22</td>
<td>Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.</td>
<td>0</td>
</tr>
<tr>
<td>23</td>
<td>The teacher was patient with students.</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>The teacher acted as a resource person, working to support and enhance student investigations.</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>The metaphor &quot;teacher as facilitator&quot; was very characteristic of this classroom.</td>
<td>0</td>
</tr>
</tbody>
</table>

Additional comments you may wish to make about this lesson:

I was glad to see that the teacher actually did use the school garden as a resource; however, this could have been done better.
The following themes emerged from the classroom observation data (building on the 5 themes already identified):

**Theme 6: Some transfer of skills and knowledge (obtained during the SANBI intervention) occurred in classrooms**

When studying the RTOP data, it became evident that some transfer of newly acquired knowledge and skills from the SANBI programme to the classroom did materialize. In the above example, the teacher, busy with a lesson on plant biodiversity (Grade 7 Natural Sciences), asked learners to complete worksheets in the school garden, where they had to find examples of mosses, ferns, gymnosperms, monocots and dicots. In another lesson observed, this time a Grade 10 Life Sciences lesson (refer to Appendix H), a teacher gave the learners an interesting assignment to produce a poster on the effects of the loss of biodiversity, and actually lobbied with a few environmental education organisations to sponsor prizes for learners with the best posters. It therefore seems as if the SANBI programme succeeded in convincing teachers of the holistic and systemic nature of EE, and that there are many organisations that can give a helping hand.

**Partnerships**

It was observed in another school that, after the teachers had participated in a SANBI Teacher Professional Development Programme, the learners started a carton (paper) recycling project. This project was being facilitated by a well-established recycling company. This pointed to the fact that these schools were beginning to look at partnerships, using partners to strengthen the teaching of Environmental Education. This was a creative way of engaging partners in education. In another school, it was observed that there was a big painting on the wall, with a clear environmental message that the school must save water: “Water is life”.

Some other observations:

- **Seniority of involvement**
  The schools were selecting relatively senior teachers to participate in environmental programmes. In one school, a deputy principal was one of the teachers who were attending the SANBI training. This sends a message to the remaining teachers that the school was taking Environmental Education seriously. This also helped in the cascading and sharing of knowledge as the other teachers tended to take something that feeds downwards from school management level more seriously.

- **Limited recognition**
  However, in the researcher’s interaction with the teachers, he realised that teachers who were taking part in environmental projects were not being acknowledged through the performance management system. The school had adopted an integrated quality management system as a performance management system for teachers. This should have provided the opportunity to motivate teachers who are going an extra mile, but this is currently being underutilised. There is also a tendency in most of the schools, to leave environmental projects to certain teachers. These teachers are given the sole responsibility to lead these EE projects. The disadvantage of this system is that other teachers do not develop an interest in the topic or subject, do not see it as their responsibility to implement Environmental Education projects in their own curriculum and do not get involved in EE school projects.

**Theme 7: Not all the teachers realize the importance of fostering self-directed learning among learners**

In the RTOP instrument (refer to Appendix H) there are a number of Likert-scale items, that are of particular relevance. During the SANBI programme, emphasis was placed on aspects such as problem-based learning, cooperative learning and assessment practices that would foster self-directed learning. It is interesting
however to see that, whereas some teachers provide evidence of fostering approaches that would improve self-directed learning (e.g. Teacher B), other teachers (e.g. Teacher A) did not seem to alter their approaches after the SANBI course. (Refer to Table 4.2). I acknowledge the fact that a Likert scale is used in quantitative research, whereas this is a qualitative study. However, several researchers have used the RTOP instrument in qualitative studies (e.g. De Beer & Ramnarain, 2012; Cronje, 2015), and therefore the use of the RTOP (with its Likert scale) in a qualitative paradigm is not something new. Due to the small sample size, the RTOP data was not subjected to any statistical analysis; it just provided a more nuanced understanding of teachers’ practices.

Table 4.2. Teacher A and Teacher B approaches to selected items in the RTOP instrument (Refer to Appendix H)

Likert scale: 0 = never occurred; 4 = very descriptive.

<table>
<thead>
<tr>
<th>RTOP Item</th>
<th>Teacher A</th>
<th>Teacher B</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lesson was designed to engage students as members of a learning community</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>This lesson encouraged students to seek and value alternative modes of investigation or problem solving</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>The focus and direction of the lesson was often determined by ideas originating with students</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Students were actively engaged in thought-provoking activity that often involved critical assessment of procedures</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Students were reflective about their learning</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Students were involved in the communication of their ideas to others using a variety of means and media</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>The teacher’s questions triggered divergent modes of thinking</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>There was a high proportion of student talk and a</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>
significant amount of it occurred among the students

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Student questions and comments often determined the focus and direction of classroom discourse</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>The teacher acted as a resource person, working to support and enhance student investigations</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

This illustrates clearly the value of supportive communities of practice. Teacher B indicated the presence of a supportive community of practice; Teacher A did not.

4.4 **Interviews in December 2013 (Three years later): Is the SANBI program a “flash in the pan”?**

So often, professional development programmes or interventions are a “flash in the pan”, ad hoc efforts: teachers complete the programme, obtain their certificates, and then go back to school, where they teach like they used to teach prior to the programme. Zeichner and Tabachnick (1981) showed that many of the concepts taught during teacher education programmes are “washed out” during teaching. The researcher attempted to determine whether this “washing out” of ideas also applied to the SANBI’s Teacher Professional Development programme, and therefore waited three years, before conducting interviews with some of the same teachers again. Quite a bit had changed at the schools since the first phase: principals had moved, teachers left and new teachers joined, buildings had either deteriorated or improved.

The interviewed teachers indicated that they are still engaged in Environmental Education work. One of the participants was the chairperson of the maintenance committee and secretary of the SGB, and utilises this seniority to bring about Environmental Education change. Another interviewed teacher is still passionate about environmental education, and has since completed an honours degree in
Environmental Education, but it seems as if she has little support in her school, to advance Environmental Education, as expressed in her statement:

“I’m isolated at the moment; the spirit is not the same like before, when we were still doing the course... (There is) a lack of interest from management”.

This would imply that the SANBI programme was effective in motivating the teachers, but unfortunately the support structure often collapses after such an intervention, and the teachers who are still committed find themselves isolated. Where there is management/principal support, the projects grow, new projects are started and built up, some of them involving the wider community (Arbour Day events, planting of trees in the community).

**Theme 8: Although the SANBI programme is beneficial, a lack of continued support leads to an erosion of outcomes**

Generally, the interviewed teachers did not show any dramatic changes to what they had stated during phase 1, they believed the workshop intervention had created knowledge, awareness, had been implemented and shared with others. However, there tended to be the attitude that EE and Science teachers were left to their own devices if the principal was not behind the EE schemes. Thus, overall, the strengths of the workshops were that they did create new impetus and knowledge and were visibly effective for some time. However, if these courses were not repeated or approached in a holistic manner throughout the whole school, their weaknesses were that they lost their impact altogether after some time.

**4.5 Program Pitfalls**

The data related to the constraints in this programme was collected through in-depth interviews and observations. Subject advisors were also participants in these workshops and they were in turn expected to take responsibility for the professional development of teachers in the schools falling under their
jurisdictions. When teachers were asked to identify the challenges and constraints related to implementing Environmental Education policy in their schools, some teachers were still uncertain as to how to implement the Environmental Education lessons into the developments in the National Curriculum Statement.

- The project was perceived to be adding more work to the teachers who felt already overloaded.

- Teachers did not have or make enough time to attend the workshops as these workshops could only be done after school. In many cases, by the time teachers attended the workshops, they were tired already, and this consequently limited their contribution or absorption ability of important facts. Due to this constraint some of the workshops were facilitated during weekends and, again, this was also perceived to be infringing on the teachers’ private time.

- The fact that the training is not accredited elicited some reservations by the teachers, as they would not get credits towards a qualification after participating in this programme.

- Teachers found themselves having to shift from “chalk and talk” to facilitation of learning. For many teachers this was not an easy transition.

- Despite the intervention of this programme, teachers still perceived themselves as not having adequate and subject-specific knowledge about environmental issues other than those covered in the workshop. They did not feel that it was up to them to carry on seeking more information. The odd teacher (from a better-performing school) looked to the internet, newspapers and magazines to improve her EE knowledge.

- Although teachers participated in these workshops, they were still not confident about developing learning programmes on their own. It was also observed that there was not enough monitoring and following up of workshop processes by SANBI facilitators.
- The workshops that are facilitated by the Department of Education used a piece-meal approach. In other words, there was no whole-school approach to active environmental learning.

- The management/principal support for this intervention in many cases was lacking. In some instances, the school management cited the fact that they themselves had no background in environmental studies, and therefore did not know how to provide leadership.

- Although there was a strong environmental focus in the National Curriculum Statement, this is not adequately carried over into provincial guiding documents, the learning programmes at schools and teachers' classroom activities, including assessment and examination practices.

- The national Environmental Education project research particularly focused on the role of subject advisors or curriculum advisors who found that this level of support was inadequate for the challenges teachers were experiencing and in terms of innovation or capacity to support implementation of the curriculum at district level.

- Curriculum advisors were themselves poorly supported to respond to the new challenges of the OBE teaching and learning environment. Therefore, to expect that school management teams will be able to provide support in this kind of project is being over-ambitious.

- It was also observed that there are not enough learning support materials to support the learning and teaching of environmental themes.

Schools, in many cases, operate on limited budgets, and therefore cannot afford to buy extra materials to supplement teaching and learning.

“We were given some booklets and brochures, but we had to make photocopies for everybody else, and that is too expensive.”

“Our photocopier has not worked for 4 months, so we cannot make copies.”
“We do not get them in bulk, making copies took us longer than expected to be able to hand them to learners.”

There were, however, also the positive responses to the availability of resources.

“We were given lots of brochures and booklets, enough for all of us.”
“We shared worksheets with others.”

However, it was also observed that teachers lacked the experience in developing environmental learning support materials as they were comfortable with working exclusively with already provided materials. From the interviews conducted, it was clear that teachers were expecting that these materials would be developed by the Department of Education and then delivered to them ready to be used. Perhaps this mind-set comes from their previous training and experience, which made teachers rely on resources that were developed by consultants, who in some cases had never been teachers. As a result, these resources never fitted the context in which they were to be used. At times, textbooks lacked sufficient content in a misguided attempt to be OBE compatible. At times, teachers have access to good resources for Environmental Education, but are unsure as to how to use them, partly because they do not have a good enough grasp of the subject, and partly because they are not experienced in using resources other than textbooks. Learner support material research in Environmental Education shows that teachers are inclined to choose easy-to-use resources that include both environmental content and ideas for activities (Van Rensburg & Lotz- Sistka 2000). This research showed that knowledge resources in resource packs were essential for informing teachers on what they could teach, since they lacked such knowledge from prior experience or training. Teachers equally need knowledge resources at the appropriate level and in appropriate languages for learners to access and read, otherwise learners are consistently dependent on what teachers say and do not get adequate opportunities to read and write, thus hampering their literacy and communication skills development. Teachers also felt that it would be essential to have Teacher Guides together with the material
given to the learners, so that they could be prepared for questions, would have a
glossary and suggestions for further reading/research.

There was also a feeling that there are too many NGOs and other government
departments approaching schools with projects. A lack of proper co-ordination of
this type of support leaves teachers confused because they do not know which
project to support and which one not to support. Research shows that the time
educators spend actually teaching has a significant impact on the results of their
learners. Programmes like the SANBI Teacher Professional Development
Programme have tried to make an effort to assist teachers with what they are
meant to teach (environmental content of the curriculum, towards environment-
related outcomes (aligned to the specific aims in the CAPS) and for extra-
curricular activities). Teachers are motivated by such programmes, but normally
this remains an isolated instance in schools, where one or two teachers stay
involved in such programmes. Frequently, teachers who make extra efforts are
also not well supported in schools by colleagues or principals and thus eventually
give up their efforts. Wider structural issues such as the quality of leadership in
the school, the habit and culture of the school and teachers’ commitment to
teaching for a full school day appear to have greater influence on innovations in
schools.

4.6 Using third-generation cultural-historical activity theory

(CHAT) as a lens to identify tensions in the activity system

Results show that the SANBI Teacher Professional Development programme is
seen by teachers to be a success. However, there are also a number of tensions
that arise, if one looks at the programme through a Cultural-Historical Activity
Theory lens. Subscribing to Van Lier’s notion of an expanded Zone of Proximal
Development, with several layers of mediation (mentoring) support, this implies:

- Inner resources (resourcefulness, self-access)
- Interaction with less capable peers ("we learn by teaching")
- Assistance from more capable peers (scaffolding; mediation)
Interaction with equal peers (If one member of a dyad undergoes developmental change, the other is also likely to do so).

From the observations and the in-depth interviews, it emerged that the less thorough education a teacher has received, the less resourceful they are in teaching, or finding innovative solutions to problems, particularly the Science subjects. This means that they expect to be spoon-fed with material for them and the learners, they do not innovate and do not understand new concepts.

Also, not all teachers enjoy the support of a community of practice – a tension between the teacher and a (lacking) community. This means that less capable peers do not receive input from their more capable peers. Interaction with equal peers again only happens at well-resourced schools where there is time available for such exchanges. Scaffolding only happens at better-resourced schools where there is clear leadership and buy-in at senior level. The management of a school/principal is not always supportive of environmental education initiatives, particularly if they had no EE or science education themselves or were never involved in any such workshops/training programmes.

Although the SANBI programme has assisted some teachers in their PCK development in teaching environmental education themes, there is still tension in terms of the subject (the teacher) and the tools.

Rogan’s Profile of Implementation makes it clear that teacher development is a long-term process. Despite the positive influence of the SANBI programme, there are still incidences during lesson observation of transmission-mode teaching, although the SANBI programme promotes inquiry-approaches and active learner engagement (and a focus on self-directed learning). Some of the teachers’ apparent content knowledge is also not of the standard expected, and in some incidences, their PCK under-developed. By using the RTOP instrument, the researcher elicited through in-class observation that teachers still do not easily structure their lessons around the environmental principles that were discussed during the SANBI programme, e.g. lessons in the school garden.
Another tension exists between the subject (EE teacher) and the school rules. One example of such a tension is where the school rules do not make provision for excursions, as recommended for environmental education to provide learners with practical proof of how plants grow, where water is wasted, how to grow a school garden, and so forth. However, there are either no funds available for such excursions or the school policy does not allow them.

**Figure 4.1. Tensions in the activity system** (In this particular instance, the black arrow (lightning stroke) refer to a tension between the rules and the subject; e.g. that the teacher find the CAPS guidelines (as part of the rules) confusing).

Another tension highlighted in this research is between the tools needed and the school leadership, e.g. where the teacher requires certain resources for teaching EE, and the principal is not supportive to provide such resources.
“Ideally, we would need a lab and apparatus, but the lab is being used as a classroom, so there are no practical demonstrations, the teacher needs to carry any apparatus from one class to the other, it wastes time to set up, can get damaged. There is no support from the principal for that problem.”

“We want to take learners on trips to gardens, but the problem is transport, money is not going to be given for that.”

“A facilitator has a difficult job to force things down, it depends on the system, the principal decides X, Y, Z…”

Since CHAT was used as lens for this study, a number of tensions were observed for example, some schools have teachers who generally like environmental education, these teachers work very hard to mobilise their schools, but unfortunately they do not get the necessary support or recognition they deserve; their efforts go unnoticed and this – in the long run – discourages them for carrying on to implement EE.

In some schools, it was observed that tensions relate to the fact that although the school principal wants to help and provide leadership, he or she does not necessarily have the required knowledge about environmental matters and ends up not knowing what to do. In other schools, it was observed that CHAT tensions relate to the fact that some teachers are overworked since many schools are short staffed, so they do not have time to try out new methods during normal school hours. Another tension relates to the fact that teachers do not have the necessary tools in the form of the appropriate learning resource materials or lack the knowledge how to use them, there are not enough text books, students have to share text books, and this in turn limits the amount of time students can spend using the text books.

There were also positive aspects emerging from the use of CHAT as a lens. The SANBI programme, and its efforts to establish a community of practice, did allow
for a more supportive “community” in this activity system. Teachers could also contact teachers from other schools (who were also part of the SANBI intervention), in their own learning mediation, where the CoP in the particular school could best be described as a pseudo-community of practice.

### 4.7 Conclusion

This chapter has provided an insight in terms of how the data was collected, and the process that was followed to analyse it. It also provided details of observations. The data obtained through in-depth questionnaire schedules is also explained in this chapter.

The researcher used triangulation to identify eight (8) emerging themes, that were discussed in this Chapter:

1. The SANBI professional development programme resulted in improved teacher knowledge
2. Integration of EE in various subjects took place: epistemological border-crossing
3. Adopting pedagogies that address environmental issues, thus moving towards mode 2 context-sensitive science
4. Enhanced environmental awareness, and appropriate affective development
5. Synergy/ linkages between schools and communities (a systemic approach to EE)
6. Some transfer of skills and knowledge occurred in classrooms
7. Not all the teachers realize the importance of fostering self-directed learning among learners.
8. Although the SANBI programme is beneficial, a lack of continued support leads to an erosion of outcomes.

The next chapter will provide a summary of findings and recommendations, as well as a reflection on the limitations of the study, as well as its contribution.
CHAPTER 5: SUMMARY OF THE FINDINGS AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses the key findings of this design-based and interventionist study. I will reflect on the emerging themes, and will also provide the design principles distilled from the study. This chapter will also provide recommendations based on the research findings. This research report is concluded by a look at key findings of the study and the main actions that need to be taken, if the identified gaps are to be closed. The aim of this study was to conduct research on the South African National Biodiversity Institute’s (SANBI’s) Teacher Professional Development programme in Environmental Education, during the different cycles of assessment and implementation of new innovations, to determine its short-term and sustainable impact on teachers’ practices.

5.2 The South African National Biodiversity Institute (SANBI)

A number of organisations have developed Teacher Professional Development Programmes to meet the challenges presented by the CAPS. The assumption is that HEI’s should not be the only grouping responsible for teacher professional development. Organisations such as SANBI can play an important role in assisting with teacher professional development. For the past six years, SANBI has been working with schools in five Environmental Education centres, located in Nelspruit, Cape Town, Pretoria, Bloemfontein and Roodepoort, to implement the Teacher Professional Development Programme (PDP). The motivation for this is that SANBI’s interventions are informed by the constitutional as well as the CAPS requirements for teachers. The programmes operate in such a way that teachers participate without having to undergo formal examinations.

Further, the programme is conducted informally, meaning it is not an accredited training programme. A group of teachers are identified, based on their interest and the interest of their schools and voluntarily trained over a period of two years.
The aim is to train teachers to acquire the skills that can assist them to identify and develop resources that in turn can be used for teaching and learning. In other words, there is a strong focus on developing teachers’ Pedagogical Content Knowledge (PCK). An example of these resources that teachers can tap into is indigenous school gardens. The programme also helps teachers to develop skills to identify environmental problems in local settings and consequently mobilise for response to the issues through facilitated learning processes as required by the CAPS. This is in line with what Gibbons (2000) calls mode 2 knowledge production, where there is a more trans-disciplinary approach, and a focus on context-sensitive science. Wanyama (2008) observed that there is no useful, relevant and appropriate “ready-made” knowledge to be copied. He argued that authentic knowledge needs to be constructed by those wanting to use it in the context they plan to do so, informed by the past, present and future aspirations, risks and challenges at hand.

Teachers and facilitators of learning processes in South Africa tend to engage in abstracted Environmental Education practices, often using resources out of context or using the materials they find “simple” and easy to use. Teachers need to teach Environmental Education from an action point of view; they must be able to demonstrate what they teach to their students (O’Donoghue & Russo, 2004; Lotz-Sistka, 2007). Abstracted practices deprive learners of the opportunities of engaging with local socio-cultural, political and economic issues that pertain to local challenges and environmental risks (Wanyama, 2008). Gibbons (2000:161) argues for “context-sensitive science which produces socially robust knowledge, that is, knowledge likely to be reliable not only inside but also outside the laboratory”. This is characteristic of the goals set by the SANBI programme. These weaknesses, in terms of how teachers deal with the CAPS, have largely informed the design and implementation of the Professional Teacher Development Programme of SANBI. The intervention was informed by the realisation that teachers needed support to integrate Environmental Education into the learning areas and subjects they taught, as required by the CAPS. The
The programme has now been running for a number of years, has utilised allocated funding and other resources and needs to be assessed as to its impact and efficiency.

As such, questions were raised that this research aimed to answer:

1. Which professional competencies are developed by teachers attending the SANBI Professional Teacher Development Programme, and how do these competencies manifest in their professional practices?
2. What are the salient strengths and weaknesses of the SANBI Teacher Professional Development Programme?
3. Which design principles can guide the curriculum of such Teacher Professional Development courses or programmes?

The objectives of the study were:

- To determine what professional skills teachers acquire through the SANBI Teacher Professional Development Programme
- To assess the strengths and weaknesses of the SANBI Environmental Education Teacher Professional Development Programme
- To provide feedback for the programme developers and implementers on how to improve the programme
- To identify “keystone species” in the ecologies of practice around which the institute could anchor support for infrastructure development of the micro-group professional development and lifelong learning communities
- To determine whether teachers achieve the recursion or de-automatisation phase in striving for potential development within the zone of proximal teacher development, by having individual interviews with selected teachers two years after the programme.
- To contribute to the literature on Teacher Professional Development in Environmental Education, by formulating design principles for such programmes.
I will now reflect on the above objectives and research questions, based on the results of this study.

5.3 Which professional competencies were developed by teachers attending the SANBI programme?

Several of the emerging themes from the data suggested that teachers developed certain competencies. The first theme that emerged (see Chapter 4) is that the SANBI programme resulted in improved pedagogical content knowledge (PCK). Not only did teachers acquire new knowledge, but they also became sensitive towards better pedagogies, and also to the importance of creating a relevant (and local) context, when creating a learning opportunity. The second theme hints to epistemological border-crossing: teachers in different subjects (e.g. Natural-, Physical and Life Sciences) learned how to include Environmental Education into the teaching of CAPS topics. Theme 3 indicated that teachers developed the skills to adopt pedagogies that would address environmental issues in the local environment. Theme 4 showed an enhanced environmental awareness among teachers, and affective development (valuing an environmental education slant in their teaching). Theme 6 pointed to transfer of new knowledge and skills in the classroom. Professional development courses are only helpful, if one sees transfer in the classroom.

5.4 What are the strengths and benefits, as well as the weaknesses of SANBI teacher professional development programme?

In the past (prior to this study) observations were made regarding the SANBI programme and forms completed by participants, but no formal reports were produced on the success of the SANBI teacher professional development programme. This is the gap that this study addressed, and in this section I would like to reflect on the strengths and weaknesses of the SANBI programme.
5.4.1 Strengths of the SANBI Programme

5.4.1.1 Practical application: hands-on environmental education

The sampled respondents pointed out a number of benefits associated with this programme. According to the findings from the interviews as well as observations made during this research, it would appear that teachers attach value to this programme due to the fact that it is practical. Through this programme, teachers were able to design indigenous school gardens by using landscaping design principles. They participated in drawing up garden plans; and further had an opportunity to work with indigenous plant materials. This included being able to identify plant species, and propagating plants. This latter aspect was particularly interesting to teachers who felt they could “save money by propagating plants for the school garden and their own homes”. Teachers were assisted in developing lesson plans that have an environmental focus. This also provided them with the opportunity to use plant specimens in their classroom teaching.

During the workshop sessions, teachers were provided with practical worksheets and booklets that they could use after piloting during the workshops and they could take these with them and use them inside the classrooms. It would appear that if teachers are involved in the development of learner support materials in a ‘community practice’ environment, with the help of expert peers or facilitators, they tend to be more passionate and keen to try out new learner-teacher support materials inside their classrooms (Wood, 2007).

5.4.1.2 Authentic environment

While the workshops took place at the Walter Sisulu National Botanical Gardens training centre, implementation of creating school gardens was school-based. Follow-up and assistance by the facilitators also took place at the various schools. Such school-based interventions in a teacher development programme allows teachers space to develop teaching skills in authentic environments, their own school yards. In other words, this programme created space for teachers not
only to learn from the facilitators, but also to learn from their own colleagues in the school environment. This notion is supported by Du Preez (2008:159) who argued that empirical research often shows that teachers feel that new ideas are being imposed on them without being offered an opportunity to contribute, even if to share their experiences of what works in their practice and what does not (reflection). He concluded that this explains why some attempts at professional development simply go unnoticed. Universities are often accused of being “ivory towers” and that what they offer, are not always relevant to the teachers’ needs. The literature shows that the theory-practice divide is a perennial issue in teacher education (Gravett et al, 2016; Holland, Evans and Hawksley, 2011; Kessels and Korthagen, 1996). The separation between teacher education institutions and schools is mentioned as contributing to the theory-practice dilemma (Cheng, Tang & Cheng, 2012). Smagorinsky and his co-authors note that university teacher educators are often viewed as ‘aloof within the ivory tower, espousing ideals and the principles that govern them’ (Smagorinsky et al, 2003, p. 1400). The SANBI programme clearly does not fall into this trap, and provides training that is relevant, authentic, and where the theory-practice divide is bridged.

5.4.1.3 Peer and expert interactions: Creating a supportive community of practice

The SANBI programme expected teachers to do presentations during the workshops, and thus allowed for a dialogue amongst teachers, resulting in the sharing of experiences in the process. Sharing was not only limited to the subject of Environmental Education, but it extended to managerial issues as some of the teachers are heads of departments as well as deputy principals. By default, teachers ended up talking during and after the workshops about good school management practice, financial management, learner behavioural issues and school cultures. This seems to support the idea of learning communities as postulated by Wood (2007). He maintained that there is a need to replace current traditional professional development approaches which usually seek expertise outside the teaching field itself, with a learning community structure designed to
foreground, critique, build and enhance practitioner expertise. This approach maintains that learning communities create space for teachers to learn from one another without having to rely on experts from outside. Instead of encouraging teachers to depend solely on external expertise to improve their practices, the learning-communities approach seeks to imbue in teachers a sense of efficacy and to seat professional expertise inside the schooling system.

These kinds of exchanges incidentally strengthened teaching and learning in many of the schools that participated in this programme, as emerged from the workshop discussions and the findings from the in-depth interviews. Thus, when teachers were asked to reflect on the benefit that came with this professional development programme, they went beyond the stated objectives. This might be called the hidden curriculum of this programme. This is also supported by Wenger (1998), who stated that for the professional community to be strong, it must push the work of improving the classroom practice and student learning forward; and for work to progress, the community must bond around common commitments, values and achievements all work related. This intervention has therefore also helped in creating a bonded community of practice in some schools, as teachers who attended the training continued communicating, sharing experiences and exchanging ideas in the better-resourced schools and where better educated teachers were active.

5.4.1.4 Partnerships and project linkages

Theme 5 that emerged from the data, is that the project supports a more systemic approach to EE, with synergy and linkages between schools and communities. One of the benefits associated with this programme is the fact that in many of the schools that participated, it was observed that their participation opened up other partnership opportunities. Some schools started can-recycling projects in order to boost their financial positions, while others started food gardens using knowledge gained during the workshops. This has helped the schools to address the problem of hunger amongst the learners. The food
gardens were developed using permaculture principles and this is viewed as a spin-off coming from Environmental Education training workshops. Some schools mentioned the fact that they joined similar programmes run by other organisations. As an example, one of the interviewed teachers mentioned the fact that after participating in the SANBI programme they joined the “Eco-schoo ls” programme and thereby took what they learnt during the training workshops further. Also, Arbour Day events, planting of trees in school grounds and communities, were the result of having participated in the SANBI programme. Partnerships at school level tend to open up many avenues, such as funding opportunities, collaborations and exchange programmes. These types of partnership have also proven to be useful in terms of improving the quality of teaching and learning. “The bio-technology and bio-diversity were excellent lesson plans, so we got hooked up with WESA, are now members and are getting a lot of material from there.” It has also been proven that they help to keep learners at school, providing interesting extra-mural activities and therefore lower school drop-out rates. In some of the cases where children benefit from feeding schemes, food gardens help to boost school attendance as many learners who come from poverty stricken families see this as an incentive to be at school. Through these partnerships, some of the schools have been able to erect new buildings or buy water tanks so that they could save money and use it in other emerging needs of the schools. Some of the poorer, less resourced schools were even provided with gardening tools such as spades, watering cans and seeds to plant as part of the SANBI programme.

5.4.1.5 Networks and additional professional qualifications

Many schools have also benefitted from professional networks that participating teachers end up getting involved in. For instance, a few of the teachers who participated in SANBI Teacher Professional Development Programme even had an opportunity to attend international conferences, and make presentations there. This on its own contributed to their professional development and further helped to strengthen their competencies. Some teachers who were inspired by this
programme decided to expand their skills by furthering their studies in subjects related to Environmental Education. This has helped to strengthen the institutional capacity of the schools not only to respond to environmental issues that are pertinent in their schools and immediate communities, but it has also helped the school to expand its knowledge base and capacity to answer the curriculum demands.

Teachers also benefitted from being exposed to a variety of teaching methods during the workshops. They had been trained in a variety of teaching methods during their years of study, but this knowledge tends to fade over the years and teachers end up relying on one dominant teaching method (as observed by the researcher in the classrooms). This compromises learning opportunities they could have discovered had new and creative teaching methods been used. It is in this context that continuous teacher professional development should inspire teachers to look for innovative ways of teaching.

5.4.1.6 Knowledge transfer

The qualitative insight gained through this research indicates that the transfer of knowledge took place in various ways at school level. The participating teachers are making good efforts in transferring what they learnt during the workshops into the classrooms (for example, see Teacher B’s RTOP instrument in Appendix H). It was observed that in different schools, teachers were trying out new learning programmes. Teachers had started using plants inside classrooms when teaching plant morphology. Teachers were seen using school grounds to demonstrate plant and seed germination. Schools started taking interest in their school grounds by planting indigenous plants and trees. Some had started giving learners environmentally-oriented tasks that were to be done in the school grounds or in the school gardens.

In some schools, judging by the researcher’s observation, teachers started putting together portfolios of evidence files. These files have a collection of lesson plans that were taught to learners. Also in the files were examples of
learner activities, with samples of learners’ work. The researcher generally found
in his experience as facilitator/trainer that in-service teacher education courses
are full of eager teachers who want to do the best for their learners and the
majority of these are very enthusiastic about the possibilities of Environmental
Education in the National Curriculum Statement, and see a close link between
environmental learning and the pastoral role they are committed to playing in
supporting learners and communities in need.

In some schools, it was observed that the teachers involved in SANBI Teacher
Professional Development Programme were setting up resource rooms, which
were like micro libraries with project files. The files had pictures of the school
grounds before the intervention was made; they also had pictures taken during
the workshops, as well as during the planting at the school. It was also observed
that teachers had started interesting collections of environmental magazines and
environmental news clippings. Although the resource rooms were not regularly
visited by teachers, they were a notable start in instilling a culture of
Environmental Education within the schools.

In some of the sampled schools, it was observed that the school had started to
have an environmental policy that covers the issues such as waste management,
water use, environmental management and electricity usage. For instance,
school teachers are not allowed to park their cars on unpaved grounds. It was
also observed that learners were not allowed to pick flowers in the school
gardens or to litter.

These examples point to the fact that township schools are starting to embrace
innovative ideas that support the teaching of Environmental Education. However,
it is still not clear to what extent the school principals have bought into these. It is
argued that if there is no support from management, these efforts will soon
disappear. It was also observed that there were no incentives for teachers who
were putting more efforts into these interventions. Although there is an integrated
quality management system at the schools, it was not clear how it was used to
acknowledge the extra efforts that some teachers were putting in improving the schools.

5.4.2 Weaknesses in the SANBI programme

Next, I would like to focus on weaknesses in the programme. These weaknesses lead to rethinking the design principles (discussed later), in order to address such shortcomings in future.

5.4.2.1 Impact of prior learning: a one-size-fits all approach is not appropriate

Whilst the programme includes helping teachers with lesson plans and how to integrate ideas into their current curriculum, much of this is actually achieved only by the better educated teachers and the better resourced schools. This is an aspect that SANBI should consider when rethinking the curriculum. It was observed in the classrooms that after the training, teachers could more easily identify areas where different learning programmes could be integrated; especially those that relate to Environmental Education. This supports the fact that Environmental Education is not a stand-alone subject. However, less well-educated teachers tend to struggle to identify environmental learning opportunities if they are not assisted, as was observed in the actual classrooms in township schools (refer for instance to the RTOP schedule of Teacher A, in Appendix H). This is due to the fact that many of the teachers in the system were not trained in Environmental Education, nor was there any environmental integration in the courses when they were trained as teachers. This aspect was particularly obvious during workshop observation, which highlighted that many teachers had a limited knowledge of environmental content. Consequently, teachers skip environment-focused themes such as “Planet Earth and beyond” and “Life and Living”, because they do not have adequate pedagogical content knowledge to deal with this theme. It is therefore particularly important to allude to the stated benefit by teachers of enhanced knowledge gained through the SANBI programme.
This programme helped teachers to be able to identify positive steps to be taken in EE, such as building school gardens, teaching learners about environment care and environmental issues. Despite the fact that teachers also stated they became more aware of environment issues, problems caused by humans on the environment or problems experienced as a result of natural incidences (e.g. climate change), observations in classrooms showed that there is a need to provide continuous ‘refresher, reminder’ support in this regard.

This programme – whilst not a formal certification training programme – also gives teachers an opportunity to participate in a professional development initiative, something that enhances their professional skills and should make their understanding of the new C2005 easier to implement.

5.4.2.2 Resources and training materials not always on standard, or available to use in the classroom

Some teachers believed that training material was not always complete, lacked a glossary that could be used to teach learners specific and difficult words, did not have a Teacher’s Guide and still had to be photocopied to be able to be distributed to learners in class. Where schools did not have (working) copiers, or did not have the funds to pay for copies and extra paper, this restricted the use of booklets and worksheets. However, this also reflects on the educators’ attitude to ideally have everything “ready-made” and not needing any further effort on their part.

Other teachers, despite having been shown how to develop their own teaching material, still felt rather insecure, even after training, to develop such material on their own, in isolation and even felt that it is too much extra work for them. As was obvious through teachers’ statements from the in-depth interviews, as well as the observations during the workshops, teachers who had been inadequately trained through the previous education dispensation, those in under-resourced schools, and those with poor PCK capabilities battled the most with preparation
of own resources or teaching materials. They were also hindered by lack of infrastructure at the schools.

5.4.2.3 Sustaining motivation: Dimmed enthusiasm

While motivated teachers believed that they benefitted from such training, they also stated, “what you put in is what you get out”, believing that teachers who did not actively participate during training or who had been forced to attend would not see any benefit and believe their attendance to be a waste of time.

Also, there were several reasons given for enthusiasm waning over time – beyond the fact that some teachers seem to “forget what they were taught” and reverted back to their standard manner of teaching and their old curriculum, “as it was easier and less work”. This is known as the “washing out effect” in the literature. While in 2010, all participating teachers had started an indigenous school garden (and some a food garden) and everybody had tried to adept the curriculum to include EE, as observed by the researcher, at the end of 2013, the researcher found that most teachers were no longer as enthusiastic as they were three years ago. This could be attributed to several reasons which might include the following:

- Lack of continued support from the SANBI staff or district officials, being left to their own application and development of material
- Change in school leadership, less or no support by the principal
- Lead teachers would have changed schools, others were not trained
- Lack of continuous workshops in EE
- Complacency, too much work and effort to continuously remain motivated when no recognition was given.

Some teachers argued during the training workshops that they needed even better materials and that there were obvious gaps in areas such as the assessment strategies (ibid). These stated weaknesses are in direct conflict with
the opinion of better educated teachers who believed that the support given by SANBI was,

“…tremendous, the greening, the school projects have become part of the school curriculum. It is helping the educators, the learners, but obviously those who are interested in using it.”

“Some educators come from a system where they were not trained well enough. So obviously one pitches questions at a higher level and they cannot answer them, so the programme then leaves them out (those teachers).”

This then highlights the problem that it is difficult to approach the training workshop from the point of view that there will be the same level of prior knowledge or education (see paragraph 5.4.2.1). If workshops were to be held at a school and not a neutral venue, the facilitator could take into consideration the level of functionality, resources available, infrastructure, as well as general level of prior training.

5.4.2.4 A longer intervention is needed (and perhaps support professional development by means of electronic platforms such as Blackboard)

It was also argued that the duration of the training was too short, to the extent that there was virtually no on-going support and development when teachers went back to their respective schools. This made it difficult for teachers to implement what they had been taught as they tended to forget what they had been told in the short time the workshop took place. The district trainers, for instance, were said to be unable to effectively conduct workshops for teachers because they also were unable to interpret and apply the knowledge and skills learnt in the pilot training in the model (Van Rensburg & Lotz-Sistka, 2000: 45). This is where more longitudinal support, e.g. by using electronic platforms such
as Blackboard, could be useful. SANBI should, in future, also work on establishing on-line (virtual) communities of practice.

Van Rensburg and Lotz-Sistka (2000) further made the point that the cascade model may water down information as it gets passed on. They observed that it may also cause the misunderstandings introduced into the system to escalate. The cascade model is also in itself limited as it is based on a limited understanding of what teacher development requires. The idea that one can cascade down or transfer information intact from one person to the next is in conflict with the constructivist epistemology said to underpin outcomes-based education (OBE) in South Africa. Furthermore, this model incorrectly assumes that the kind of information that can be passed on in such a way is adequate to bring about the fundamental changes in teaching, learning and education that transformative outcomes-based education necessitates.

Therefore, there is a school of thought that argues for a school-based professional development programme, where teachers are active through experimentation, inquiry, writing, dialogue and questioning that encourages collaboration and teachers working together, focuses on student learning, takes place over time and provides follow up support, mentoring and coaching in teachers’ classrooms (Lieberman & Pointer-Mace, 2008; Shulman & Shulman, 2004, cited in Bertram, 2011). Lieberman and Pointer-Mace (2010) suggested that teachers learn best when they are members of a learning community, provided there are supportive working relationships. They subscribed to Wenger’s (1998) theory that most people learn in communities of practice where learning happens through experience and practice. Vygotsky believed that children learn by following the example of an adult or more knowledgeable other, until they gradually develop the ability to perform certain skills independently (Vygotsky, 1978). In this study, participative intervention research could be a good way of developing programmes for teachers with the help of teachers themselves. This could mean that the research process of piloting and developing Professional Development Programmes in co-operation with teachers
would also be included, rather than the research only being the means of professional development. In this way, participants are freed from being taken as objects of research into collaborators and partners in the research process, who also provide valuable information in that process. An important aspect is also that management of the school personally has to be involved in the training to achieve buy-in and ensure sustainability of any programmes put in place.

In the researcher’s view, it is also the social responsibility of the schools to show best environmental practice, and extend this to the surrounding communities. This can be done if schools can start celebrating days of environmental significance with communities. Such occasions might be used to identify a prominent environmental issue such as invasive plants and to use the environmental calendar days such as “weed buster week” to raise awareness about invasive or toxic plants.

5.4.2.5 Sustainability: developing a menu of offerings/ short learning programmes

Teachers are very keen on being involved in a long-sustained professional development programme. However, in many cases, professional development programmes are once-off interventions that are short-lived. When Teacher Professional Development programmes do not last long enough, they tend to leave teachers confused, not committed and thus do not benefitting from them. It was also established that where these programmes are supported by the Department of Education and school management teams/principals, teachers find interest in attending them. It was observed during classroom observation that where this was not the case, teachers would participate only if they felt like it; and were not driven by the desire to improve their schools. This is a limiting factor.

However, the limitation that comes with interventions imported from outside is that no matter how good external experts are, they tend to be cut short by a lack of continuous funding. In some cases, when these organisations are forced to restructure, they decide to cut down resources that were initially earmarked for
teacher development programmes. On the other hand, a project can also create a project-dependency syndrome. This is a mind-set of teachers where they become very dependent on the project and become complacent to take the process forward on their own once the project has come to an end. Teachers have to be encouraged to work on their own even after their participation to the SANBI Teacher Professional Development workshop has come to an end, be it by SANBI facilitators or by their own management/principals.

In paragraph 5.4.2.1 I have mentioned that one cannot adopt a “one-size-fits-all” approach to teacher professional development. It would be good for SANBI to expand their list of offerings, and have programmes for teachers who are novices in EE, as well as other (more advanced) courses for teachers with more nuanced pedagogical content knowledge.

5.5 Which design principles can guide the curriculum of such teacher professional development programmes?

There is a need to re-conceptualise the model of SANBI’s Teacher Professional Development programme. This research has shown that, despite its strengths, there are also weaknesses that should be addressed. The current model is not effective enough to support teachers in their professional development. Based on this data, I have developed the following design principles for SANBI’s future offerings:

(a) Despite the efforts to address 21\textsuperscript{st} Century skills in the SANBI programme, such as problem-based learning that could result in more self-directed learning, there is room for improvement. More emphasis should be placed on problem-based learning, cooperative learning, and teacher critical reflection.

(b) The SANBI programmes should emphasize “local relevance” even more. Not all teachers who participated in the programme, attempted to address local environmental problems in the community. I urge SANBI to consider
Gibbon’s (2000: 161) mode 2 knowledge production: “Reverse communication is generating a new kind of science, let us call it context-sensitive. In epistemological terms, context-sensitive science is new in the sense that it produces socially robust knowledge that is, knowledge likely to be reliable not only inside but also outside the laboratory”.

(c) Apart from the physical community of practice established in the SANBI programme, support should also be provided to teachers in an on-line (virtual) environment, e.g. by using a Blackboard system.

(d) Teachers should receive incentives for participating in the SANBI programme. Teachers need to be able to earn points when attending workshops, so that eventually these professional development points add up to a qualification.

(e) Cooperation/ partnership with universities (for possible accreditation of the SANBI course). It would be advisable if teachers could be encouraged to participate in Teacher Professional Development programmes that have relevance to curriculum development. It is suggested that the Department of Education, through the South African Council of Educators (SACE), comes up with quality assurance procedures for all service providers that work in the Teacher Professional Development field. Teacher Professional Development service providers would have to meet certain minimum standards before they are allowed to work with teachers. It is recommended that teacher education programmes at higher education institutions adequately cover the environmental content across all faculties of university schooling. There is a need to lobby for the inclusion of Environmental Education in all teacher education programmes so that when teachers graduate from the institutions of higher learning they are able to facilitate environmental learning programmes. A partnership between universities like WITS and UJ with SANBI could strengthen this notion.
(f) **Scaffolding teachers' learning across the zone of proximal teacher development: design principles**

The construct of Warford that suggests a number of stages for the scaffolding of teacher PCK within the zone of proximal development is useful and worth considering when planning SANBI teacher professional development programmes:

**Phase 1:** Teachers are required to **reflect on prior experiences and assumptions.** Korthagen and Kessels (1999) showed that preconceptions about learning and teaching often do not agree with the theories taught in Teacher Professional Development programmes, and furthermore that these preconceptions have a remarkable resistance to change. For instance, when the researcher facilitated the Teacher Professional Development workshops, participating teachers were grouped into small groups; they were then asked to discuss their understanding of Environmental Education, and it was noted that teachers had different views about what can be referred to as Environmental Education. Each group then consolidated their understanding into one paragraph. As each group interpreted the Environmental Education concept differently, it was a clear indication that teachers have preconceived ideas as to what Environmental Education is. In many cases, teachers' own perceptions of what environment is, guide their broader understanding of environmental issues. In some instances, even socio-economic circumstances can determine the conceptual understanding of the word Environmental Education. The resulting design principle is that the programme should allow for teachers to reflect on prior experiences and assumptions.

**Phase 2:** The next phase is the expert-other assistance. The Japanese lesson study model is a very effective way of establishing effective communities of practice. The design principle is that innovative pedagogies (such as Lesson Study) are needed to establish effective communities of practice.
Phase 3: The third phase, is that of internalisation. After each cycle of lessons, teachers need to individually reflect on their lessons. Through critical reflection and journaling, the teachers start to develop an own footing and voice, and they slowly develop a more nuanced teaching philosophy on environmental education. The design principle is that teachers should be assisted in their own reflective practices.

Phase 4: Warford also distinguishes a fourth stage- the recursion or de-automatisation phase, the ‘theory into practice’ stage.

In the case of SANBI programme, Teachers started seeing themselves as designers of programmes and creators of knowledge. This also strengthens the idea that theories help us to have a better understanding of practice. A practice that is not underpinned by theoretical assumptions is not a grounded practice. The design principle is that teachers should be provided with a strong theoretical framework during the programme.

5.6 Recommendations

5.6.1 Recommendations with regard to curriculum management and planning

Teachers need to be supported in curriculum planning. This should include the sharing of resources such as information packs and example lesson plans. The schools need to interpret the integrated quality management system to include the participation in SANBI Teacher Professional Development programme so that teachers can be incentivised to participate in such programmes.

Where it is possible, Teacher Professional Development needs to be identified as a need by teachers at school level. This can be done as a workplace skills-based audit as is done in other organisations so that teacher development is not seen as an external intervention that has no buy-in from the teachers. If this is done well, it might strengthen the teacher participation in the Teacher Professional
Development. As was suggested by some teachers who were interviewed, some teachers can even be trained to a point where they could themselves help in the facilitation of the workshops.

5.6.2 Recommendations with regard to support related to school management systems

There is a need for all the schools to review their school policies to ensure that there is enough reference to environmental management consideration. Schools need to have a policy on how they manage their waste in a similar manner that they would have a policy on learner admissions. Schools need to have a policy that is communicated to all stakeholders, including parents, on their commitment to their wider environment and how they will help to improve the conditions of the environment. This might include a policy position such as: “alien trees cannot be planted within the school yard” or “learners are not allowed to litter in the school grounds”. This can be done in the same manner that municipalities write their by-laws. If this is done well, it would also translate into classroom teaching on environmental issues.

During this study, the researcher had informal discussions with school principals who indicated that although they would love to support their teachers in teaching Environmental Education, they are not sure how to go about doing this as they themselves have had no background in Environmental Education.

Schools have not been in the forefront in raising environmental awareness. They need to improve this by celebrating environmental days such as World Wetlands Day, Water Week, Biodiversity Day, and so on. Schools can use such celebrations to draw parents closer to the school. These celebrations can be done annually and the school can take the initiative to invite relevant government departments to come and address the school community. Schools often underestimate the role they could play in providing Environmental Education to their communities. They can do this by, for example, adopting a nearby river or wetland. Their Science teacher could use this river to teach students about water
quality studies or water testing, or conducting ecological studies to establish the level of cleanliness of the river. This can be done using simple experiments and sharing the results with the broader community.

5.6.3 **Recommendations with regard to environmental policy and implementation**

The fact that teachers describe themselves as lacking confidence in facilitating outdoor learning programmes, points to a possible lack of understanding of the expectations of the SANBI Teacher Professional Development Programme. These include strategies to ensure that the status of environmental learning within the school curriculum is clearly understood by all teachers. It is not sufficient to acknowledge that the environment is integral to all learning. The link between the policy on the position of environmental learning and the actual implementation possibilities in the curriculum need to be articulated and reinforced.

The environment should not be viewed or interpreted as an add-on. If such position is not taken, environmental issues and concern will remain peripheral to other learning. This could also mean that the responsibility to ensure that environmental issues form part of learning experiences will be relegated to those only who are concerned with, and about, the environment in teaching and learning. There is also a tendency by teachers to view environmental learning as falling exclusively to the general education and training band. This mind-set needs to be corrected. Environmental learning needs to be viewed as a lifelong learning opportunity.

5.6.4 **Recommendations regarding support from the Department of Education**

The Department of Education might need to appoint Environmental Education specialists to be located at district offices. Such persons can head processes to write provincial guidelines on how to implement environmental learning
programmes. The Environmental Education specialist could also serve as a resource person and assist in the translation of the environmental learning component of the CAPS into provincial guidelines.

There is also a need to house SANBI-run Teacher Professional Development programmes within the Department of Education as this programme can be sustainable. There is a threat in having a programme like this located in an external organisation that does not have Environmental Education as its core business, because should they restructure, they might find it easy to cut down or discontinue it, based on operational reasons without taking a long-term view.

5.7 Limitations of this Study

During the time the researcher conducted this study, he was working fulltime; this did not allow him enough time to spend with the research participants and in many cases he could only interview teachers after school when teachers were busy teaching and did not want to be interrupted. Some teachers are not comfortable with participating in research activities and some even though they agreed to being interviewed or observed, were not comfortable at being observed while conducting their lessons in classrooms. This study took much longer than anticipated as a result of interfering strikes, the gap between first phase and second phase and findings were also impacted on by teachers being exposed to other workshops, changes at school and in their lives. Teachers were also not comfortable at being videotaped whilst conducting lessons.

5.8 Contributions of the study

This study explored the potential partnership between institutions such as SANBI, and Higher Education Institutions. It shows how teacher professional development (especially for Environmental Education) can be supported through institutions such as SANBI. The study argued for the inclusion of indigenous knowledge from a relatively new paradigm, namely that of context-sensitive science (Gibbon’s concept of mode 2 knowledge production). Cultural-Historical
Activity Theory (CHAT) is seldom used in the environmental education literature, and a methodological contribution of this study is the use of CHAT as a research lens.

5.9 Conclusion

This study has highlighted many areas that need attention in the Teacher Professional Development in South Africa, although this research was conducted only in a qualitative manner. The study revealed that many teachers are not adequately skilled to respond to the CAPS in relation to the teaching of Environmental Education at schools. The higher education institutions are not training enough teachers that have adequate knowledge in Environmental Education.

There is not enough support that is being given to teachers at school level in implementing EE, due to the fact that school principals themselves are not sure how to provide this support. Curriculum facilitators often also do not have adequate content knowledge of environmental issues. This is due to the fact that in some instances facilitators are asked to be responsible for certain subjects not because they have expertise in those subject, but because the Department does not have enough qualified personnel. This is also the case in many schools due to the shortage of qualified teachers, particularly in Science subjects. The situation needs to be addressed by ongoing professional support for teachers in the subjects that are affected. The researcher asked during his interaction with the educators how they address capacity building for teachers in the area of Environmental Education. They responded by saying they address this gap by inviting external partners to address teachers on this topic. It is submitted that this is only a reactionary strategy, and there is a need to deal with this gap decisively.

The idea of communities of practice amongst teachers exists at a very shallow level as teachers do not engage one another adequately, and therefore an opportunity to learn from each other is not being realised adequately. Whereas
SANBI in the past has mostly addressed this through physical (face-to-face) communities of practice, the institution should start exploring on-line (virtual) communities of practice, e.g. by using a Blackboard system to support teachers in their professional development. There is also a need to deal with environmental education issues at the highest level, without adopting a reactionary approach that seeks to address environmental issues as they arise. Such an approach is problematic and is, further, not holistic. The gaps identified through this study point to a need for a visionary long-term plan to deal with the inadequate training of teachers in Environmental Education by both the previous training system as well as by the present one. This training system is not decisive and focused enough to deal with these structural challenges. However, the proposed continuing Teacher Professional Development (CPD) might be a good start, but the question might be: does it give enough attention to environmental training of teachers?

There is a need for further quantitative research to capture other areas such as the level of minimum environmental literacy that is required from all teachers that enter the teaching profession; perhaps also looking at international benchmarking in this regard. Lastly, there is a need for the Department of Education to take ownership for Environmental Education. Currently, this area of education is handled by external NGOs, universities, parastatals and academics.
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List of abbreviations

CAPS – Curriculum Assessment Policy Statement

EE- Environmental Education

IQMS- Integrated quality management system

SANBI- South African National Biodiversity institute

GIS- Geographical information system

PAR- Participatory action research

Chat- Cultural activity theory

DOE- Department of Education

CPTD- Continuing professional teacher development

OBE- Outcome based education

PCK- Pedagogical content knowledge

ZPD- Zone of proximal development

ZFI- Zone of feasible innovation

AS- Assessment Standard

SA Specific Aims

FET- further education and training

GDE- Gauteng department of Education