UNDERSTANDING LIFE SCIENCES TEACHERS' ENGAGEMENT WITH ONGOING LEARNING THROUGH CONTINUOUS PROFESSIONAL DEVELOPMENT PROGRAMMES

by
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Submitted in fulfilment of the requirements of the degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

at the

University of KwaZulu-Natal, South Africa

April 2014

DECLARATION

I, Bulelwa Keke, declare that:

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2. This thesis has not been submitted for any degree or examination at any other university.

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April 2014

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- Processed on 26-Nov-2013 8:32 PM CAT
- ID: 377659048
- Word Count: 68545

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ABSTRACT

Teacher education in South Africa has had to be overhauled in line with the reform of the South African school curriculum since 1996. Both initial and continuous teacher qualification programmes are constantly being reviewed to improve impact on prospective and currently practising teachers. In addition, efforts are being made to scale up non-qualification continuous professional development programmes for better implementation of the curriculum. Despite these endeavours, there is evidence that continuous professional development programmes in particular, are not responding adequately to the needs of the teachers and the education system in general. This is partly due to the failure by the system to differentiate between the needs of different groups of teachers who received their initial teacher education in racially segregated teacher education institutions. This research study aims to determine what teachers of Life Sciences perceive as their development needs, and how these needs are addressed through various forms of in-service teacher education, both formal and informal. Life Sciences is the name of the subject called Biology in the pre-reform curriculum. It is offered only in the final three years of schooling, Grades 10 – 12. The Life Sciences curriculum has experienced at least three revisions in a period of six years since the implementation of the National Curriculum Statement in 2006.

Data was gathered in two phases, using mixed methods approaches. During the first phase, data was collected using a teacher questionnaire. The questionnaire dealt with teachers' content and pedagogical development needs; their participation in both qualification and non-qualification CPD programmes; their motivation (or lack of) to engage in CPD programmes; and the perceived benefits of CPD programmes. Semi-structured interviews were conducted with Subject Advisors dealing with similar themes. During the second phase of the study, intervention programmes in the form of teacher training workshops were conducted and data was gathered through documenting the workshop activities and by conducting evaluations.

Findings revealed that whilst a large proportion of Life Sciences teachers were furthering their studies through formal qualifications, they were not necessarily choosing Biological Sciences specialisations. A considerable proportion of teachers in the study were teaching out of their field of specialisation. These limitations likely account for teachers' low self-confidence, articulated as a strong need for development in almost every area of the content and pedagogy. Teachers that choose Biological Sciences specialisations in formal in-service qualifications seem to be benefiting significantly. Life Sciences teachers also benefit immensely from 'hands on' training in practical work skills rather than using passive, demonstration methods of training. Cluster-based CPD programmes present an ideal opportunity for teachers to learn and share knowledge and expertise in content and pedagogy, yet this platform is constrained mainly to development of assessment activities. Filling vacant posts and increasing the number of Subject Advisors is critical to ensuring that teachers received adequate support from districts.

Acknowledgements

I would like to express my gratitude to the following people who made this project a success:

My special appreciation goes to my supervisor, Dr. Edith Dempster, for her meticulous and professional supervision of this research project. Her expert advice, guidance and support throughout the study made it possible for me to complete this thesis.

Mr Robert Mtshali for his invaluable assistance and support during data collection and analysis.

Teachers and subject advisors who agreed to participate in the study.

My sons, Xola and Siyasanga, my niece Awuvuyina, and my nephew, Lelethu for their understanding and patience.

My mother, father, and sisters for their encouragement.

I am also thankful to the Schools of Life Sciences and Education for the financial support provided during the study.

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LIST OF ACRONYMS

ACE	Advanced Certificate in Education
B Ed	Bachelor of Education
CAPS	Curriculum and Assessment Policy Statement
CHE	Council on Higher Education
CPD	Continuous Professional Development
CPTD	Continuous Professional Teacher Development
DBE	Department of Basic Education
DHET	Department of Higher Education and Training
DoE	Department of Education
ELRC	Education Labour Relations Council
FET	Further Education and Training
GET	General Education and Training
HSRC	Human Sciences Research Council
IQMS	Integrated Quality Management System
ISPFTED	Integrated Strategic Planning Framework for Teacher Education and Development
KZN	KwaZulu-Natal

NCS	National Curriculum Statement
NCF	New Content Framework
NSE	Norms and Standards for Educators
NPDE	National Professional Diploma in Education
OBE	Outcomes-Based Education
PD	Professional Development
PGCE	Post Graduate Certificate in Education
REQV	Relative Educational Qualification Value
RNCS	Revised National Curriculum Statement
SACE	South African Council for Educators
SAQA	South African Qualifications Framework
TIMSS	Trends in International Mathematics and Science Study
UKZN	University of KwaZulu-Natal

CHAPTER 1

ORIENTATION OF THE STUDY

1.1 Introduction

Following the first democratic elections in 1994, the South African government embarked on a process of developing a new curriculum for the school system. Two imperatives influenced this change. First, the old South African school curricular needed to be changed to reflect new ideals of the Constitution of South Africa (DoE[1], 2003). Secondly, the magnitude of change globally, in particular, the progress in terms of science and technology in the 21st Century, necessitated higher level skills and knowledge than what currently existed (DoE, 2003). South Africa had been lagging behind in 'innovation (the creation of new knowledge within the country) and technology absorption (the ability to exploit knowledge developed elsewhere)' (DHET, 2012: 13). Internationally, educational reform is underway, and has intensified in the last few decades (Fullan, 2002, 2005; Hargreaves, Earl, Shawn, & Manning, 2001). Rapid and wide-ranging changes in curricula are taking place against the backdrop of the global economic development (Sahlberg, 2006).

It is an implicit but widely held view that the success or failure of any curriculum reform is largely determined by the quality of teachers (Wilson & Berne, 1999). Similarly, Fullan & Miles (1992) and Spillane (1999) contend that changes in classroom practice demanded by the curriculum reform are implemented by teachers. Hence, teachers' readiness to implement a new curriculum is critical in determining whether that curriculum will be successfully delivered.

When changes are of great magnitude, as experienced in South Africa, they demand profound learning on the part of teachers and are challenging to implement without support and guidance (Ball & Cohen, 1999; Wilson & Berne, 1999). Teachers need opportunities for professional development that will enhance their competency in subject matter knowledge as well as instructional methods, especially in view of the rapidly evolving and continually changing subjects like science (Noh, Cha, Kang, & Scharmann, 2004). In response to the

[1] Department of Education (DoE) was split into the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET) in 2009.

constantly changing curricula, Continuous Professional Teacher Development (CPTD) has progressively become a priority. Many professional development programmes have been proposed, all with a common goal, to improve teacher quality to take on the demands of the new curricula.

A complete overhaul of the school curriculum has major implications for teacher education and development, as has been the case in South Africa. The challenge in South Africa is that the majority of the currently serving teachers in South Africa had been trained through the college system during the apartheid dispensation where education was racially segregated (Sayed, 2002). The college system differed markedly in emphasis from universities (CHE, 2010). University qualifications equipped teacher trainees with a much stronger knowledge base, whilst the colleges believed that training into the teaching profession depended on sustained practice (CHE, 2010). As a result, a large majority of the teachers were inadequately trained to take on the demands of the new curriculum (Chisholm et al., 2005). Enacting the new curriculum has been a challenge to all teachers including those that received adequate pre-service training, but more so for those that received their professional education and entered teaching when education was an integral part of the apartheid project (DoE, 2006). Because of the broad scope of the reform, many of the South African teachers therefore required extensive retraining to equip them with the necessary knowledge and competences to implement the new curriculum.

Several CPTD strategies were initiated by the Departments of Education (basic and higher education) and the relevant stakeholders to orient teachers to the new curriculum. Subsequently, various professional development programmes were introduced, and some expanded to address issues of teacher quality. Following the publication of the Norms and Standards for Educators (NSE), 2000 policy (DoE, 2000), old teacher education certificates, diplomas, higher diplomas and further diplomas were phased out. A large number of teachers however, were still in possession of the old diplomas and certificates. Provision was therefore made for these teachers to improve their existing qualifications through the NSE (DoE, 2000). When some of the teacher training colleges were incorporated into universities and others closed down (to improve quality and cut costs), some of the old qualifications were replaced with new qualifications (DBE & DHET, 2011). The purpose was to better align teacher education with the curriculum changes. The new qualifications also enabled teachers to upgrade their qualifications and to cater for teachers that were changing roles. A new CPD qualification programme called the Advanced Certificate in Education (ACE) was intended for up-grading or further training in a specialisation or for re-training (DoE, 2000). Its minimum entry requirement was a three-year diploma in education. The National Professional Diploma in Education (NPDE) was introduced as an interim qualification with the aim to provide under-qualified teachers (those with less than three years of initial teacher education) an access route into the new qualifications (DoE, 2000). A new flexible B Ed Honours programme was also introduced to enable teachers, including those with old qualifications to advance their academic or professional competence. A more detailed context for these qualification programmes is explained in the succeeding sections.

Furthermore, non-qualification-driven CPD programmes in the form of centralised short training workshops were introduced to disseminate mainly curriculum information. School-based and cluster-based CPD models were also introduced to support teachers with curriculum implementation (DBE & DHET, 2011).

Nonetheless, with all these initiatives established, challenges of teacher education and development associated with the demands of the new curriculum, in particular, those relating to CPTD have persisted (DBE & DHET, 2011). Recently, the National Education Evaluation and Development Unit report (DBE, 2013a) reveals that qualification programmes such as the ACE have done very little to improve teachers' subject matter knowledge. Attempts by district officials to capacitate teachers through workshops and clusters are also proving ineffective (DBE & DHET, 2011; DBE, 2013a). There is clearly a need to continually assess the impact of ongoing teacher professional development and the Professional Development (PD) programmes thereof, in order to improve their impact on teachers and teaching. This research thus focuses on teachers' continuous professional development that ensued as a result of the curriculum reform. The study is contextualized in the discipline of Life Sciences, a new subject which emerged during curriculum change replacing the old Biology subject. The study explores Life Sciences teachers' participation in various professional development programmes, (both qualification and non-qualification programmes). The study further looks into teachers' perceived development through these CPD programmes. Teachers' motivation to engage (or not engage) in professional development activities is also explored. The study also examines Life Sciences teachers' perceived professional development needs for subject matter and general pedagogical content knowledge in view of the curriculum change.

The study was conducted in KwaZulu-Natal province in South Africa. KwaZulu-Natal (KZN) has 6000 schools spread over a largely rural geographic area, with a learner population of 2,8 million. At the time of this study there were more than 88 287 teachers in the province (KZN DoE, 2012). Of these, 14 809 were unqualified and under-qualified. 8 738 of these teachers were registered as unqualified. The remaining 6 071 had degrees or diplomas but with no professional teaching qualification. A large number of these un/under qualified teachers teach in rural schools, where many of them teach Mathematics, Science and Technology subjects, including Life Sciences (KZN DoE, 2012). In South Africa, the qualifications of teachers in the system are evaluated and assigned a Relative Educational Qualification Value (REQV) to indicate their qualification status. A teacher with Grade 12 only and no form of training is assigned an REQV level of 10 and is considered unqualified. A teacher with Grade 12 + up to 2 years of training is assigned an REQV level of 11-12 and considered under-qualified. The benchmark in terms of teacher qualifications was initially set at REQV level of 13. However, a number of teachers at REVQ 13 remained under-qualified if they had a three-year diploma or degree in the subject they teach, but no pedagogical qualification. The benchmark was therefore raised to REQV level of 14, which means that a teacher must at least have a four year qualification which includes some training as a teacher.

1.2 Continuous Professional Teacher Development: A South African context

South African teachers bring along diverse historical qualifications and educational backgrounds which were achieved under apartheid systems, which created separate ways of teacher education based on race (ELRC, 2009; Sayed, 2002). This variability in initial teacher education has resulted in major discrepancies in the development needs of currently practising teachers across the system, particularly regarding confidence and competence in dealing with curriculum changes, (ELRC, 2009). Whilst greater institutional capacity and resources seem to be devoted towards continuing professional development of practising teachers than to the training of new teachers, it appears that many CPD programmes fail to make an impact on teachers (DBE & DHET, 2011). One of the critical challenges has been the limited conceptual and content knowledge of many of the teachers (Taylor & Vinjevold, 1999; Adler & Reed, 2002; DoE, 2007), which has proven difficult to address through CPTD. Teachers' poor conceptual and content knowledge is thought to be contributing to low levels of learner performance (DoE, 2007).

Furthermore, in terms of the current qualification requirements, a number of serving teachers in South Africa remain either unqualified or under-qualified, mainly due to the continued hiring of unqualified personnel (DBE & DHET, 2011:33). This is particularly the case in rural schools in comparison with urban schools where the demand for science teachers does not meet the supply (SACE, 2010). These teachers have thus had to learn basic knowledge and skills for teaching on-the-job, through CPTD. This is clearly an unfavourable situation given the scale of curriculum reform in the South African education system. It is however envisaged that through ongoing adjustment and improvement of the CPTD system, teachers will benefit meaningfully so that they can meet the demands of the curriculum. There is therefore a need to ensure the availability of quality continuous professional development programmes that will address the diverse needs of teachers, which will improve the overall quality of teachers in South Africa.

1.3 Continuous Professional Teacher Development Programmes

In South Africa, two avenues are available for practicing teachers to improve their qualifications, knowledge and skills. Adequately qualified teachers generally opt for non-qualification programmes, which primarily take the form of workshops, conferences and seminars, focusing mainly on the orientation to the new curriculum, introduction to new content areas and content revisions thereafter. Non-qualification CPTD strategies are also utilized by unqualified and under-qualified teachers, but generally the unqualified and under-qualified teachers embark on structured, formal qualification programmes to upgrade their knowledge and skills.

1.3.1 Qualification programmes

As indicated above, although teachers trained through the then teacher training colleges could specialise in one or two subjects, the academic level was not equivalent to that of a Bachelor’s degree. Because a large number of currently serving teachers received their initial training in the colleges, there is still a significant number of them that remain either unqualified or under-qualified. Of the 89% percent of the teachers that have a professional teaching qualification, only 18% are university graduates, (i.e. with a four-year BEd or a degree plus PGCE or its equivalent) (DoE, 2009a). It is clear that upgrading through qualification programmes is critical in ensuring that teachers receive an appropriate level of knowledge and skills to meet the demands of curriculum reform.

Qualification-based CPTD programmes are aimed at providing teachers with opportunities to strengthen or supplement existing, or develop new specializations, particularly the unqualified and under-qualified teachers. Three primary qualifications are being utilized by unqualified and under-qualified teachers to improve their qualifications, namely: the National Professional Diploma in Education (NPDE), the Advanced Certificate in Education (ACE) and the Post Graduate Certificate in Education (PGCE).

The NPDE has as its purpose the upgrading of unqualified and under-qualified teachers. As highlighted above, the NPDE was introduced as a short-term measure to deal with the systems' inheritance of teachers with qualifications below the previous Ministerially approved norm of REQV 13. It was not intended to be an alternative form of initial teacher education. In 2004 SAQA introduced a new 360-credit NPDE as way to deal with the many unqualified teachers employed in the system (at REQV 10). However, between 2005 and 2007 there was an observed increase in the number of teachers at REQV 10 level, largely due to the continued hiring of unqualified personnel in provinces such as the KZN (DoE, 2009b). Because of both the need and demand for this programme, it was thus allowed to continue. The NPDE is now being phased out. The last date for entry for students into this qualification type is July 2014.

The ACE programme was envisaged to be a form of continuing teacher professional education with the intention of enabling educators to develop their competences and/or to change their career path and adopt new roles (DoE, 2007). The ACE enables teachers to specialize in a subject or discipline; to retrain for a new specialization; and to advance studies in one or more roles. The ACE programme does not qualify candidates as professional educators in schooling, as admission to the programme requires applicants to already have a professional qualification in the field of education and training. The ACE qualification was phased out as from 2013, and replaced by the Advanced Certificate in Teaching, which focuses only on subject specializations (DHET, 2011).

The PGCE is meant to 'cap' an undergraduate qualification (CHE, 2006). The minimum prerequisite for PGCE is the Bachelor's degree. The assumption is that teachers have prior content knowledge, and therefore use the PGCE as a way of enabling them to consolidate their prior subject knowledge and develop appropriate pedagogical content knowledge (CHE, 2006).

With all these programmes in place, there is still a great demand for teachers to improve their qualifications. CPTD thus clearly needs to be given much higher prominence in the conception of teacher education in view of the qualification profile of serving teachers in South Africa. Whilst it is evident that a large number of South African teachers have not yet reached minimum qualification levels, the main challenge is whether those that are qualified possess appropriate qualifications for the subjects they teach. It remains unclear how many teachers in the system are teaching out of their fields of specialisation (SACE, 2010). This is because the data on teacher demand and supply is 'hidden' i.e. it does not explicitly indicate teachers teaching out of their areas of specialisation (SACE, 2010). Similarly, data on the actual levels of training that the teachers in the system received remains concealed (SACE, 2010). The actual needs of the teachers can only be comprehensively addressed when the actual demands of the system are made explicit. Hence, achieving minimum qualifications is only just part of a bigger problem.

1.3.2 Non-qualification programmes

Various non-qualification CPTD programmes have been explored in South Africa; with the most widely used being the centralized and the cascade training models. The centralized model involves training (by experts usually associated with higher education institutions) where teachers from different schools gather at a central venue for workshops, seminars, conferences or courses, for a day or longer (Craft, 1996). Because the changes in the South African curriculum had been so far-reaching, it has been impossible to train all teachers adequately through this method. Other non-qualification training strategies that would cover a wide range of teachers were explored by the Department of Education. A cascade model was introduced, which involved the training of a few selected teachers, who would in turn pass their knowledge on to their colleagues (Ono & Ferreira, 2010).

Another strategy introduced in the midst of curriculum reform in South Africa was a school-based model. With the school-based model, training occurs within the normal schooling setting and is managed largely by the school's own personnel in order to fulfil the immediate and specific needs of the school (Engelbrecht, Ankiewicz, & de Swardt, 2007). The school-focused model was also strengthened, training teachers outside the normal working environment. Training is presented by organisations like higher education institutions, (Engelbrecht et al., 2007).

The widely used centralised model which takes the form of workshops, has received criticism because of its sporadic nature, poor coordination, short duration, once-off and without follow-up or support (Taylor & Vinjevold, 1999; Williams, 2011; Maistry, 2008). These factors have rendered many of the workshops ineffective in developing teacher subject matter knowledge or even pedagogical knowledge (Adler & Reed, 2002). The cascade model also has its shortcomings. Teachers frequently complain that the district trainers themselves do not always understand the curriculum, owing to numerous changes in the curriculum. The result has been the "watering down and/or misinterpretation of crucial information" (Fiske & Ladd, 2004:162; Ono and Ferreira, 2010).

The Departments of Basic Education (DBE) working in conjunction with the Department of Higher Education (DHET) have now developed a new map to address the challenges facing teacher professional development. One of the key strategies in addressing the challenges of continuous teacher education is by enabling individual teachers to identify their own learning and professional development needs and to access opportunities to address these needs (DBE & DHET, 2011). Another objective is to expand the form and capacity of the qualification-based as well as the non-qualification CPD programmes. These initiatives and programmes have to meet the needs of all types of teachers.

In line with these objectives this study seeks to explore teachers' professional development needs relating to subject matter and pedagogical knowledge, within the context of Life Sciences discipline. In view of the proposal to increase the capacity of the professional development programmes, this study seeks to explore teachers' experiences and perceptions of the impact of various forms of CPD programmes. Motivation for participation as well as the reasons for non-participation in professional development activities are particularly important and will be explored. According to Grundy & Robison (2004:174), it is important to explore the reasons for a "personal desire and motivation by teachers to sustain and enhance their professional lives", so as to assist providers plan appropriate content and knowledge that will stimulate teachers and thus retain them in the profession (Martinez, 2004). As rightly argued by Harvey (2005) a great deal of research on motivation to learn has been focused on student motivation, and as a result, not much is understood about the motivations teachers may or may not have to engage in professional development. Research into CPTD has mainly focused on external factors such the structure and content of PD activities and the impact of professional development on teachers' practices (Desimone, Porter, Garet, Yoon, & Birman, 2002). There is inadequate research looking into all aspects that may impact on teacher learning, i.e. individual/teacher factors (e,g. teachers' own interests in developing themselves), program factors (e.g. the quality of programs) as well as the system factors (e.g. support from the schools/districts/province). This research therefore offers a wide-ranging perspective into all these factors by investigating individual (teacher) factors; program (professional development) factors as well as the system factors that interact to impact either positively or negatively on continuous teachers' professional development.

1.4 The development of the new South African curriculum

The new South African curriculum drastically changed the 'discourse of curriculum' (Avenstrup, 2007: 5) when it introduced Curriculum 2005 (2005 being the envisaged final year of phasing in the new curriculum). Curriculum 2005 brought with it an outcomes-based education (OBE) approach, which was intended to replace the content-based approach that was used in the schooling system prior to 1994. OBE advocated a learner-centred approach, moving away from the traditional teacher-centred model of teaching. Curriculum reform in the form of Outcomes-Based Education (OBE), involved a shift from a relatively "pure behaviourist to an eclectic constructivist approach" (Avenstrup, 2007: 1). Primarily, teachers needed to have an understanding of the philosophical underpinnings of the OBE/constructivist approach, because failure to understand reform means that the best ideas and good intentions have limited impact in the education system (Sahlberg, 2006).

Secondly, teachers needed to have a clear conception of the curriculum statements. Clear conception of curriculum is necessary for improved implementation of the new curriculum (Sahlberg, 2006). Analyses of the curriculum reform in South Africa however revealed that neither was there understanding of the change in teaching approach, nor was there conception of the curriculum. A number of factors limited and negatively affected successful implementation of the reform (Jansen, 1998, 2002; Rogan and Grayson, 2003; Chisholm et al., 2005; Chisholm, 2009). Of main significance to this study, is the lack of adequate training for teachers to understand both the new constructivist approach in teaching as well as the core curriculum. As put forward by Sahlberg (2006), the crucial dimension of successful curriculum reform is by improving teachers' knowledge and skills.

As a consequence of inadequate teacher training, the implementation of the National Curriculum Statement brought about some challenges and shortcomings. Not only was teacher training a predicament, but there were structural design flaws which needed to be re-examined to bring about an implementable, streamlined curriculum (Chisholm, 2009). In a subsequent review of the curriculum, recommendations were made to strengthen and streamline the design features and to simplify the language through the production of an amended National Curriculum Statement (NCS) (Chisholm et al., 2005). Further proposals were made to work with a minimum number of curriculum design features, cutting them down from eight to three. Implementation was to be reinforced by improving teacher orientation and training, learning support materials and provincial support, (Chisholm et al., 2005).

The National Curriculum Statement for Grades R-9 was then revised in accordance with the recommendations of the Report of the Review Committee (DoE, 2000). The review of Curriculum 2005 culminated in the development of the Revised National Curriculum Statement (RNCS) in the General Education and Training (GET) band, i.e. Grades R-9 and the National Curriculum Statement in the Further Education and Training (FET) band, i.e. Grades 10-12. Thus, prior to the implementation of the National Curriculum Statement in Grade 10 in 2006, the curriculum had already been revised.

Whilst there was constructive support for the revised curriculum, there was also condemnation of various aspects of its implementation, evident in learner underperformance in international and local assessments (DoE, 2009b). In view of this, the newly-appointed Minister of Education constituted yet another task team in 2009 to review the implementation of the National Curriculum Statement. It emerged from the report that many teachers, as well as some DoE and Provincial Department of Education (PDE) staff, had not made the shift from C2005 to the revised NCS. This resulted in general misunderstanding of the status of curriculum and assessment policies (DoE, 2009b). The task team then recommended that

National Curriculum Statement documents be streamlined into single, comprehensible documents per subject or learning area per phase from Grade R to Grade 12. An all-inclusive national Curriculum and Assessment Policy Statement (CAPS) was developed for each subject replacing the old Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines in Grades R - 12. The amended National Curriculum and Assessment Policy Statements came into effect in January 2012 replacing the Revised National Curriculum Statements Grades R - 9 and the National Curriculum Statements Grades 10 - 12.

Every single revision of the curriculum as elucidated above had direct implications on teachers. Teacher ongoing retraining was critical in order to keep the teachers abreast of the constant amendments of the RNCS and the NCS. Nevertheless, there has been a unanimous sentiment from the teachers about the 'generic and superficial' nature of the current teacher development policies to support the curriculum, which as a result did not provide the needed support to teachers. Teachers generally express the need to upgrade their knowledge and skills; explicitly calling for teacher training that is subject specific rather than a 'one size fits all' approach (Lieberman & Mace, 2008; Lee, 2011; Day, 2011) Training, in teachers' views should also extend to support staff such as school management, subject advisors and district staff, (DoE, 2009b).

Broadly, this research will be looking at professional development of teachers in light of the ensuing curriculum changes. In particular, focus will be given to teachers of Life Sciences whose curriculum has experienced numerous revisions, possibly, more than the other subjects of the NCS.

1.5 The development of the Life Sciences curriculum

Biology was one of the subjects transformed and implemented in Grade 10 in 2006. As described by Doidge, Dempster, Crowe, & Naidoo (2008:1), the old Biology syllabus was "highly structured and outdated and had not kept pace with new developments in the biological/life sciences". Hence, a new Life Sciences curriculum was developed along with other subjects of Curriculum 2005 to replace the old Biology curriculum. This curriculum was phased in at Grade 10 level in 2006, with the first National Senior Certificate examinations being written in 2008. The 2006 version of the Life Sciences curriculum was criticised, mainly due to the under-specification of the content (DoE, 2007). Year 2009 saw the implementation of a second version of the Life Sciences curriculum (FET phase) called the New Content Framework (NCF). The NCF for Life Sciences was implemented in Grade 10 in 2009, in Grade 11 in 2010 and in Grade 12 in 2011. The NCF was yet again revised in 2010, in conjunction with other subjects of the NCS, resulting in a new Life Sciences curriculum statement in the CAPS document which is currently being implemented in Grade 10 in 2012, Grade 11 in 2013 and Grade 12 in 2014.

It is worth noting at this juncture that there was a decline in the Grade 12 pass rates for Life Sciences in KwaZulu-Natal province in year 2011 (68.8% passed with a mark ranging between 30-100%) as compared to year 2010 (76.6% passed with a mark ranging between 30-100%). The decline in the pass rate in 2011 was attributed to the change in the Life Sciences content framework. From the report on the national senior certificate examination for 2011, it emerged that a number of teachers were not aware of a number of changes in the curriculum, resulting in teaching of content that was not prescribed by the National Examination Guidelines (DBE, 2012). By implication, the teachers' perceived lack of 'curriculum knowledge' may have played a role in the decline in learner performance. It is thus imperative that this study addresses the issue of teachers' curriculum knowledge, particularly in view of the recurring changes. Hence, following this analysis by the DoE, the Life Sciences subject was targeted for interventions and formed part of the common assessment programmes in 2012. This involved the setting of provincial quarterly common tests which are used by used by all teachers in schools. However, there was a further slight decline in the performance of candidates in 2012 compared to 2011 from 68.8% to 67%. The quality of passes also declined in 2012 with 42% of candidates passing at 40% and above, which is a 0.3% decrease from 2011 (KZN DoE, 2013). Nationally, similar trends have also been observed. The performance of Life Sciences candidates who passed at 40% and above decreased from 46.2% in 2011 to 43.5% in 2012. This downward trend clearly suggests challenges in the teaching and assessment of the subject.

Over and above the changes that have taken place since the inception of the Life Sciences curriculum, possibly resulting in poor performance by learners, Life Sciences is a broad subject that requires competence in a range of concepts. As outlined in the CAPS document, Life Sciences comprises various sub-disciplines such as Biochemistry, Biotechnology, Botany, Zoology, Genetics, Microbiology, Physiology, Anatomy, Morphology, Taxonomy, Entomology, Environmental studies and Sociobiology (DBE, 2011a).

The Life Sciences content framework is organized into four "*Knowledge Strands*". These Knowledge Strands, which are developed progressively over the three years of FET, are:

1. Life at the Molecular, Cellular and Tissue level
2. Life processes in Plants and Animals
3. Environmental Studies, and
4. Diversity, Change and Continuity, (DoE, 2011).

Owing to its multidisciplinary nature, the new Life Sciences subject has a number of conceptually demanding topics. Teachers of Life Sciences thus need to be competent in a wide range of topics. They need to possess the necessary knowledge of the subject matter knowledge as well as pedagogical content knowledge. Hence, continuous professional development of Life Sciences teachers is vital.

1.6 Continuous Professional Development for teachers of Life Sciences

One of the most critical variables in ensuring teacher competency particularly during curriculum change is quality continuous teacher education and development (Villegas-Reimers, 2003). Given the broad scope of transformation throughout the continuous evolution of the Life Sciences curriculum, it has been important that teachers of this new subject engage in ongoing development, both for subject matter knowledge and instructional strategies. For example, teachers of Life Sciences have had to learn new topics such as Evolution, a topic that was introduced for the first time with the introduction of NCS. A large majority of the teachers have found this topic conceptually demanding largely because they had not been exposed to it during their schooling and during their training. In addition, teachers of Life Sciences have had to deal with continuous reshuffling of topics between the Grades (10-12). Furthermore, as a science subject, Life Sciences places emphasis on inquiry-based teaching which involves the teaching and assessment of practical work. Teachers are expected to engage their learners in practical investigations, imparting different inquiry skills. These skills ought to be assessed through formative and summative assessment, with the latter involving practical examinations set by teachers. This has proven to be another challenge for the majority of the teachers who were trained to focus more on content and less on inquiry during their teaching. This research thus focuses on Life Science teachers' continuous professional development in view of these curriculum adjustments. The scope of this research is limited to teachers that are already practicing, i.e. the research excludes pre-service training teachers.

1.7 Formulation of the problem

As discussed above, challenges relating to CPTD in the South African system are evident, emerging from the fundamental but rather un-ending review and adjustment of the curriculum without the necessary support. Although diverse initiatives have been put in place to improve the quality of teachers, many of these initiatives have failed to address the individual needs of teachers in developing their subject matter and pedagogical content knowledge, which is a significant factor in the delivery of quality teaching. A 'one size fits all' approach of CPTD has not been appropriate in dealing with the diverse needs of teachers across the education system (Lieberman & Mace, 2008; Lee, 2011; Day, 2011). Teachers in the South African education system "continue to work in different and unequal contexts and with different levels of resourcing and support, especially in rural schools in comparison with urban schools and township schools compared with suburban schools" (ELRC, 2009). Professional development initiatives ought to respond more effectively and efficiently to these inherited inequalities in access to and the quality of teacher development. Quality professional development programmes are needed to enhance teacher competency (Villegas-Reimers; DBE & DHET, 2011).

In view of these challenges, the researcher developed an interest in investigating teachers' continuous professional development, within the context of the discipline of Life Sciences in KwaZulu-Natal province. By undertaking this research, it is envisaged that the following **critical questions** will be answered:

1. How do Life Sciences teachers engage with learning in continuous professional development programmes? i.e. what methods of professional development programmes do they use?

2. Why do Life Sciences teachers engage in ongoing learning through continuous professional development programmes? i.e. what are teachers' attitudes and motivation towards learning through professional development programmes?

3. What are Life Sciences teachers' perceived professional development needs in terms of subject matter and pedagogical knowledge and skills?

4. What gains in knowledge in skills are achieved through engaging in continuous professional development programmes?

1.8 Objectives and significance of the study

In view of the ongoing curriculum changes and the decline in learner performance, this study seeks to explore Life Sciences teachers' development needs in order to determine necessary forms of intervention. The study also explores the extent of teachers' engagement in continuous professional development and the perceived gains of through such engagements. The following specific objectives and their significance were formulated:

- To develop an inventory of Life Sciences teachers' needs for development in subject matter and related pedagogical knowledge and skills required for teaching Life Sciences. It is envisaged that this inventory of needs will assist professional development providers in developing programmes that will appropriately address the needs of Life Sciences teachers. Both qualification-driven and non-qualification CPD programmes are expected to benefit from the comprehensive needs that will be gathered through this research study.

- To investigate the extent to which Life Sciences teachers are generally motivated (or not motivated) to engage in continuous professional development programmes. The purpose is here to explore teachers' motivation to engage in continuous professional development programmes. Teachers' reasons for non-participation in professional development activities will also be brought to the fore. The findings from this inquiry should assist provincial departments who carry the responsibility of ensuring that teachers are adequately qualified and competent to teach their subjects.

- To investigate the methods of CPD programmes that teachers of Life Sciences utilise to upgrade their qualification profile and improve their competence to teach. These findings will help determine whether teachers of Life Sciences in particular, are using appropriate qualification routes to expand their knowledge and skills for teaching Life Sciences.

- To document teachers' perceived gains from participating in continuous professional development programmes i.e. perceived level of development. The purpose is to identify programmes that significantly benefit the teachers, and suggest ways of strengthening them where necessary. Further, it is envisaged that the findings will indicate if and why certain programmes are not adequately benefiting the teachers.

In order to achieve the objectives outlined above, the study will begin by examining teachers' development needs. When planning for teacher's professional development it is necessary to assess and identify their needs, expectations and experiences in order to develop more effective PD systems (Chval, Abell, Pajera, Musikul, & Ritzka, 2007). Teachers tend not to be asked about their training needs, with the impact of CPD programmes not often assessed (DBE, 2012). Baird & Rowsey (1989) concur that, without accurate data on teachers' needs, the outcome of the professional development is likely to be disappointing to both teachers and those who offer PD programmes. The first step in designing a curriculum for continuous professional development should therefore be assessment of teachers' needs (Craft, 1996; Day, 1999). Any intended professional development activities ought to respond to the diverse needs expressed by South African Life Sciences teachers. Hence, the purpose of this study was to develop an inventory of needs specific to Life Sciences teachers. Also significant, are teachers' experiences of various CPD programmes; their motivation to engage in CPD; their reasons for non-participation in CPD activities, as well as their development as a result of participation in PD programmes. Fundamentally, it is the exploration of professional development programmes that respond to teachers' needs that will ensure success.

It is envisaged that this study will contribute to the Department of Education's broader objectives to better understand and address the challenges confronting teacher education in South Africa. As articulated in the Integrated Strategic Planning Framework for Teacher Education and Development (ISPFTED), also referred to as The Plan, one of the main goals should be to improve teaching skills and subject knowledge of teachers throughout their careers (DBE, 2012). Whilst focusing on teachers of Life Sciences, this study aims to contribute to the strengthening of continuous professional development of teachers in general.

1.9 Overview of thesis structure

The thesis consists of six chapters outlined below.

Chapter 1 – Introduction

This chapter gives the context of the study, providing background information on curriculum reform in South Africa in general and the restructuring of the Life Sciences subject curriculum in particular. Also presented in this chapter is the problem statement, the research questions and the objectives of the investigation.

Chapter 2 – Literature review

This chapter is divided into two parts. In Part one, the review of related literature is presented. The literature is based on Continuous Professional Development of teachers, looking at various CPD programmes and practices internationally and within the South African context.

Chapter 3 - Theoretical framework

The theoretical framework guiding the study is presented in this chapter.

Chapter 4 - Research methodology

This chapter focuses on methods and procedures followed when collecting data. Sampling, data collection instruments, piloting, issues of validity and reliability of instruments, and data analysis approach are discussed. Ethical considerations are also presented.

Chapter 5 – Data analysis and discussion

Data gathered from the first phase of the study is analysed and presented in this chapter, and the findings are discussed.

Chapter 6 – Data analysis and discussion

This chapter presents data and findings from the second phase of the study.

Chapter 7 – Summary of findings, conclusion and recommendations

Here, the findings of the study are presented and conclusions are drawn upon which recommendations are made.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

This research study seeks to understand teachers' engagement with continuous professional development through qualification-driven and non-qualification CPD programmes. By using the context of Life Sciences discipline, the study will explore teachers' perceived needs for professional development in subject matter and general pedagogical content knowledge, including curriculum knowledge. The study also seeks to establish teachers' motivation/reasons to engage or not engage in professional development activities. The study identifies various CPD programmes that Life Sciences teachers are engaged with and their expectations and perceptions of such CPD programmes. The study will further establish teachers' perceived development as a result of engagement in CPD activities.

The idea that teachers are the epicentre of the global educational reform is widely recognised. Teacher quality is critical in fostering student learning. Ground-breaking initiatives of teacher professional development are emerging, whilst existing programs are being explored and improved to advance teacher quality. The quality of teachers is improved by expanding knowledge base, skills and competence, which will in turn enhance students' learning and success (O'Sullivan, 2002; Darling-Hammond, 1993). To attain quality teaching, it is important that stable, coherent, high quality, ongoing professional development and support is provided to teachers (Kent, 2004). As described by the Department of Education, the quality of teachers is critical as it is at the root of the quality of schooling. The development of teachers should therefore be a continuing process that lasts for the duration of the career of a committed professional teacher (SACE & DoE, 2008: 4).

Transition from old to new curricula is a challenge to many of the practicing teachers, including those in South Africa. Not only are teachers confronted with new content during curricular reform, they also need to become skilled in new innovative and effective ways of enacting the new curriculum. Within the context of curriculum reform, teachers ought to develop and expand their knowledge base. As proposed by Shulman (1986, 1987), teacher knowledge base includes aspects of subject matter knowledge; content knowledge; pedagogical content knowledge, curriculum knowledge; knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational aims, purposes and values.

It is generally expected that teachers already possess these knowledge domains. Nevertheless, with curriculum reform, these knowledge domains need to be modified and broadened. There is evidence that intensive professional development programs can facilitate teachers' development of new knowledge and foster change in instructional practices (Borko, 2004). To enrich their knowledge base, teachers generally engage in ongoing professional development, which fundamentally involves teacher continuous learning. Globally, there is a shift towards improvement of continuous teachers' professional development and South Africa is no exception to this trend. Of great importance is a need for coherent, effective, continuous teachers' professional development approaches.

2.2 Conceptualising Teachers' Professional Development

There seems to be no single universal definition of teacher professional development, as the construct is viewed differently by various scholars. Teacher professional development is perceived to be those processes and activities engaged in by teachers which enhance professional career growth, i.e. aimed at enhancing the professional knowledge, skills, and attitudes of educators so that they are able to improve the quality of teaching and students' learning (Ferraro, 2000; Guskey, 2000). Teacher professional development is also viewed as a teacher learning process comprising three facets; the professional; social; and personal developments, (Bell & Gilbert, 1994). In his description, Ferraro (2000) places emphasis on individual development as well as continuing education. In a similar vein, Hargreaves and Fullan (1992) partly view teacher learning as involving self-reflection. Bell and Gilbert's (1994) personal development involves……self-initiated development…., where teachers initiate discussions to solve their own problems. In other words, teacher professional development goes beyond the meaning of just an in-service training; it includes the development of an insight into one's pedagogy, practice and understanding of one's own needs. Albeit implicit, the implication here is that professional development for teachers should arise intrinsically, i.e. teachers need to take ownership of their learning and development.

Other researchers put emphasis on the continuity of teachers' professional development. They consider teachers' professional development as an ongoing process of learning and development. Fullan (1991: 326), for example, defines teacher professional development as 'the sum total of formal and informal learning experiences throughout one's career from pre-service teacher education to retirement'. Huberman (2001) also views teacher professional development as having different stages that start from the novice stage to retirement. Bell and Gilbert (1994) describe teacher development as being part of an ongoing change process that should occur continuously. By implication, Fullan; Huberman; Bell and Gilbert (ibid) consider professional development of teachers as lifelong or ongoing opportunities for teachers to learn, which may take both a formal, structured and less formal approach.

Teachers' professional development is conceived as a process of teacher change by some scholars. Day (1999: 34) defines teacher professional development 'as a process by which, alone and with others, teachers review, renew and extend their commitment as change agents to the moral purpose of teaching; and by which they acquire and develop critically, knowledge and skills, through each phase of their teaching lives'. In addition, Hargreaves and Fullan (1992) contend that professional development involves more than changing teachers' behaviour, that it also involves changing the person the teacher is.

2.3 Professional development and Professional learning: contested concepts

In view of teacher professional development being considered a learning process, several researchers suggest a shift from the concept of 'professional development' to 'professional learning'. Fraser, Kennedy, Reid, and McKinney (2007: 157), for instance, draw a distinction between these two concepts. They posit that professional learning represents processes that, whether spontaneous or deliberate, individual or social, effect changes in the professional knowledge, skills, attitudes, beliefs or actions of teachers (Fraser et al., 2007). Teacher professional development on the other hand is taken to refer to the wide-ranging changes that occur over an extended period of time resulting in qualitative shifts in aspects of teachers' professionalism (Evans, 2002: 124). Bell and Gilbert (1994: 493), view professional development for teachers as teachers learning rather than as others getting teachers to change. The narrow perception that professional development activities are mere formal training courses linked to gaining a qualification (Friedman & Phillips, 2004) has been criticized, and a new paradigm has emerged, which shifts professional development from the notion of simply enrolling for courses and attending training, to a broader concept of lifelong or continuing learning (Day & Sachs, 2004; Fraser et al., 2007).

In view of this broader professional context, it is clear that development of teachers by someone else is not sufficient; teachers must become learners; they must be self-developing and self-motivated, particularly considering ongoing curricular reforms. Fullan (2001, 2007) emphasizes that professional development for teachers is not merely about workshops and courses but that learning should be an ongoing process that occurs daily in the life of a teacher. This excerpt suggests that, although participation in professional development activities is critical for teachers' professional growth, it may not adequately provide teachers with all the necessary skills needed for the demands of recurrent education reform. To effectively respond to the education changes, teachers need everyday professional learning. They need to consider their professional development as a lifelong learning process (Friedman & Phillips, 2004).

The concept of teacher professional development/professional learning is indeed broad and remains unclear. The lack of a collective definition from available literature may be an indication of a need for further research in understanding precisely how teachers develop. Nonetheless, the shared view from amongst the authors is that teacher professional development has its purpose to continuously improve teachers' knowledge and skills, and that it should therefore be ongoing. A number of authors place emphasis on self-initiated professional development which is about teacher's internal desire for growth. The position taken by these authors is that teachers should not be viewed as objects to be changed. This has clearly come against the criticism that many teacher developers simply aim to 'change' teachers' practices. Similarly, calls have been made for teachers to engage intimately with the learning process. When teacher professional development is conceived in a mutual way, with both the teachers and the developers contributing, this is likely to result in meaningful and successful learning.

2.4 Need for Continuous Professional Teacher Development

Internationally, CPTD is rapidly becoming the cornerstone of education policy, this against the backdrop of global curriculum reform. Education reforms are ultimately executed by teachers (Fullan & Miles, 1992; Spillane, 1999). Essentially, teachers ought to be skilled to implement the reforms. Curriculum changes have however been of such great magnitude, that many of the teachers have become challenged in their own knowledge base. Implementation of any new curriculum requires profound learning on the part of teachers (Borko, 2004). Many of the teachers have had to strengthen their knowledge base such as the subject matter knowledge base, pedagogical content knowledge and teaching skills, because teachers' knowledge of the content and of general pedagogy exert a strong influence on how they teach (Borko, 2004). As such, a re-invention of teacher professional development activities has become a fundamental process to elevate teachers' knowledge base for teaching.

In the South African context, CPTD's key priority has been to re-train teachers within the framework of the new curriculum, as well as upgrade qualifications for the unqualified and under-qualified teachers. In essence, both qualification-driven and non-qualification programmes had to be revised concomitantly on a large scale to cater for the major changes in curricular. The quality and impact of these programmes is of the essence during the development of teachers. The expansion of the CPTD system in South Africa occurred partly as a result of the need to develop teachers' conceptual/subject matter and pedagogical knowledge and skills. The enhancement of the CPTD system in South Africa is based on two fundamental reasons. Firstly, it is necessary to integrate teachers' content and pedagogical knowledge so that their skills of implementing the curriculum can be enhanced (DoE, 2006; DBE & DHET, 2011). Secondly, it is clear that CPTD programmes are not yielding the desired impact on classroom teaching, and therefore there is a need to strengthen and improve the provision of both qualification and non-qualification-based professional development programmes (DoE, 2006; DBE & DHET, 2011).

Furthermore the Skills Development Act (No. 97 of 1998) aims to ensure that skills are developed in order to ensure economic growth and also to address the brain drain. This Act includes the training and re-skilling of teachers. The Provincial Education Departments are expected to set aside 1% of their wage bill as an allocation for skills development. However, the DBE reported that this obligation had not been accomplished by all of the provinces, and that the resources reserved for training were utilised for other purposes (DBE & DHET, 2011). According to the DBE and DHET (2011), the decline in the general performance of teachers may be attributed to poor training of teachers for the implementation the National Curriculum Statement. Where training has taken place, it has been seen to be inadequate, lacking impact and not directed to teachers who need it most (DBE & DHET, 2011). The development of a new, strengthened, integrated national Plan for teacher development has come against the background of the current challenges of CPTD.

2.5 Continuous Professional Development for Science Teachers

Globally, science education is currently going through a process of change, with some countries adapting better to the reforms than others. Whilst PISA (Programme for International Student Assessment) is preferred and used by many (±70) European countries it is not tied to school curricular but focuses more broadly on real-world contexts. TIMSS (Trends in International Mathematics and Science Study) studies, on the other hand, which measure traditional classroom content have revealed substantial differences in science education between countries (Van Driel, Beijaard, & Verloop 2001). For example, when South Africa's statutory research agency, the Human Sciences Research Council (HSRC), conducted TIMSS studies in South Africa in 1999 and 2003, testing learners at the Grade 8 level in Maths and Science, South Africa had the lowest score in Science and Maths. South African results also showed the largest distribution of scores (very low as well as a few very high scores) in Mathematics and Science of all the countries that participated in the study, which reflected inequalities in education in the South African system, (HSRC, 2004). Whilst South Africa continued to demonstrate low performances in TIMSS 2011 (being second last in the 42 countries that participated), there was an overall improvement in achievement scores for both Maths and Science for the Grade 9 learners that were tested (HSRC, 2012). The variance in the range of scores also decreased, suggesting that the country is moving towards more equitable educational outcomes, particularly in poorer schools (HSRC, 2012).

Whilst there are differences in performance in TIMSS across different countries, there has been a unanimous criticism of the rigid way in which science is presented, i.e. a rigid body of facts, theories and rules to be memorized (Van Driel et al., 2001: 138). This has been the basis of reform in science education. Science education in its traditional form has been considered 'outmoded', failing to adequately prepare learners to understand science and technology issues in a rapidly evolving society (Van Driel et al., 2001). This reflection on science curricular has provided the basis for changing the traditional way in which science is presented, where the focus has typically been on the development of basic skills and academic knowledge. Science curriculum reform has involved changes in course content, approaches of instruction, teacher education and development, and student assessment (Shymansky & Kyler, 1992). There has been a considerable shift from teaching science as a rigid body of facts that must be memorized to a more learner-centered approach that presents science as an active learning process. Constructivism which dominated science curriculum reforms in the 1960s and 1970s was shaped by the widespread revolution against empiricism and positivist theories of science i.e. the transmission mode of teaching science (Osborne, 1996; Matthews, 1993). Constructivism as a theory has not been without controversy. Whilst it set off to separate itself from positivism and empiricism, some scholars challenged that it can't be detached entirely from the two philosophies (Matthews, 1993). Osborne (1996) earlier pointed out a number of epistemological flaws in constructivism, including the misrepresentation of the nature of science through an over-emphasis of the construction of concepts. Amidst the criticism, some scholars have argued for a middle ground, proposing that both constructivist as well as positivist proponents begin to acknowledge limitations posed by each of their epistemological views (Schmidt, 2001).

Reform in science emphasizes the development of knowledge and higher order thinking skills or science process skills through scientific inquiry, which helps link classroom knowledge to real life situations, i.e. situations beyond the classroom. Scientific inquiry provides learners with an opportunity to participate in the teaching sessions, thus create and solve their own problems rather than memorize and rote-learn concepts (Rehorek, 2004). According to Damnjanovic (1999), the primary purpose of inquiry teaching and learning is to develop students' intellectual autonomy. Damnjanovic (1999) contends that in inquiry classrooms, students learn to construct their own understanding of phenomena and take ownership in establishing their own knowledge base. Whilst the proponents of constructivism, mainly in the developed countries argue that inquiry-based learning enhances students' interest and motivation in science (Damnjanovic, 1999), critics of the constructivist approach on the other hand challenge that unguided, inquiry based learning can actually slow down knowledge acquisition (Kirschner, Sweller, & Clark, 2006). According to Kirschner et al., (2006) evidence from measured studies consistently supports direct, strong instructional guidance rather than constructivist-based minimally-guided learning.

Despite the criticism of the constructivist approaches, many developing countries including South Africa have followed suit, bringing in aspects of scientific inquiry-based teaching and learning in their curricular. According to the South African National Curriculum Statement (DoE, 2003), inquiry-based learning involves learners observing and comparing phenomena, asking questions, making predictions, conducting investigations and collecting data, recording results, and evaluating and communicating their findings. Although some teachers find scientific inquiry beneficial, others have experienced difficulty in implementing the 'student-centered and activity-based' science (Damnjanovic, 1999: 71). Implementation problems relating to inquiry-based teaching seem to persist not only in developing countries but also in some developed countries. For example, Kennedy (1998), Loucks-Horsley, Hewson, Love, and Stiles (1998) had also found that most elementary (primary) teachers in America were not familiar with inquiry-based science instruction. South Africa has also experienced implementation problems with regard to inquiry-based science teaching. In a recent study to investigate the implementation of science process skills (which are developed through inquiry-based teaching and learning) in Natural Sciences subject, Ambross (2011) found amongst other factors that led to poor implementation of inquiry-based learning, teachers' lack of subject matter knowledge, lack of understanding of the science processes, their beliefs about science, their lack of confidence in teaching science, resistance towards a new teaching approach, lack of science equipment and lack of ongoing professional support.

Inquiry-based teaching is indeed an abstract idea for many of the practicing teachers as they themselves never encountered it during their own education (Kazempour, 2009). As suggested by Hammerness et al. (2005), to develop competence in an area of science inquiry that allows teachers to enact what they know, they must possess deep foundation of factual and theoretical knowledge. However, the teachers' continued poor grasp of the knowledge of subjects like Maths and Science acts as a major barrier to teaching and learning of these subjects in South Africa (Taylor & Vinjevold, 1999). In essence, teachers require adequate knowledge of science content and effective instructional strategies so that they can engage their students in science inquiry.

In view of these complex teaching strategies and new multifaceted science knowledge, professional development for science teachers is often epitomized as a complex activity (Hewson, 2007). Professional development for science teachers ought to empower teachers to be able to embrace new knowledge and innovative teaching strategies which will enable them to successfully implement modern curricular. Professional development for science teachers needs to pay explicit attention to a range of knowledge bases such as subject matter knowledge, and beliefs about teaching and learning, as well as teachers' professional contexts (Loucks-Horsely et al., 1998); including elements of teaching scientific reasoning, development of science process skills, problem solving and conducting scientific experiments (Borko, 2004). For science teachers to deliver their teaching efficiently as envisaged in the new science curricular, they must be equipped with all the necessary scientific knowledge and skills (Osman, Halim, & Meerah, 2006). Strengthening science teachers' content knowledge and pedagogical knowledge has thus become an essential component of any professional development programme (Kriek & Grayson, 2009). This will in turn enhance their confidence to implement novel methods of teaching such as inquiry-based approach. When teachers embark on a continuous journey of professional development/learning, they hope that they will expand their knowledge and skills and become better teachers. In science, the role of professional development programmes should thus be to advance teachers' knowledge and practices, which will improve students' understanding and appreciation of science (Van Driel, 2010).

2.6 Principles Underlying Continuous Professional Teacher Development

A number of scholars have developed a range of general but significant principles that are core to the effectiveness of continuous professional development for teachers. Loucks-Horsely, et al. (1998) developed a set of characteristics that should constitute teachers' professional learning. In their subsequent study, Loucks-Horsely et al. (2009: 5) augmented this list, stating that successful teachers' professional development:

- is aligned with student learning needs;
- is intensive;
- is ongoing and connected to practice;
- focuses on the teaching and learning of specific content;
- is connected to school initiatives;
- provides time and opportunities for teachers to collaborate and build strong working relationships, and
- is continuously monitored and evaluated.

Several scholars (Desimone et al., 2000; Lieberman, 1995; Darling-Hammond & McLaughlin, 1995) reiterated similar principles of effective professional development. Similarly, Villegas-Reimers (2003) conducted an international literature review of teachers' professional development and supported these principles. Villegas-Reimers (2003: 13) reiterated and summarised the features of teacher professional development into the following:

- It is based on constructivism rather than on a transmission-oriented model
- Is perceived as a long-term process as it acknowledges that teachers learn over time
- It is a process that takes place within a particular context; is intimately linked to school reform
- It conceives a teacher as a reflective practitioner
- Is conceived as a collaborative process; may look and be very different in diverse settings.

Based on the above literature review, there has been a general consensus on the principles underlying effective teachers' professional development. The following is a discussion of some the principles pertinent in this study.

a. CPTD is continuous and ongoing with follow up and support for further learning

A number of scholars (Bredeson, 2002; Lessing & De Witt, 2007; Villegas-Reimers, 2003) concur that a series of related experiences rather than a one-off, isolated learning incident is more effective as it allows teachers to relate prior knowledge to new experiences. This suggests that for professional development to proceed successfully, it should be a continuous process, contributing to the general improvement of education. Ongoing professional development includes the aspect of follow-up support, especially when teachers had been exposed to professional development of a short duration. According to Goderya-Shaikh (2010), follow-up and feedback after a professional development activity leads to transfer of learning in the school classrooms. Continuous support by education leaders can motivate teachers to ensure transfer of learning into school classrooms by the teachers (Goderya-Shaikh, 2010). Continuousness in teacher development should however not be viewed only from the perspective of professional development providers. More importantly, teachers themselves need to view their professional development as a lifelong learning process (Fullan, 1991; Day & Sachs, 2004; Friedman & Phillips, 2004).

b. Is based on constructivism rather than on a transmission-oriented model

Many scholarly authors including Liberman (1994) and Borko (2004) believe that teachers should be treated as active learners, rather than passive recipients. On the contrary, Lessing and de Witt (2007) argue that teachers do not necessarily see professional development as a process of critical thinking, reflection and self-direction. They often rely on rote learning of meaningless facts in their preparation for the teaching profession (Waddington, as cited in Lessing & De Witt, 2007). Research suggests the inclusion of techniques, during professional development, which will improve teachers' engagement; getting them interactively and highly involved in their process of learning rather than passive involvement (Villegas-Reimers, 2003).

c. Is perceived as a process that takes place within a particular context

As proposed by Kazemi and Hubbard (2008), the impact of professional development in classroom practice is left unspecified in most CPD programmes. Desimone et al. (2002) assert that professional learning activities that focus on instructional practice increase teachers' use of those practices in the classroom. CPD facilitators therefore need to develop PD tasks and lesson plans that are relevant and can be enacted in classroom situations. Professional development should involve making learning experiences applicable to the elements that teachers work with daily. According to Putman, Smith, and Cassady (2009), it is the practicality and usefulness of the information learnt through CPD programmes that will enable teachers to link this new information to their own professional and classroom environment and to newly established goals. Hence practical demonstrations during teachers' learning enhances teacher engagement and enables them to see the concepts in practice (Putman et al., 2009). In brief, there needs to be co-evolution between CPD and classroom practice.

d. Is linked to school or curriculum reform

Educations reforms place high demand on teachers to transform their pedagogy and learn new methods of teaching so that they can properly implement the changes (Bybee & Loucks-

Horsley, 2000). For teachers to cope with changes, sustained school-based and curriculum-aligned training may be necessary (Villegas-Reimers, 2003).

e. May look and be very different in diverse settings

Because there is such diversity in educational backgrounds, particularly in the South African context, it is critical to ensure that professional development of teachers take cognisance of contextual factors. Professional development activities need to cater for individual settings such as teacher, learner and school contexts (Guskey, 1995; Evans, 2002). In South Africa, there is need to accurately capture data on teachers' actual needs for development so that intervention methods can appropriately respond to such needs. A one-size-fits-all approach in the development of teachers practicing in different settings, with disproportionate needs clearly reduces the impact of professional development activities, which has been the case in South Africa (Ono & Ferreira, 2010).

f. Conceives the teacher as a reflective practitioner

There exists a knowledge base in every teacher that enters the profession. Taking into consideration teachers' prior knowledge, the role of professional development is to assist teachers build and expand their knowledge, thus helping them develop expertise in their fields, (Villegas-Reimers, 2003).

g. Is aligned with student learning needs

During professional development, teachers should be allowed to contribute in planning learning programs (Merriam, 2001). This can be achieved by seeking information on the areas that teachers need to be treated during a professional development activity. This principle also supports adult learning principles. Because practising teachers are adults who generally plan their lives, their professional development should embrace adult learning principles (Knowles, 1968; Trotter, 2006) and be based on their perceived needs.

Literature presented above demonstrates some consensus about the features of effective professional development. There is no doubt that effective professional development is that which takes a constructivist approach; addresses teachers' needs based on student needs; is contextual and classroom based. A number of scholars however, seem to over-generalise the view that professional development activities should be of longer duration. Whilst this view may true, it should not suggest that all short term PD activities are ineffective. A plethora of literature widely criticises short-duration PD activities and places almost no value on them. Some scholars have challenged this view, arguing that of utmost importance during professional development of teachers is what is done rather than the amount of time spent (Lauer, Christopher, Firpo-Triplett, & Buchting, 2014; Kennedy, 1999; Desimone et al., 2002; Ingvarson et al., 2005). Citing empirical studies, these scholars have found that the main influence in professional development is generally the extent to which the training activity provides teachers with opportunities for active learning rather than how long it lasts (Kennedy, 1999; Desimone et al., 2002; Ingvarson et al., 2005). This may be particularly true when professional development focuses on developing specific skills where active learning is involved. Even when a PD programme is of short duration, an active learning approach during teacher development is likely to incorporate the other key features of PD discussed above, such as constructivist approach; addressing contextual issues; linking PD activity to classroom settings; aligning PD to student needs. What seems necessary following any short duration PD programs is follow-up and feedback. So, whilst the length of a PD activity is important, a balanced view in literature clearly needs to be considered, ensuring that the value of short-duration PD activities is not diminished.

2.7 Identifying teachers' professional development needs

According to Moeini (2008), compiling an inventory of teachers' professional development needs is frequently an omitted aspect in many of the teacher professional development activities. Identification of teachers' training needs should precede any professional development activity, argues Moeini (2008). In a similar vein, Grant (2002: 156) believes that learning may lead to change in practice when needs assessment has been conducted. Failure to pay attention to teachers' perceived development needs may thus be to the detriment of many CPD programmes.

For teachers' professional development to be effective, it must commence with an understanding of teachers' needs, to specify explicitly what form of training is required (Moeini, 2008). Conducting a needs analysis prior to providing professional development is therefore critical. As described by Cohen, Manion, and Morrison (2003), a needs analysis helps to identify the objectives of professional development programme, which will in turn improve the implementation and the outcome of an intervention. Moeini (2008) articulates that a needs analysis prepared before a teacher-training program helps in clearly defining the areas and skills that teachers need developed on. In addition, Moeini (2008) emphasizes the importance of considering ‘teachers’ perceived self-proficiency’ about the topics in which they believe they are well-informed and those in which they lack the knowledge. Consistent with this view is Wanzare and Ward (2000), who propose that in-service programs should be aimed at meeting teachers’ own in-service training needs. The purpose of learning needs assessment/analysis for teacher development helps diagnose individual weaknesses and strengths, which will assist planners of CPD programmes prepare appropriate intervention strategies. It is thus clear that training programs are most beneficial and effective when they are based on teachers’ perceived needs.

One of the key policies designed to address teachers’ development needs introduced by the South African department of education is a system called the Integrated Quality Management System (IQMS) amongst other methods of addressing teachers’ development needs. The IQMS consists of three programmes, namely: the development appraisal, performance measurement and Whole School Evaluation programmes which are aimed at enhancing and monitoring performance of the education system. The purpose of IQMS is to identify specific needs of teachers, schools and district offices and provide support for continued growth, promote accountability, monitor an institution’s overall effectiveness; and evaluate teachers’ performance (ELRC, 2003). It is the developmental appraisal that deals specifically with the identification of teacher’s development needs. It is intended to appraise individual teachers with a view to determine teacher competence, assess areas of strength and weakness, and to draw up programmes for individual development. Thus, continuing professional development for teachers is positioned within the IQMS (Mestry, Hendricks, & Bisschoff, 2009). Nonetheless, there have been challenges with regard to the implementation of the IQMS (Umalusi, 2007), largely because teachers had not been properly training to understand how the system works (Mestry et al., 2009). Some of the teachers were still not participating in IQMS in 2009 (DBE, 2012). This has subsequently meant that the system has not been able to properly identify teachers’ development needs so that they could be adequately addressed. Commitment has thus been made to improve mechanisms for identifying and responding to teacher development needs, paying particularly attention to developing curriculum competence (DBE & DHET, 2011). This research envisages a contribution towards this cause.

Learning needs are generally defined at one of the three levels, namely: organizational need, group need and individual need. Groups of teachers usually bring along different needs, and can thus require attention to specific/individual needs of professional training. Osman et al. (2006) draw attention to the fact that teachers, especially those at secondary schools, are from diverse groups, requiring different needs. Based on their survey of secondary school science teachers' needs in the USA, Baird and Rowsey (1989) concluded that without accurate data on teachers' needs, planning becomes difficult and in addition, results generated generally become unsatisfactory to both teachers and those who offer training programmes.

Although teacher professional development is a prominent feature in the landscape of both developed and developing countries, the training needs of science teachers in developed countries differ from those of science teachers in developing countries (Osman et al., 2006). According to Osman et al., (2006: 2), empirical research studies indicate that the needs of science teachers in developed countries lean more towards the development of the students, for example, they aim 'to develop strategies on conceptual understanding' and 'to develop strategies to promote analytical thinking and problem-solving skills' or 'to motivate students'. In contrast the needs of teachers from developing countries are directed more towards improving teachers' self-competence (Kamriah, Rubba, Tomera, & Zurub, 1998), mainly because of lower teacher qualification levels in the developing countries (UNESCO, 2006).

In many developing countries including South Africa, a number of teachers begin to teach without having been adequately trained. The majority of the teachers entering the profession in many developing countries are therefore among the least qualified in the world (Villegas-Reimers, 2003). Villegas-Reimers (2003) cites Malawi and Pakistan as examples of countries where a large number of unqualified teachers were appointed to meet the demands brought by the widening of access to education. Similar trends are observed in South Africa, where a large number of serving teachers in South Africa are un/under-qualified (DoE, 2006), mainly due to the continued hiring of un/under-qualified personnel (DBE & DHET, 2011). These un/under-qualified teachers thus receive in-service preparation, rather than pre-service to learn the most basic aspect of teaching on the job (Villegas-Reimers, 2003). Professional development needs of such teachers are indeed immense. Green, in Villegas-Reimers (2003) identifies four categories of 'in-service' education and training:

- For unqualified teachers
- To upgrade teachers
- To prepare teachers for new roles
- Curriculum related, particularly when there are curriculum changes in the system

It is clear that in developing counties, continuous professional development for teachers takes on very different forms whilst in developed countries, the experiences are expected to be more homogeneous and not as varied. In South Africa, the heterogeneity in the development needs of teachers across the system would be evident mostly in areas such as content/subject matter knowledge and pedagogical content knowledge. The review of literature for this study however demonstrates that South Africa needs empirical studies that will document the actual development needs of teachers. There are very few comprehensive studies that have been done to determine both the subject matter as well as the pedagogic needs of teachers for specific subjects in South Africa. Without this information, CPD initiatives may not adequately address teachers' needs, especially with so many revisions of the curriculum in South Africa.

2.8 Continuous Professional Teacher Development Programmes

With the strengthening of teachers' professional development to reflect changing curricular and contexts, diverse models of teachers' continuing professional development have been proposed over the years. CPTD programmes are structured and organized in many different ways for various reasons (Kennedy, 2005). Research evidence shows that certain types of professional development activities have a lot more impact than others on teachers' practice (Boyle, Lamprianou, & Boyle, 2004). Research also indicates that sustained learning opportunities for teachers, which pay necessary attention to various 'knowledge domains' needed by teachers are likely to increase knowledge and skills, and encourage meaningful changes in classroom practice, ultimately resulting in improved student learning (Garet et al., 2001; Kennedy, 2005).

Practicing teachers participate in a variety of professional development activities, which may involve a more formal route, i.e. a qualification-driven programme or follow a less formal path i.e. a non-qualification model. Whether formal or informal, structured or unstructured, the critical point is that during professional development, meaningful learning should take place and make an impact on teachers (Wilson & Berne, 1999).

2.8.1 Non-qualification models

A number of non-qualification models of professional development have been developed and implemented in different countries to promote and support teachers' continued professional development (Villegas-Reimers, 2003). Long before the introduction of the new curriculum in South Africa, various teacher professional development initiatives were in place. These initiatives were accelerated and new strategies were put in place following the reform of the school curriculum with the purpose to train teachers for the new changes. This section provides a review of various non-qualification models and examines their perceived impact on teachers internationally, but particularly in the South African context. A few examples of selected projects in each model are also discussed. The list of models discussed here is not necessarily exhaustive, but rather these are some of the significant models within the context of South African CPTD.

a. *The centralized training model*

The centralized model involves training where teachers from different schools gather at a central venue for workshops, seminars, conferences or courses, for a day or longer (Craft, 2000). The training personnel of centralized CPTD programmes are generally linked to a higher education institution (Craft, 2000). The centralized model of training in the form of workshops is predominantly used worldwide, and has also been greatly utilized in South Africa following curriculum reform, playing a major role during the orientation of teachers to the new curriculum. The training model generally involves experts conducting the training. The training program is often defined by the expert, effectively placing the teacher being trained as a passive recipient (Kennedy, 2005). Whilst training can be done off-site, it is important that classroom context is adopted during training. Many scholars have argued that a number of these workshops generally lack classroom context; and that they are sporadic nature and poorly organised at times (Taylor & Vinjevold 1999; Maistry, 2008, Kennedy, 2005). As discussed previously in this chapter, whilst short-duration teacher training programmes can be effective, if they fail to address aspects such as active learning and teacher contexts, with no support afterwards, they consequently become ineffective in developing teachers' subject matter knowledge or pedagogical knowledge, something that has been observed in many centralized teacher training workshops in South Africa (Maistry, 2008). Darling-Hammond and McLaughlin (1995) also censured the tradition of 'in-service days' as inadequate and inappropriate in the context of current large scale educational reform.

In spite of its shortcomings, the centralized/training model is recognized as a useful means of introducing new knowledge, albeit in a de-contextualized setting (Kennedy, 2005). According to Bantwini (2009: 180) the key with using the training models is to clearly articulate a plan of how teachers will be supported in order to facilitate the transfer of the newly acquired knowledge into their classroom practice.

b. ***The cascade model***

The cascade model also uses a centralized form of training but involves few individual teachers training their colleagues. Cascade training is preceded by 'training-the trainer to ensure that the message flows down from experts and specialists, eventually to the teachers' (Peacock, 1993: 61). This involves providing short training courses to a group of teachers who in turn, pass on their knowledge and skills to further cohorts of teachers through formal courses (Peacock, 1993). The cascade model thus involves transmission of knowledge or important information from the top to the lower groups of teachers (Ono & Ferreira, 2010). This approach is favourable in that information is disseminated quickly and to a large number of teachers, (Ono & Ferreira, 2010), which can be an efficient way to convey information about aspects of educational reform (Leu, 2004). The cascade model is indeed widely used for its ability to reach many participants in a short time (Leu, 2004), utilizing fewer resources (Kennedy, 2005). The cascade model of teacher training has for example been used in countries such as Indonesia and Scotland, where there were reduced budget allocations (Kennedy, 2005).

South Africa implemented the cascade training approach when the new curriculum (Curriculum 2005) was introduced. The first group of people was trained in the new curriculum. These people in turn trained the district officials. The district officials then cascaded the information to a few groups of teachers, mainly through courses lasting three to five days (Robinson, 2002). A major limitation of cascading information is the possible watering down or misinterpretation of crucial information when transmitted to the next level (Fiske & Ladd, 2004). This predicament occurred in South Africa, resulting in confusion during the implementation of the new curriculum (Ono & Ferreira, 2010). A further shortcoming of the cascade model is that the kind of information that is disseminated is mainly focuses on knowledge and skills that must be attained without paying attention to teachers' beliefs, attitudes and values (Nieto, 2003). As argued by Kennedy (2005), the cascade model supports a 'technicist' outlook of teaching, where focus is on knowledge and skills.

c. *Teacher clusters (teacher communities of learning or teacher networks)*

Teacher clusters or teacher networks or teacher communities of learning were formed with the purpose to pool together a group schools and teachers in order to share pedagogic information and resources (Giordano, 2008). The geographic location within which the schools in the same cluster fall is an important determinant of how regularly the teachers can convene (Chikoko, 2007). In these clusters, teachers collaborate and share knowledge and information whilst reflecting on their practices (Lieberman & Grolnick, 1996; Jita & Ndlalane, 2009). Teachers' networks bring teachers together to address the problems which they experience in their work, and thus promote their own professional development as individuals and as groups (Villegas-Reimers, 2003). As was argued by Wenger (1998), learning within a community of practice happens as a result of interactions amongst members of that community. Teachers share such information as content knowledge, pedagogical content knowledge in a meaningful way (Guskey, 2000). Facilitation at clusters is usually carried out by cluster leaders who are generally teachers themselves. The role of districts is usually to provide support in terms of materials for facilitation of the cluster PD programme (Leu, 2004). Graven (2003) and Maistry (2008) advocate the presence of an expert to lead the cluster/community of learning at the initial stages, a key element that Wenger (1998) did not include in his model (Bertram, 2011).

Cluster-based CPD programmes have been utilized for a relatively long period since their conceptualization in the developed countries (Liberman & Mclaughlin, 1992; Liberman & Grolnick, 1996). They have flourished in recent years in Asia, Africa, and Latin America (MacNeil, 2004). Developing countries such as Zimbabwe (Chikoko, 2007; Delport & Makaye, 2009) have also introduced the concept of teacher clusters in professional development of teachers. In South Africa, use of teacher clusters is gaining momentum, but its effectiveness on teachers has not been widely researched. The most recently documented and successful is the study conducted by Jita & Ndlalane (2009), which focused on a cluster of 120 science and mathematics teachers in the Mpumalanga province. From studying this cohort of teachers in a cluster, it emerged that teacher clusters were challenged by issues such as insufficient content knowledge possessed by cluster leaders. Another challenge is related to misconceptions that the cluster leaders had on certain topics, (Jita & Ndlalane, 2009). For example, some of the cluster leaders for 'Biology' (Life Sciences) demonstrated poor organization of facts; misconceptions relating to concepts such as photosynthesis; and lack of appropriate content knowledge about topics such as plant growth (Jita & Ndlalane, 2009: 63). Jita & Ndlalane (2009) nonetheless believe that clusters have the potential to enhance the process of teacher change, and break the barriers for teachers to confront their inadequacies in terms of content knowledge and pedagogical content knowledge. It is clear that cluster leaders need development in areas such as subject matter knowledge. The benefits of clusters will however be attained by individual teachers who show enthusiasm as clusters do not offer identical benefits to all its participants, Jita & Ndlalane (2009: 66). Given that the model is relatively new in South Africa, more empirical research is necessary to bring to the surface factors that bring about success in teacher clusters.

d. *School-based Professional Development*

School-based teacher learning opportunities are considered beneficial because of their classroom context, an important element missing in many of the teacher learning programmes. As a result, a number of school-based approaches to support CPTD have been explored. South Africa has also explored this model in the midst of curriculum reform. In South Africa, a much broader concept of Whole School Development was introduced to enable schools, amongst other purposes, to develop their own school-based teacher development needs and implement teacher professional development programmes that respond to the needs of teachers. In a study conducted on the effectiveness of school-based professional development programmes in South African schools, it emerged that whilst the majority of the teachers believed that the school-based model assisted in their personal and professional growth, what hampered the process was lack of consultation by school management on teachers' development needs (Rage, 2006). The relevance of any form of school-based programmes is thus important to ensure that teachers benefit, and this has to start with proper identification of teachers' needs and involvement of teachers in planning training programmes.

e. *University-school partnerships*

University-school partnerships involve a partnership between higher education institutions and schools, with the purpose of developing teachers from particular schools. The wide range of relationships that are currently being implemented between universities and schools are either periodic or on-going (Coble & Williams, cited in Mutemeri & Chetty, 2011). These partnerships serve the purpose of bridging the gap between theory and practice (Villegas-Reimers, 2003).

There are a number of partnerships, in particular for science and mathematics, which have reported success. An example of such school partnerships is the *Project SMART* in the United States (Morris & Chance, 2006). This program targeted science and mathematics teachers in eleven schools. The program was successful partly because the professional development activities were customized, i.e. they were designed based on the needs identified during school improvement planning. Most importantly, the programme was sustained for three years, providing intensive ongoing support that is greatly needed to make an impact on teachers. A number of scholars concur that the key indicators of a successful partnership between university and schools for teacher professional development are longevity, stability, follow-up support, mentoring and coaching in teachers' classrooms, (Lieberman & Mace, 2010; Mutemeri & Chetty, 2011).

There are collaborations between different institutions of higher learning and schools in South Africa. Many traditional universities in South Africa which offer teacher education programmes have partnered with local schools providing teacher development programmes. Some of these collaborations have been in existence for some time, whilst others run on short-term basis. These projects are generally targeted at teachers in historically disadvantaged schools.

NGOs also play a pivotal role. For example, one of the long-standing partnerships in KwaZulu-Natal is that between the Centre for the Advancement of Science and Mathematics Education (CASME) linked to the University of KwaZulu-Natal and the KZN department and schools. CASME targets rural schools and offers teacher development programmes for teachers and for learners. CASME has been able to sustain its programmes since 1985, an important aspect of CPTD. Whilst CASME focuses on science, mathematics and technology education, it appears that teachers of Life Sciences in particular have not been benefiting as much as Mathematics and Physical Sciences. This may be linked to the system-wide emphasis on the latter rather than the former.

Other partnerships such as the newly founded Moses Kotane Institute have been using Grade 12 examination diagnostic reports to identify poorly performing schools in Science, Mathematics and Technology subjects. They then partner with the department, bringing experts in the subjects, focussing on teacher development for areas needing improvement.

Whilst a number of partnerships have recorded success, others reportedly fail due to a multiplicity of reasons such as the lack of time, and lack of buy-in from the teachers and teacher unions (Ono & Ferreira, 2010; Grant, 2008). Any initiative to improve the professional development of teachers thus needs absolute commitment from all stakeholders.

f. *Mentoring/Coaching*

A coaching/mentoring model generally focuses on a one-on-one relationship between two teachers (Kennedy, 2005). Mentoring/coaching involves ‘counselling and professional friendship’ between a novice and an experienced teacher usually from the same school (Rhodes & Beneicke, 2002; Clutterbuck, as cited in Kennedy, 2005). Research indicates that teachers who have mentors/coaches to support them as they develop their knowledge and skills are likely to be successful professionally (Fullan, 1998; Hargreaves & Fullan, 2000). They are likely to adopt from their expert coaches, implementation strategies that are pertinent to their needs (Joyce & Showers, 2002).

Although mentoring/coaching has been utilized mostly to orient novice teachers, research indicates that experienced teachers can also benefit from each other’s expertise. Some schools thus adopt a peer coaching approach, where teachers assist one another. Peer coaching is viewed as a meaningful activity in that professional learning takes place within the school context, where teachers share dialogues and learn from each other (Sandholtz, 2002; Kennedy 2005). The coaching/mentoring type of teacher professional development is however only available to few teachers (Spencer & Logan, 2003). An expert coach/mentor could also come from outside the school and remain with the school for an extended period of time, assisting teachers with new challenges that arise (Neufeld & Roper, 2003). Mentors have a number of tasks to implement, including sharing of information, providing access to resources, being a role model, counselling, coaching, encouraging reflection, providing career advice and supporting new teachers (Ballantyne, Hansford, & Parker, 1995).

Various forms of coaching and mentoring have been explored in South Africa. Mentoring has for example been used as a method of supporting teacher learners in distance education (Dilley and Roman, 1998; Mohono-Mahlatsi & van Tonder, 2006; Kriek & Grayson, 2009; Bush, Kiggundu, & Moorosi, 2011). Mentoring through qualification programmes is extended to programmes such as the ACE and the PGCE (Kiggundu & Nayimuli, 2009; Holloway, 2001).

The DoE in partnership with the Universities and the Education, Training and Development Practices Sector Education and Training Authority (ETDP-SETA) have established a mentorship course for school subject advisors. The course empowers subject advisors to mentor teachers. The DoE aims to expand the training of mentor teachers and lead professional teachers such as teaching and learning specialists and subject advisors. The purpose is to train them to not only become mentors for new teachers but to in turn, train lead teachers or facilitators of professional learning communities. Coaching and mentoring is thus considered an integral part of teachers' professional development activities in South Africa.

g. *District Professional Development models*

A constituent of the non-qualification methods of teacher development is carried out through education districts. Education district officers play a significant role in teachers' continuous professional development, especially during curriculum reform. Within the district office, it is generally the Subject advisors (subject specialist in the district office) that assume an immediate responsibility for teachers' professional development and on-the-job support. As indicated above, they are also seen to play the role of mentors, providing support to teachers.

In the South African education system, the position of Subject Advisor exists to ensure that for every subject there is specialist capacity to:

- "monitor and support the implementation of the curriculum in the relevant subject;
- provide and or source relevant teaching and learning material to improve performance in the subject;

- ensure that teachers have all the requisite curriculum and assessment documents for the subject;
- support teachers in effectively delivering the curriculum in the classroom;
- support teachers in strengthening their content knowledge;
- moderate school based assessment, including Annual National Assessment and support teachers in organising relevant/related co-curricular activities" (DBE, 2011b: 41).

The core duties and responsibilities of the Subject advisors with regard to teachers' professional development include:

- Conducting capacity building training for teachers in areas in which they need professional development support;
- Supporting the formation of clusters of schools with similar or common challenges to encourage working cooperation, sharing of best practices amongst teachers;
- Drawing up plans to assist teachers in strengthening content knowledge (DBE, 2011b: 41).

The subject advisor is without a doubt positioned as a subject specialist in his/her field, demonstrating depth of content knowledge as well as its pedagogy. Hence, the South African education system depends heavily on Subject Advisors to ensure that teachers demonstrate the necessary knowledge and skills to implement the curriculum. They act as intermediaries between curriculum policy and classroom implementation (DBE, 2010). However, many subject advisors do not have sufficient knowledge and skills to offer teachers the support they require to improve learner performance (DBE, 2010: 8). This perceived lack of adequate knowledge and skills by some of the subject advisors has resulted in many challenges relating to teachers' continuous professional development and implementation of the curriculum thereof (DBE & DHET, 2011). In an effort to improve the capacity to support teacher development at district level, the DBE has undertaken to identify subject advisors that need support providing them with pedagogically sound, content-rich courses that will enable them to support teachers better in their area of specialization. Because the system also relies on teacher clusters/teacher learning communities, subject advisors ought to be trained to be better facilitators of professional learning communities in their districts, (DBE, DHET, 2011: 13). Bantwini (2011: 20) supported this proposal arguing that districts should improve their communication channels and develop effective working rapport with their teachers to improve their understanding of matters confronting teaching at the ground level. Another challenge confronting the districts is the limited number of subject advisors appointed to support teachers in schools. There are so few Subject advisors that they can't do justice to thorough and qualitative in-class support for teachers (DBE, 2010).

Whilst there are successes reported for some of the PD models in South Africa, more still needs to be done to improve the effectiveness of a number of these initiatives. Although the centralized model used during the introduction of the new curriculum was very useful in reaching a large number of teachers, poor transmission of critical information to the teachers compromised the significance of this PD model. If the model is to be exploited in future, lessons would need to be drawn from the shortcomings experienced.

The teacher cluster model on the other hand has great potential to support concepts such as 'learning communities' which have been widely recognized for their success in enhancing teacher learning, yet under-utilised in South Africa. Expansion of this model is vital, but more empirical studies that will document successes associated with the model are necessary.

Models based on partnerships between universities and private institutions are clearly sustained over longer periods, thus provide better opportunities for continuous development teachers. It was clear during the review of literature that the scale of implementation of these partnerships in South Africa is not well known mainly because the successes of these partnerships are documented as isolated cases.

There is over-reliance on too few and sometimes, inadequately trained Subject Advisors to manage district professional models in South Africa. The level of support provided to teachers seems to be minimal as a result of these limitations.

The critical factor in strengthening these CPD models is to invest more resources, both personnel and otherwise. There are various other viable CPTD models that still need to be explored that may improve the institutional capacity of the teacher education system as a whole in South Africa. However, as noted by Johnson, Hodges, & Monk (2000) teachers in developing countries experience different challenges than those in developed countries, demanding different CPTD models that are pertinent to such contexts. Different models therefore require careful selection and modification to suit South African contexts because what works in one context may not necessarily work in another (Guskey, 1995).

2.8.2 Qualification-driven models

In addition to learning from-and-in practice, the knowledge-base for teaching needs to also include formal academic and professional knowledge (Umalusi, 2009). Unqualified and under-qualified teachers generally engage in more structured and formal continuous professional development programmes to upgrade their qualifications. The state of teacher qualification in South Africa is such that many of its teachers require access to institutions that will offer quality programmes to address the existing teacher qualification shortfalls. Although 89% of the national teaching corps have a professional teaching qualification, only 18% are graduates i.e. have a four-year Bachelor of education (B Ed) or a degree plus Post Graduate Certificate in Education (PGCE) or its equivalent (DBE & DHET, 2011: 30). That means that 72% of the teachers qualified with a diploma in education previously offered in the colleges of education.

In terms of qualification levels, in 2009, 4% of teachers were at an REQV level of 10; 1% at REQV level 11; 3% at REQV level 12, and 32% at REQV level 13 (DoE, 2009a: 2). The approximate number of REQV 13 teachers that would need to upgrade their qualifications to attain REQV 14 was 111 000 in 2009 (DBE & DHET, 2011). On the whole, about 40% of the teachers needed to upgrade their qualifications in 2009. In 2011, these percentages had decreased significantly nationwide (with the exception of KwaZulu-Natal). Only about 2% of the teachers were unqualified (REQV 10), and just below 1% were under-qualified (DBE, 2012). Although trends point to an improved teacher qualification profile, it appears that the majority of teachers have not yet been sufficiently equipped to meet the education needs (DoE, 2006; DBE & DHET, 2011). There has been no impact on learning outcomes, which questions the value of these qualifications (DBE, 2010). The analysis below focuses on the purpose of continuing teacher qualification programmes, the reviews, as well as the reported impact of these programmes.

Continuous Professional Teacher Development in the form of qualification programmes is the only route to force teachers to upgrade their qualifications. Following curriculum reform, fundamental changes were made to teacher education in South Africa to align it with the requirements of the new curricular. A new way of designing and delivering teacher education was introduced. The old teacher education certificates, diplomas, higher diplomas and further diplomas were phased out and new qualifications were introduced (DoE, 2000).

According to the NSE (DoE, 2000), the following CPTD qualifications have been used to address issues of unqualified and under-qualified teachers:

- The National Professional Diploma in Education (NPDE)
- Advanced Certificate in Education (ACE),
- Post Graduate Certificate in Education (PGCE). PGCE is considered to be an initial teacher qualification programme rather than a continuing form of PD and hence will not be discussed here.

a. Advanced Certificate in Education (ACE)

Research shows that most countries, both developed and developing, have longstanding concerns about the shortage of trained and qualified teachers in the fields of Mathematics and Science, (Darling-Hammond, 1990; Marx & Harris, 2006). The ACE enables teachers to upgrade from REQV 13 to REQV 14, or to retrain in a new subject/learning area, or to further specialise in a subject/learning area that they are currently teaching.

It is conceived as a form of continuing professional education with the purpose to up-skill and re-skill teachers which will generally develop their competences (CHE, 2006; DBE & DHET, 2011). The ACE is intended to 'cap' an initial teaching qualification, and therefore does not qualify candidates as professional teachers. Hence, admission to the programme requires a professional qualification in the field of education and training (CHE, 2006), such as a three-year diploma, a B Ed, or a PGCE.

Enrolment in the ACE programmes showed considerable growth with Full-time Equivalent (FTEs) growing by 15.3% from 2008-2009. The Western Cape had the greatest growth of about 23.3%, while KwaZulu-Natal region experienced an 11.6% decline during this period. Total enrolments in ACE programmes indicate the greatest regional growth of 33.6% in the

Eastern Cape region whilst KwaZulu-Natal region recorded a decline of 23.4% in the same period (DBE & DHET, 2011).

This declining trend in enrolments for ACE in the KwaZulu-Natal province is undesirable as this province accounted for 85.5% of under-qualified teachers nationwide in 2011 (DBE, 2012). The PERSAL report (DBE, 2012) indicated a total of 10 219 unqualified teachers nationwide in 2011, with 8 738 practising in KwaZulu-Natal. Between 2004 and 2007, the KwaZulu-Natal Department of Education had been upgrading the qualifications of close to 3 000 unqualified and under-qualified teachers, (KZN DoE, 2007). Based on teacher qualification data, the upgrading of teacher qualifications in the KZN region ought to be happening at a much larger scale considering the current number of teachers not meeting the required minimum qualification levels.

An in-service programme in South Africa has to address three important issues concurrently: providing access, improving teachers' skills, and giving them an opportunity for re-skilling in new areas (SAQA, 2010: 105). At the early stages of ACE implementation it emerged that, although the NSE (DoE, 2000) had laid out one of the purposes of ACE programmes as that of development of new subject specialisation competence, it failed to provide sufficient guidelines on what the areas of specialisation for the ACE should be. This resulted in the emergence of multiple specializations from different institutions, with some areas of specialisation not sitting comfortably with the stated purpose of the ACE qualification (CHE, 2010). For example, when the review was conducted, there were 69 different kinds of ACEs in the country with over 290 specialisations being offered (CHE, 2010: 107). This occurred because the NSE did not provide sufficient guidelines on what the areas of specialisation for the ACE should be. As a result there was a lack of uniformity in the areas of specialisation. Very few ACE programmes in Mathematics for example were able to provide a clear statement of their broad purposes, making it difficult to determine the level of mathematics content. According to the CHE (2010), institutions usually have a generic ACE qualification as well as several specialisations all of which are accredited as one qualification. When reporting their programmes to the regulatory authorities, the institutions list only the generic ACE (CHE, 2010).

The review of the ACE programmes (CHE, 2010) also indicated a need for differentiation of the programme on two levels: by *purpose* and by *phase.* According to the review report, (CHE, 2010), the *purpose* needs to be clear in terms of re-skilling, upgrading and access. The *phase* level that a particular ACE targets, also needs to be clearly articulated as either the GET phase or the FET phase. The review also revealed a weakness in the ACE programmes which is a result of the absence of a sustained plan that addresses poor subject specialisation knowledge (CHE: 2010). Based on the review, two types of ACE programmes were proposed. The first programme was a specialisation ACE intended for teachers who already have foundation in the field of specialization. Teachers needed to have a three-year qualification such a diploma or NPDE to enrol for his ACE. The purpose was to expand teachers' existing knowledge-base (CHE, 2010). The second programme was an advanced 'extended role' ACE intended to re-skill teachers in a range of areas such as education management and inclusive education. Teachers admitted to this ACE programme would already have a 480 credit qualification in their area of specialisation, which may include a specialised upgrading ACE (CHE, 2010: 136-137).

These two recommendations were partially implemented in the minimum requirements for teacher education qualifications (DHE, 2011). A new qualification called the Advanced Certificate in Teaching will now replace the ACE programme (DHET, 2011). The new Advanced Certificate in Teaching will focus on subject specialisations. It will not be available for new roles in education such as Management and Leadership. Teachers who want to take a new role will be directed towards an Advanced Diploma in Education.

The distinction being made between the two types of ACEs was intended to put emphasis on the difference in purpose, content and outcomes between upgrading and re-training programmes, and to prevent the tendency of teachers to use the ACE as a pathway to REQV14 status without improving competence in their area of specialisation first (CHE, 2010: 137). Whilst the enrolment for ACE saw significant growth, it appeared that a substantial number of teachers were choosing the Education Management specialisation (Morrow, 2007). This may suggest that the ACE has produced a large number of managers and fewer subject-specific skilled teachers. Consequences of this have indeed been an improved qualification profile for the country's teachers, with many teachers attaining the REQV 14 status, yet subject specific knowledge gaps remain unaddressed.

The ACE has been a key qualification in re-skilling and up-skilling of teachers who are unqualified or under-qualified in specific subjects, as well as developing skills in specific learning areas that are continually introduced in the curriculum. Following the review of ACE programmes, a number of higher learning institutions have introduced more focused and more specialised programmes, such as the ACE Biological Sciences; the ACE Life Sciences, which deal specifically with Biological/Life Sciences content and related pedagogy. Although limited to only one institution, this study will evaluate one of these ACE specialisations to assess their impact in addressing content and pedagogical content knowledge.

Another pertinent issue of the ACE programmes is that of distance vs contact modes of delivery. Whilst some institutions offer ACE through distance education, others are contact programmes, with the latter considered to have more advantages. The review nonetheless revealed a high dropout rate with distance programmes recording a much lower retention rate, (CHE, 2010).

A few empirical studies examining the impact of ACE programmes on professional development of teachers have been conducted highlighting successes and challenges. As indicated above, a number of these studies (Aluko, 2009; Bush, Duku, Glover, Kiggundu, Kola, Msila, & Moorosi, 2011) focused on ACE in School Leadership and Management. These studies have reported improvement of the participants' professional performance in their schools. However, using school achievement as the measure of impact, Bush et al., (2011) argued that whilst most of their respondents (75% based on 430 participants) claimed that their schools were improving, the secondary school case studies showed that only 12% had produced clear improvements in matric results. The outcomes of this study (Bush et al., 2011) may suggest that the impact of the programme does not result in immediate and significant impact.

A few studies have looked at the impact of ACE programmes on the development of teacher subject knowledge (Schudel, le Roux, Lotz-Sisitka, Loubser, O'Donoghue, & Shallcross, 2008; Mudaly & Moore-Russo, 2011; Gierdien, 2008). These studies have also reported success. But, because these studies are done at a small scale, it is not possible to make widespread claims of success.

b. National Professional Diploma in Education (NPDE)

The National Professional Diploma in Education (NPDE) is another qualification programme initiated for upgrading teachers' qualifications. The NPDE was introduced as a short-term measure to deal with the systems' inheritance of teachers with qualifications below the Ministerially approved norm of REQV 13. The NPDE was originally intended for teachers at REQV levels of 11 and 12 to upgrade to REQV 13. This was however revised to accommodate currently serving teachers classified as REQV 10. Although the NPDE was intended as an interim measure, the continued employment of unqualified teachers in certain provinces increased the demand for the programme. Enrolment to the revised version of NPDE required a minimum of five full years of prior teaching experience in a public school. According to the DBE & DHET (2011), the implementation of this version of the NPDE saw it being exploited as an initial teaching qualification and distorting the original intention of assisting teachers with historical qualifications to gain access to new qualification pathways.

The Department of Education had initially anticipated that the backlog would eventually be overcome, and that teachers who wished to upgrade further would enrol for degree study in the BEd programmes (DoE, 2007). A decline in first-time enrolments in NPDE programmes in the country's institutions of higher learning has also been noted, suggesting that the usefulness of, and demand for, this kind of upgrading qualification is coming to an end (DBE & DHET, 2011). As a result, the NPDE is being phased out. The last date for entry for students into this qualification type is July 2014. Unqualified practising teachers holding a Level 4 school leaving qualification or equivalent will now need to register for a Bachelor's degree in Education (DHET, 2011). Those who do not meet access requirements will seek access by completing an equivalent access programme at the Higher Certificate 13 level, designed to enable entry into degree studies (DHET, 2011).

The NPDE programme has been practice-based with a strong classroom focal point to equip educators with the foundational, practical and reflective competencies required for further study at NQF level 6 (SAQA, 2006). The NPDE required evidence that educators demonstrate applied competences of exit level outcomes in the classroom setting which could be evaluated through classroom-based evaluation conducted during school visits (Ngidi, 2005).

A few evaluation studies to determine the impact of the NPDE programme have been conducted (Ngidi, 2005; Ngidi, Sibaya, Sibaya, Khuzwayo, Maphalala, & Ngwenya, 2010), indicating that the programme is equipping the teachers with the necessary competences for their careers. Some teachers, however, indicated a need for further assistance and support after completion of their studies (Ngidi et al., 2010). However, despite the positive evaluation and the DoE's large investment in the NPDE programmes, the current teaching force continues to manifest poor subject and professional competence (CHE, 2010: 104). The discontinuation of the NPDE and the subsequent introduction of a Bachelor's degree as an initial qualification for all teachers will hopefully improve the current state of subject matter knowledge, since the B Ed degree allows for fair development of subject matter knowledge.

Although teacher qualifications are continuously reviewed, and access widened, it appears that these efforts are not bringing about any significant changes in the quality of teaching in South Africa. From conception, specialisations of some of these qualifications have been poorly articulated, thus limiting in terms of development of teachers' subject-specific knowledge. Certain institutions seem to be affected more than the others, suggesting inconsistencies in quality across different institutions. It is perhaps against this backdrop that the CHE sought to once again review teacher qualifications.

2.9 Professional Development as Teacher change

Although teacher professional development has by and large, been conceptualized as a mechanism to improve teachers' professional knowledge, it has to some extent been also viewed as a mechanism for driving change in educational systems (Day & Sachs, 2004). Earlier proponents of educational change such as Day (1999: 27) perceived professional development to be a process by which teachers review, renew and extend their commitment as change agents to the ethical purposes of teaching. Curricular reforms aspire towards more integration of subject content and for organizing learners' opportunities to learn. The intention of teacher change is always to improve student learning (Guskey, 2002). In essence, curriculum reform brings about changes in teachers' practices as they assume new roles. Professional development programs bring about change in the classroom practices of teachers, in their attitudes and beliefs, and in the learning outcomes of the students (Guskey, 2002: 381). According to Guskey (2002) the majority of teachers perceive professional development as a way to improve their competence and enhance student learning outcomes, a view also held by other researchers, (for example, Fullan, 1991 & Hagreaves, 1996). Guskey (2002) further contends professional development appeals to many teachers because they believe it will enhance their knowledge and skills, contribute to their growth, thereby improving their teaching effectiveness. Guskey (ibid) however cautions that PD programs that fail to meet such expectations are unlikely to influence any changes in teachers' practices.

Clarke and Hollingsworth (1994: 948) had earlier described six perspectives on teacher change. Within these perspectives, they considered teacher change as 'something that is done to teachers' which implied that teachers are changed. The perception that teacher learning is something that is done to teachers has been rejected by some scholars (Clarke & Hollingsworth, 2002). Increased criticism based on research has provided justification for re-conceptualising teachers' professional development as 'professional growth or learning' or 'opportunities for learning' (Clarke & Hollingsworth, 2002; Johnson, 1996). There has been a considerable shift to the idea of teacher change as a complex process that involves ongoing learning on the part of teachers (Clarke & Hollingsworth, 2002). Teachers are now considered to be shaping their professional growth through reflective participation in professional development programs and in practice (Clarke & Hollingsworth, 2002: 948). The perception here is that change is identified with learning, and is regarded as an intrinsic and expected feature of the professional activity of teachers. This idea of teacher learning has culminated in the concept of ongoing lifelong learning where teachers become reflective practitioners through professional development (Fullan, 1991; Day, 1999).

Other key perspectives of teacher change developed earlier by Clarke & Hollingsworth (1994: 948) included:

- Change as adaptation - teachers adapt their practices to changed conditions.
- Change as personal development - teachers seek to change in an attempt to improve their performance or develop additional skills or strategies.
- Change as local reform - teachers change something for reasons of personal growth.
- Change as systemic restructuring - teachers enact the changed policies of the system.
- Change as growth or learning - teachers change inevitably through professional activity; teachers are themselves learners who work in a learning community.

Various models have been developed to explain how teachers change through professional development. Earlier models of professional development programs however fell short in considering the process of teacher change (Fullan, 1992). The first models that recognized teacher change subsequent to engaging in professional development, presented divergent views on when the teachers change. These models attempted to change teachers' beliefs and attitudes, with the expectation that changes in beliefs and attitudes will lead to changes in classroom practices and behaviours. Guskey (1986) pointed out flaws in this view of change and developed an alternative model of teacher change. Guskey's linear model of teacher change assumes that participation in professional development leads to changes in teachers' classroom practices, which in turn causes a change in students' learning outcomes, resulting in changes in teachers' knowledge, attitudes, and attitudes. In essence, Guskey argued that noteworthy changes in teachers' beliefs and attitudes are likely to take place only after considerable changes in student learning outcomes.

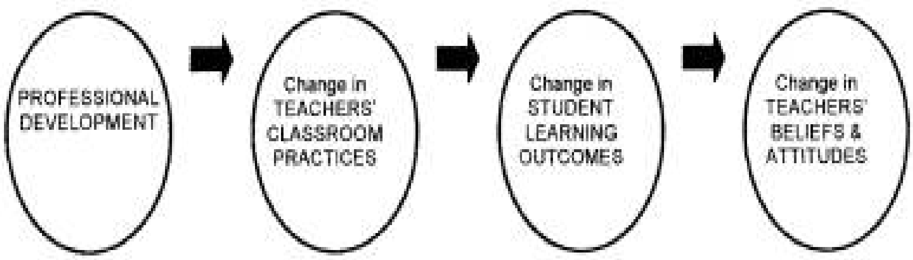


Figure 2.9.1: A model of teacher change (Guskey, 1986)

On the contrary, Desimone (2009) has recently proposed another model, which somewhat reverts to the earlier models of teacher change. As articulated by Desimone (2009: 184), this model 'represents interactive, non-recursive relationships between the critical features of professional development, teacher knowledge and beliefs, classroom practice, and student outcomes'.

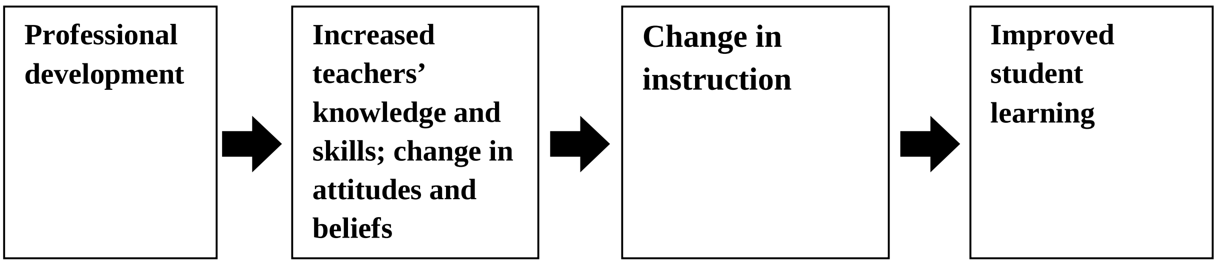


Figure 2.9.2: Effects of professional development on teachers and students (Desimone, 2009)

Regardless of when change occurs following professional development, of significance is that a professional development activity should seek to alter and expand teachers' knowledge, skills and beliefs, which will in turn positively influence their classroom practices, a change in instruction that will foster student learning and improved outcomes. Smith, Hofer, Gillespie, Solomon, & Rowe (2003), proposed three major factors that influence the type and amount of change teachers undergo during professional development. These include:

- ***Individual factors -*** their experience, background, and motivation about teaching as they come into the professional development.
- ***Professional development factors -*** the quality and amount of professional development attended.
- ***Program and system factors -*** the structure of and support offered by the program, adult education system, and professional development system in which they work, including teachers' working conditions, which is defined as their access to resources, professional development and information (Smith et al., 2003: 2).

In a study to investigate the most influential of the individual factors, Smith et al., (2003) found that motivation to attend the professional development was amongst the most significant individual aspects influencing teacher change. They established that teachers with a strong desire to learn changed more following professional development (Smith et al., 2003). Teachers' motivation to engage in professional development is thus considered a significant determinant of teacher change (Bell & Gilbert, 1994; Smith & Gillespie, 2007). Teachers' motivation to engage in professional development has a direct influence on teachers' classroom practices (Anderson, 2000; Guskey 2002). It is the teacher's intrinsic drive towards self-improvement that makes them gain more knowledge during professional development (Komba & Nkumbi, 2008). In the words of Komba and Nkumbi (2008) no amount of pressure from the educational managers can result in teacher change. Each individual teacher has to perceive professional development positively and be willing to learn new knowledge and skills (Komba & Nkumbi, 2008). Alexander (2008) believes that motivation can be stimulated by quality professional development programmes, influencing teachers to attempt new unfamiliar instructional practices in their classrooms, thus fostering change. Investigating teachers' personal desire and motivation to enhance their professional lives is important because it improves the planning of appropriate content and knowledge prior to engaging in professional development (Grundy & Robinson, 2004; Martinez, 2004).

Harvey (2005: 5) cites other potentially driving factors for teachers to engage in professional learning, which ultimately promote change in teachers' practices. Some of these factors include:

- **Pedagogical content knowledge –** professional learning motivated by the opportunity to improve teaching competencies and skills and by the acquisition of knowledge in specific subject areas.
- **Serving and enabling students** - professional learning motivated by the desire to relate to learners more meaningfully and help them learn better.
- **Educational philosophy –** professional learning motivated by the exploration of beliefs and values in education and the exploration of educational issues and motivated by the desire to reform educational practice in the school and classroom.
- **School support** - professional learning motivated by teacher release time and remuneration and leadership, management, and collegial support.
- **School/system expectations** - professional learning motivated by registration requirements.

Reforms in subject matter standards, curriculum content and pedagogy demand a greater capacity in teachers, expecting then to change their practices (Little, 2002). As articulated by Little (2002), curricular reforms represent a substantial departure from teachers' previous experiences, established beliefs, and present practice. Mansour et al., (2011), argued that global education reform has created uncertainty, and is becoming increasingly complex and difficult to implement. Fullan, who has written extensively on educational change since the inception of global educational reforms, had also earlier argued that education reform is a much more complex process than it was projected (Fullan, 2007). Fullan (2007) pointed out a number of fundamental flaws even with the successes that have been recorded. For example, he locates the core reason for change failure to infrastructure that is weak, unhelpful, or working at cross-purposes (Fullan, 2007). By infrastructure, he refers to all the relevant stakeholders such as the school managers and the districts. Teacher change, he contends, is largely determined by such factors as the school culture, and in turn, the school's effectiveness is dependent on the level of support from the district. Sadly, in the South

African schooling education system, there appear to be challenges not only within the schools but also with the nature and level of support provided by the districts. Whilst professional development can be used as a vehicle to impact teachers' practices, there is a strong need for change that will start at the district level, filtering down to school managers and eventually to the teachers. Much consideration needs to go towards improving support for teacher continuous learning and development both from the districts and within individual schools.

On the whole, there is a multiplicity of factors that can promote change in teachers' practices through professional development. These include factors such as their commitment to change; their effort to implement new teaching methods; their ongoing learning experiences and opportunities; their motivation, interest, morale and professional identity; understanding of reform ideas; the content focus of the PD program; the design of the programs; support from the district officials as well as support from within the schools.

2.10 Domains of Teacher Knowledge – '*Knowledge base for Teaching*'

Loucks-Horsley and Matsumoto (1999) argue that teachers need opportunities to develop knowledge of their disciplines. Based on their research exploring key features for effective professional development, Birman et al., (2000), place emphasis on strengthening teacher knowledge in order to advance teacher learning and their practices. Along the same line of argument, Hawley and Valli (1999) see the development and expansion of teachers' professional knowledge base as being critical in overall professional development.

The development of teacher knowledge is influenced by teacher learning processes (Putnam & Borko, 1997). Hence, Verloop, Van Driel, and Meijer (2001) argue that learning processes should be seen as knowledge construction processes, rather than the acquisition of theoretical knowledge. During teachers' professional development, explicit attention should thus be paid to a range of knowledge bases for teaching (Loucks-Horsley et al., 2009) in an attempt to improve student learning of subject matter. As the discourse on teachers' knowledge became prominent, it became important to identify the place of this teacher knowledge in the total knowledge base of teaching (Van Driel et al., 2001). Shulman (1986, 1987) pioneered the research into the kinds of knowledge that a teacher needs to possess in order to impart quality teaching. Shulman (1986) focused on specific content knowledge domains, initially organising this knowledge into three categories, namely: subject matter knowledge;

pedagogical content knowledge and curricular knowledge. He later expanded these into seven categories. These domains will be discussed under the theoretical framework.

2.10.1 Subject matter knowledge in Life Sciences

Subject matter/content knowledge as proposed by Shulman (1986: 9) refers to “the amount and organization of knowledge per se in the mind of the teacher”. Shulman (ibid) further contends that subject matter content knowledge goes beyond knowledge of facts or concepts of a particular domain. It requires understanding the structures of the subject matter, which include both the substantive structures; “the variety of ways in which the basic concepts are organized to incorporate its facts” and the syntactic structures; “the set of ways in which truth or falsehood, validity or invalidity are established” (Shulman (ibid). Goldschmidt and Phelps (2007) agree that good knowledge of the subject matter knowledge is needed to teach effectively. In a similar vein, Bertram (2011) concurs that it is the understanding of fundamental concepts and how the concepts are related and organised that enables teachers to use their subject matter knowledge for teaching.

Taylor and Vinjevold (1999) point to South African teachers’ poor grasp of the knowledge structure of science as the major factor that inhibits efficient teaching and learning of the science subjects. Strengthening science teachers’ content knowledge should therefore be a key element of any professional development programme (Kriek & Grayson, 2009).

As outlined in the introduction, Life Sciences subject comprises a variety of specialisations as shown in figure 2.10.1 below.

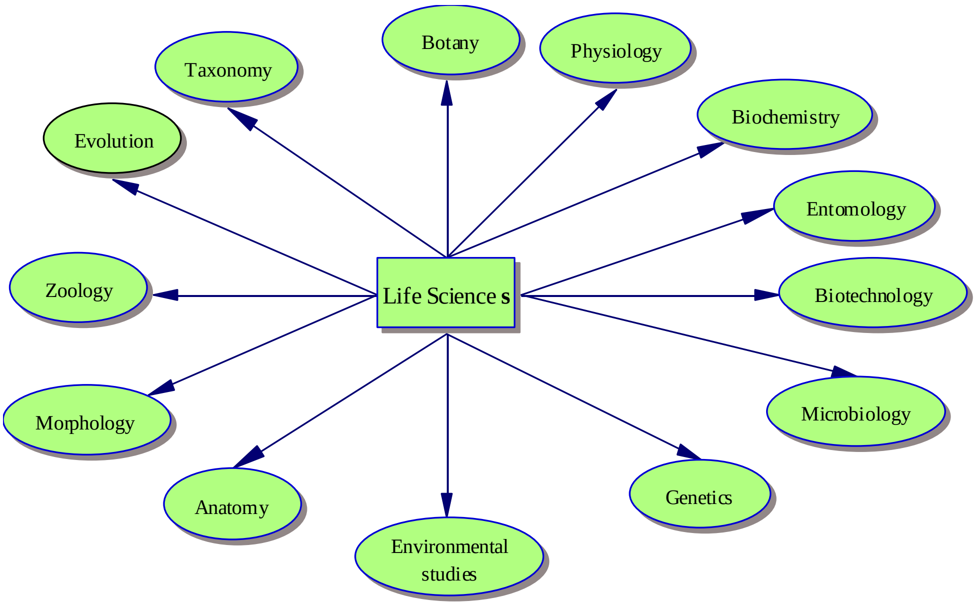


Figure 2.10.1: A diagrammatic representation of sub-disciplines in Life Sciences curriculum

Different topics are selected from these sub-disciplines and amalgamated into four knowledge strands, namely:

- Life at the Molecular, Cellular and Tissue level
- Life processes in Plants and Animals
- Environmental Studies
- Diversity, Change and Continuity (DBE, 2011c).

By inference, South African Life Sciences teachers ought to possess the knowledge for all the sub-disciplines so as to provide learners with a broad and profound knowledge of Life Sciences. Shulman (1986) also made a strong case that a biology teacher must understand the variety of ways in which the discipline is organised. Shulman further argued that a well-prepared biology teacher should also recognize alternative forms of organizing the discipline, and be aware of the pedagogical grounds for selecting one kind of organization over the other. The teacher should also appreciate the 'syntax[2]' of biology. Shulman further cites an example of how there can be competing claims regarding the same biological phenomenon; asserting that teachers should have an understanding of such contending claims, and how the controversy has been adjudicated to arrive to a particular viewpoint. The following excerpt from the South African Life Sciences curriculum document (CAPS) aligns with Shulman's conceptions:

[2]According to Shulman (1986:9) syntax is "the set of rules for determining what is legitimate to say in a disciplinary domain and what "breaks" the rules".

> "Knowledge production in science is an ongoing endeavour that usually happens gradually but, occasionally, knowledge and insights take a leap forward as new knowledge, or a new theory, replaces what was previously accepted. As with all knowledge, scientific knowledge changes over time as scientists improve their knowledge and understanding and people change their views of the world around them. A good teacher will tell learners something of the debates, arguments and contestations among scientists who were the first to investigate a phenomenon" (DBE 2011: 7).

Furthermore, the South African Life Sciences curriculum documents delineate three broad Specific Aims relating to the purposes of learning science. These are:

1. Specific Aim 1 - relates to knowing the subject content ('theory');
2. Specific Aim 2 - relates to doing science or practical work and investigations; and
3. Specific Aim 3 - relates to understanding the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and science.

Subject matter knowledge as defined by Shulman links up with Specific Aims of the South African Life Sciences curriculum. As outlined in *Specific Aim 1,* which relates to subject matter content knowledge, teachers need to know and understand all the relevant Life Science concepts, processes, phenomena, mechanisms, principles, theories, laws, models, etc. They need to know, understand and make meaning of Life science topics, thereby enabling learners to make connections between the ideas and concepts. Teachers need to ensure that learners acquire a deep understanding of the subject matter content more than just accumulating knowledge of disconnected facts.

Further, Shulman's conception of Subject matter knowledge is also links with Specific Aim 2 which relates to the ways of investigating natural phenomena, and the warrants by which we know that something is true. Investigating nature (practical work) plays an important role in the teaching and learning of science content/subject matter. Specific Aim 2 outlines seven investigative skills that teachers ought to impart when teaching investigations/practical work. These include taking instructions; making observations; designing/planning investigations/experiments; handling equipment; measuring, recording and interpreting data

(DBE, 2011c). Whilst the Life Sciences curriculum envisages teachers that possess the necessary knowledge to facilitate these skills, it appears that many teachers lack confidence in doing and teaching practical work (Motlhabane & Dichaba, 2013), which may hinder the implementation of this important aspect of the curriculum in general, and impact negatively on the teaching of the important of science process skills in particular. Based on an empirical study conducted with ACE teachers studying at a South African university, Motlhabane and Dichaba (2013) observed that teachers were reluctant to draw up lesson plans on practical work activities even when they had ample time to do so. This reluctance was caused by teachers' lack of confidence in doing practical work. Motlhabane and Dichaba (2013) recommended andragogical approaches such as discussions of lesson plans and role modelling during professional development and then allowing teachers to perform practical work activities before they teach them to their learners.

Shulmans' subject matter knowledge also links up with Specific Aim 3, which includes the nature of science. Specific Aim 3 relates to understanding the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and science. The knowledge that is taught in respect of Specific Aim 3 always relates to subject content. Specific subject matter knowledge is therefore required so that teachers can use it as the context for teaching about various aspects of the nature of science.

According to Shulman (1986) there is a 'pedagogical price' to be paid when the teacher's subject matter competency is compromised by lack of proper training. By implication, teachers that have been inadequately trained in subject matter content knowledge are likely to fall short in their pedagogical strategies. Teachers are unable to assist their students comprehend what they themselves do not understand (Loucks-Horsley & Matsumoto, 1999). Research on teacher learning underscores the need for professional development to help teachers understand amongst other knowledge and skills, subject matter content knowledge (Birman et al., 2000; Putman & Borko, 2000; Loucks-Horsley & Matsumoto, 1999; Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008). Content-based professional development is essential for teachers' learning, particularly in science subjects, where many of the teachers possess inadequate subject matter content knowledge.

2.10.2 Curricular knowledge in Life Sciences

Curriculum knowledge, as stated by Shulman (1986: 9) includes a complete set of programs designed for the teaching of a particular subject and specific topics. Curriculum knowledge also includes a range of instructional materials for teaching specific subjects and topics Shulman (1986). Shulman identified two important components of curricular knowledge essential for teaching, namely: lateral curriculum knowledge and vertical curriculum knowledge. Lateral curriculum knowledge relates to teacher's awareness of the topics or issues being discussed simultaneously in other classes. Vertical curriculum knowledge involves knowledge of topics taught in the same subject area in the earlier and later years in school (Shulman, 1986).

In Life Sciences, teachers are expected to develop links across grades, i.e. they need to be familiar with similar topics taught at various grades. This is to enable them to create links between students' prior knowledge and new knowledge. The first section in Grade 10, called Subject Orientation, is designed to prepare learners for the FET phase, and is intended to connect what learners learned in the GET (Natural Sciences) with what they will be learning in the FET (Life Sciences). The Life Sciences subject builds on knowledge and skills acquired from the Life and Living knowledge area in GET (DBE, 2011c). Without attaining this curriculum knowledge, teachers are unable to achieve the objectives as laid out in the Life Sciences curriculum document. Hence, teachers need to have proper knowledge of the curriculum to implement the new changes.

Teachers also need to have vertical knowledge of the curriculum within FET, so that they can build on concepts and skills developed below the current grade, and lay solid foundations for development of knowledge and skills in higher grades.

In a study conducted by Behar and George (1994) to assess how teachers used their knowledge of curriculum during the implementation of a new innovative model of curriculum, it emerged that teachers' lack of curriculum knowledge, as well their ability to use curriculum knowledge affected the implementation of the new curriculum model. According Behar and George (1994), any diversion from the traditional curriculum to an innovative new form of curriculum requires amongst many factors, appropriate re-conceptualization of the teaching role; a process to ensure that all teachers share a common view of what the new curriculum entails; administrative support, and instructional guidance. Development of teachers' curricular knowledge should therefore be an integral part of teachers' professional development, especially during reform.

In his definition of curricular knowledge, Shulman included not only the knowledge of topics, but also the knowledge of the variety of instructional materials available. Various scholars believe that it is the lack of understanding of primary principles of the curriculum that prevents effective use of curriculum materials by teachers (Lieberman & Miller, 2001; Singer, Krajcik, Marx, & Clay-Chambers 2000; Wiggins & McTighe, 1998). Therefore, professional development should incorporate time for instructional planning, discussion, and consideration of underlying principles of curriculum to be more effective in supporting implementation of innovations (Penuel, Fishman, Yamaguchi, & Gallagher, 2007: 931).

It is generally expected that curriculum reform will bring about new changes in teaching strategies, approaches and techniques, (Vacirca, 2008). At the outset, teachers need awareness of the philosophies of the new curriculum before implementation (Stein, McRobbie, & Ginns, 1999). In turn, teachers require knowledge of new curriculum so as to change their philosophy (Brady & Kennedy, as cited in Barnes, 2005). This has to occur through teacher development, failing which, the implementation of new curriculum becomes unfeasible (Givens, as cited in Barnes, 2005).

2.10.3 Pedagogical Content Knowledge for Life/Biological Sciences

As argued by Adler and Reed (2002), content knowledge alone is not adequate for teaching; teachers need to further acquire subject knowledge for teaching, i.e. pedagogical content knowledge (Shulman, 1986). When Shulman (1986) first introduced the concept of pedagogical content knowledge (PCK), he looked at it as the knowledge which goes beyond mere knowledge of subject matter, but into the dimension of subject matter knowledge for teaching. Within the category of PCK, Shulman includes key aspects of representing the subject matter. Shulman, (ibid) defined pedagogical content knowledge as encompassing:

> "the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of

> representing and formulating the subject that make it comprehensible to others…. Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons", (p.9) .

In a subsequent editorial, Shulman (1987: 8) rearticulated PCK as a 'special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding'. In this way, Shulman emphasized teachers' combination of content knowledge with pedagogical knowledge as central to teaching. Likewise Loughran, Berry and Mulhall (2012) assert that PCK does not simply involve use of a teaching procedure because it works but it is about integrating knowledge of pedagogy with content together, so that the content is better understood by learners. As expressed by Loughran et al. (2012), for the development of PCK, teachers need to possess good conceptual understanding of the subject content. According to Loughran et al., (2012: 7) a teacher who uses strategies such as illustrations, examples, explanations, concept maps to explore concepts within a specific topic to challenge students' thinking, demonstrates PCK. Use of such strategies during teaching helps learners understand concepts better, bringing to the fore any possible misunderstandings and difficulties (Loughran et al., 2012).

In line with the principles of PCK, the South African Life Sciences curriculum explicitly lays down what the learners need to achieve by learning the Life Sciences concepts. The curriculum document specifies that in the process of making meaning and achieving understanding of concepts and ideas in Life Sciences, learners must:

- build a conceptual framework of science ideas;
- organise or reorganise knowledge to derive new meaning;
- write summaries;
- develop flow charts, diagrams and mind maps; and
- recognise patterns and trends (DBE, 2011c:14).

The curriculum document further sets down other kinds of skills that the learners must attain in the process of learning Life Sciences. These include the ability to:

- analyse information/data;
- recognise relationships between existing knowledge and new ideas;
- critically evaluate scientific information;
- identify assumptions; and
- categorise information, (DBE, 2011c: 14).

The assumption here is that teachers have acquired the desired PCK to facilitate these kinds of skills during their teaching. In reality though, some of the teachers (if not many) may be lacking not only in their PCK, but also hold a superficial conceptual understanding of many of the concepts to facilitate the kind of learning envisaged in the curriculum documents. As pointed out previously, teachers also need to have the necessary knowledge and strategies to teach process skills through the teaching of science investigations.

Based on earlier research by Lederman, Gess-Newsome and Latz (1994), it was believed that both prospective or novice science teachers generally possess little to no PCK. Along the same line of argument, Smith and Neale (1989) claimed that teacher training programs regularly did not exert any significant effect on science teachers' PCK. On the contrary, based on an earlier study to examine the influence of an intensive workshop on fostering PCK growth among science teachers, Clermont, Krajcik, and Borko (1993) reported a significant improvement as a result of the workshop. Similarly, Van Driel, Verloop, and de Vos (1998), made a case that both in-service and pre-service training programs have potential to result in changes in the teachers' conceptions of teaching and learning science.

Literature presents PCK in science as including teacher's knowledge of science learners, curriculum, instructional strategies, and assessment (Abell, 2007; Magnusson, Krajcik, & Borko, 1999). Whilst teachers generally possess these kinds of knowledge for teaching science and various teaching strategies, the introduction of a new curriculum automatically shapes the evolution of new strategies in teachers' pedagogical knowledge. When the new outcomes-based education was introduced in countries like South Africa and Australia, shifting traditional way of presenting science facts to a constructivist-based pedagogy to better develop learners' understanding of science concepts and phenomena, teachers were faced with considerable challenges (Appleton, 2008: 530). According to Appleton (2008), during curriculum change science teachers' PCK needs a lot of attention which may hopefully be attained through teacher learning in various PD models and programmes.

2.11 Challenges relating to teacher knowledge in South Africa

As articulated in the CAPS documents, the Life Sciences content framework focuses on ideas, skills, concepts and connections between them, rather than on listing the facts and procedures that need to be learned. In principle, the emphasis here is on teachers moving away from a teaching approach which presents science as a rigid body of facts that must be memorized. Without prescribing any particular instructional strategies or methodologies, it is evident in the CAPS documents that teachers of Life Sciences are instead expected to present the subject as a way of knowing, rather than merely emphasizing acquisition of facts and information. Teachers have the freedom to expand concepts and to design and organise learning experiences according to their local circumstances, including the availability of resources. This indeed requires an autonomous but competent teacher with regard to subject matter knowledge as implementing this teaching approach requires deep understanding of "higher order" concepts and perspectives from the teacher (Welch & Gultig, 2002).

The reality though, is that the majority of the South African teachers had been trained in a system that promoted passive absorption of facts and skills through rote learning (Nykiel-Herbert, 2004) without critical reflection. There has thus been a strong need for developing teacher leaning programmes that would move teachers from this dogma of pedagogy, i.e. teaching in an almost uncritical way, to a position where teachers reflect critically on their teaching practices. The shift towards a learner-centred paradigm has indeed proven to be complex for many teachers familiar with the traditional top-down approach. Teachers need to attain deep subject matter content/conceptual and skills knowledge as well as sound pedagogical content knowledge in order to support any innovative approach such as the inquiry-based, learner-centred approach. Findings from empirical studies conducted in South Africa (Ngema, 2011; Hattingh, Aldous, & Rogan, 2007; Pillay, 2004) indicated that whilst teachers conceived practical work as a 'hands-on' activity, they relied mostly on demonstrations as the main method of doing practical work. During practical work, South African teachers focus largely on basic science process skills (Ngema, 2011; Hattingh et al., 2007; Pillay, 2004). These studies revealed that it was not just contextual factors such as the lack of resources, large classes (as usually reported) that impact on the teaching of practical work skills. The biggest challenge is that of limited teacher preparedness to teach and therefore engage learners in 'hands-on' practical work activities (Pillay, 2004; Rogan & Aldous, 2005; Hattingh et al., 2007; Motlhabane & Dichaba, 2013). The results of these studies clearly indicate a persistent gap between theory and teachers' classroom practices. South African teachers require experiential support so that they can effectively use inquiry-based teaching approaches.

2.12 Development of teacher knowledge through learning through CPTD programmes

A number of scholars have argued that teachers' knowledge such as subject matter knowledge, general pedagogic knowledge and pedagogic content knowledge can be developed and enhanced through pre-service and in-service professional development such as qualification programmes, specific courses, training workshops, etc., (Johnson, Hodges, & Monk, 2000; Van Driel et al., 1998; van Dijk & Kattmann, 2007). Bertram (2011: 13) makes a case that deep conceptual disciplinary knowledge needs to be learnt in formal, structured ways, which must be led by an expert who can organize the knowledge systematically and can make the conceptual connections clear. Once the teacher has developed this deep conceptual knowledge, then he/she should be able to access new knowledge (brought about by curriculum reform), through the already existing disciplinary knowledge (Bertram, 2011). The point of departure here is whether teacher learning programmes can help practicing teachers learn this kind of knowledge. So, the starting point for any professional development programmes should be to ensure that the nature of intervention planned must be able to generate tangible evidence that it will develop transferable knowledge that can be used in a classroom context.

Teachers however need more than deep conceptual knowledge; they need conceptual knowledge for teaching, i.e. pedagogical content knowledge. Although PCK as a construct was widely explored, studies on approaches that can be used to develop teachers' PCK through teacher in-service programmes seem to be fairly recent (Clarke & Hollingsworth, 2002; Van Dijk & Kattmann, 2007; Henze, Van Driel & Verloop, 2008; Abell, Rogers, Hanuscin, Lee, & Gagnon, 2008, Appleton, 2008). According to Van Driel (2010) earlier research studies paid little attention to the effects of continuing professional development courses on expanding science teachers' pedagogical content knowledge (PCK). Van Driel (2010) is of the opinion that PCK development has focused on pre-service teachers, within the framework of initial teacher education. Along this line of reasoning, Botha and Reddy (2011) also argue that the concept of PCK for a long time remained theoretical, without it being actively introduced into teacher training programmes, especially pre-service programmes. This was largely due to the fact that much rigor was directed towards the evaluation of PCK as a construct, as opposed to exploring practical examples of how teachers can approach the teaching of specific content topics in ways that promote understanding (Loughran et al., (2012).

Models and research studies such as those of Clarke and Hollingsworth, 2002; Van Dijk and Kattmann, 2007; Henze, Van Driel, and Verloop, 2008; Abell, Rogers, Hanuscin, Lee, and Gagnon, 2008, Appleton, 2008, address PCK in continuing teacher education and training. For example, Van Dijk and Kattmann's model called Educational reconstruction for teacher education (ERTE) epitomizes an integrated approach of PCK, with the purpose of improving teacher education. Van Driel's (2010) model of continuing professional development for science teachers' PCK, borrows heavily from certain elements of an existing model for teacher professional growth by Clarke and Hollingsworth (2002). Appleton (2008) suggested a mentoring approach towards professional development of science teachers' PCK, where he argued for reflection on classroom support that will improve science teachers' PCK.

2.13 Development of teacher knowledge through CPTD: A South African context

Qualification-driven and non-qualification programmes for CPTD equally aspire to develop teachers' knowledge base. Whether through workshops or qualification courses the objective should be to expand teachers' knowledge that will lead to improved teaching and learning. The scenario in South Africa has been that many of the training workshops (especially those that are Departmental) have focused on 'propositional knowledge of the curriculum' (Bertram, 2011), i.e. how to implement the curriculum, to the neglect of the subject matter content knowledge and pedagogical content knowledge (Bantwini, 2009, 2011).

There are many factors to which South African teachers' lack of rich conceptual understanding of subject matter knowledge may be attributed. Firstly, the diversity in the initial teacher training has meant that many of the practicing teachers were inadequately trained in subject matter content knowledge. Furthermore, many of the teachers are still grappling with new content in their subjects which evolved (and continue to evolve) a result of the curriculum reforms. For example, evolution was not taught in schools or colleges of education until 2008, when it was included in the Grade 12 curriculum. As a result, many currently practising teachers who were not exposed to evolution topics during their initial training did not understand the concepts they were expected to teach (Stears, 2006; Magubane, 2012; Ngxola, 2012). With the frequency of curriculum reform as well as the inappropriate models of teacher development, teacher learning opportunities have not met the needs of many teachers. Another setback in the development of teachers' PCK may also arise as a consequence of teachers teaching outside their areas of subject expertise. This is a fairly common scenario in the South African education system. No matter how capable the teacher maybe, once they are made to teach outside their established area of subject expertise, they become considerably challenged (Loughran et al., 2012).

The DBE and its relevant stakeholders has acknowledged the superficial and generic nature of many teacher development initiatives, calling on the strengthening of the CPTD models by focusing more on key knowledge domains such as the subject matter knowledge, deep conceptual knowledge and pedagogical content knowledge. Although knowledge is not simply transferred from a learning programme to the classroom context, careful planning of PD programmes can however allow for development of certain knowledge that can be applied in a classroom. For example, content knowledge workshops should 'focus on developing teachers' deep knowledge of the organization and structure of the discipline, not simply on knowing facts about the discipline' Bertram (2011: 19). Teacher training workshops may also develop teachers' PCK, for example, through modeling new instructional methods. Qualification driven CPTD programmes also need to pay close attention to these knowledge domains, ensuring that teachers have access to quality programmes. The critical factor here is offering sustained programmes with follow-up support and ongoing mentoring and coaching of teachers in classroom; strengthening communities of learning; and providing adequate resources for teachers to try out new instructional strategies.

Shulman's work discussed above is significant in this study because it provides a clear perspective on how and why the revisions and the re-organisation of the topics in the South African Life Sciences curriculum have been essential. Shulman's position is that teachers ought to be cognisant of the pedagogical justifications for organising the discipline in a particular way. The downside is that teachers are not always educated to understand the context for these modifications. This has precisely been the case in Life Sciences subject, where constant amendments were necessary to better articulate the curriculum. Such curriculum improvements however, should go hand in hand with the development of teachers' knowledge of the curriculum, the subject matter, and general pedagogical knowledge. These knowledge areas greatly influence teachers' PCK. Literature presented here however suggests that teachers of Life Sciences may not have been particularly adept to implement the changes, and hence, seen to be teaching more at basic levels.

2.14 Conclusion

South Africa continues to develop policies and programmes to support ongoing development of knowledge base for all teachers in view of the curriculum changes. Nonetheless these policies and programmes have very little impact in developing teachers to appropriately meet the demands of the curriculum. Part of the problem is that the system has failed to differentiate between the actual needs of teachers to address the existing gaps in subject-specific knowledge. CPTD in South Africa clearly needs to place emphasis in developing discipline-specific knowledge, ensuring the expansion of teachers' conceptual knowledge for all subjects including Life Sciences.

CHAPTER 3

THEORETICAL FRAMEWORK

3.1 Introduction

Constructivism is used as an over-arching theoretical framework underpinning this study. Within this broader framework, there are a number of theories/conceptual frameworks. These include *Adult learning and motivation theories, Communities of Practice* and *Pedagogical Content Knowledge*. The following diagram illustrates the interconnectedness of these smaller frameworks within the larger constructivism framework.

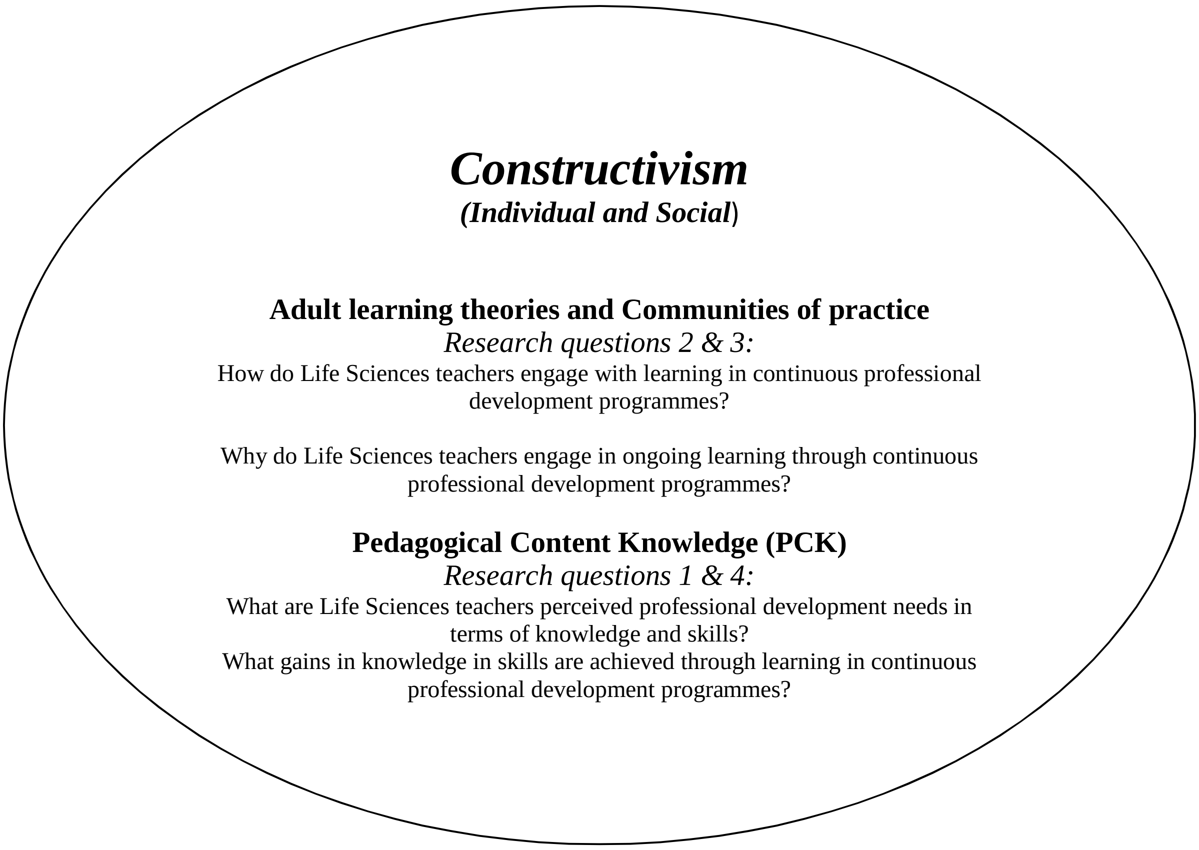


Figure 3.1.1: A theoretical and conceptual framework for the study

3.2 The Constructivist Epistemology

This research study is concerned with teachers' development needs which should be guiding teacher learning. Further, this study investigates how teachers learn through professional development programmes. Finally, the study examines the gains achieved through these professional development programmes. Constructivism in this study is thus used on the premise that for effective learning to occur, teachers need to determine: (1) what should be taught, i.e. learning in professional development programmes should be based on teachers' actual development needs; (2) how it should be taught, i.e. methods and strategies of learning in CPD programmes should embrace adult learning theories because teachers are adults; (3) whether learning has been effective, i.e. evaluation of learning to determine the gains achieved through learning.

Constructivism focuses on knowledge construction and is contrasted with the positivist model of learning. Instead of focusing on learning objects which are transmitted from one person to another, learning occurs as the result of interactions, reflections, and experiences (Howard, McGee, Schwartz & Purcell, 2000). Earlier theories of positivism had hypothesized knowledge as the awareness of objects that exist independent of any subject (Murphy, 1997). This static, passive way of viewing knowledge was later challenged by constructivists who argued that knowledge does not have an objective or absolute value (Glasersfield, 1995). Most constructivists concur that: 1) learners should construct their own learning; 2) new knowledge is built on previous learning; 3) social interaction plays a critical role in learning; 4) it is necessary to have authentic learning tasks for meaningful learning to occur (Pressley, Harris, & Marks, 1992).

The role of prior knowledge is emphasized in constructivism because it facilitates connections between new and prior information (Leinhardt, 1992). Connections between prior knowledge and new information are critical during teacher continuous learning as they would facilitate conceptual change (Hausfather, 2001) which can be transformed into good PCK. Through establishing prior knowledge, teacher education programs need to promote approaches that will challenge teachers' own preconceptions so that they are better prepared to deal with their learners' preconceptions (Hausfather, 2001). The idea of prior knowledge relates to Piaget's individual constructivist perspective which posits that individuals construct new knowledge from their experiences through the processes of assimilation, where they assimilate a new experience into an already existing framework; and through the process of accommodation, by modifying or reframing existing knowledge to fit new acquired knowledge (Bennett, 2005). The importance of teachers constructing their own learning, i.e. self-directed learning, is underscored through Individual constructivism. Piaget viewed knowledge as something which an individual constructs and re-constructs for themselves (Thompson, 2001). Teachers as adults are expected to engage in their own learning which is self-regulated. According to Bell and Gilbert (1994: 483) teachers often at their own initiative, in their own time, at their own expense and with a commitment to professional development, engage in personal learning. Personal development as further expounded by Bell and Gilbert (1994) is usually private, self-initiated and sustained. The teacher then draws on this personal development when engaging with a teacher development programme. In their three-year study Bell and Gilbert (1994) found that through personal constructivism, teachers bring to the teacher development programmes, different ideas, beliefs, experiences, concerns, interests, and feelings which facilitate learning. Individual constructivism is therefore an important aspect that teachers should bring along to any professional development activity so that they can benefit significantly. It is therefore important to examine the extent at which teachers embrace the theory of individual constructivism through engaging in own personal learning.

While knowledge is personally constructed, each individual's constructions are mediated by the actions of others in a social setting (McRobbie & Tobin, 1997). So while individual constructivism deals with the meanings that individuals construct for themselves, social constructivism moves beyond constructing meanings, viewing learning as a process that can be shared and discussed (Thompson, 2001). Social constructivists recognize the interplay between the personal and the social aspects for meaningful learning to take place. Other key contributors to the conceptualization of social constructivism (Bruner, Lave and Vygotsky) argued that social interaction plays a fundamental role in the development of cognition. Vygotsky (1978) was mostly recognized for his development of the concept of 'Zone of Proximal Development', a high level of cognitive development attained when one engages in social learning. In Vygotsky's opinion, in order to bridge the gap between what the learners know and what they ought to know, they need to utilize the social support system. Learning according to Vygotsky does not occur in isolation, but it is a complex process that occurs as a result of association with significant others. The idea of placing an individual within a social setting, as a social participant in the learning process lends itself to social learning. Social learning as expounded by Vygotsky (1978) complements Lave and Wenger's (1991) theory of 'situated learning', which also emphasizes the importance of social learning. A critical component in 'situated learning' is social interaction amongst members involved in the practice of learning, forming a 'community of practice' (Lave & Wenger, 1991). With the introduction of the concept of Clusters, teachers generally convene in geographical groups for professional development. In general, teacher clusters form sites of learning, and thus conform to principles of communities of practice. As with personal development, Bell and Gilbert (1994) found in their study that the expected benefits of working with other teachers to improve teaching and learning were perceived as greater. Teachers were able to share information on what was happening in their classrooms, giving support and feedback to each other, offering suggestions for new teaching strategies, and suggesting solutions to problems. This study will thus investigate the extent to which learning within cluster groups enables teachers to apply social constructivist approaches, and whether learning takes place at a meaningful level, imparting the necessary knowledge and skills to teachers.

3.3 Communities of Practice

As illustrated above, Communities of Practice are a social learning system. Wenger (2000: 227) views learning as an interplay between social competence and personal experience, which combines personal transformation with evolution of social structures. Wenger (2000) points out different modes of belonging to social learning systems. One of the key modes of belonging includes engagement, i.e. doing things together such as helping a colleague with a problem. Imagination is another mode of belonging, which involves the construction of an image of oneself, their communities and of the world (Wenger, 2000: 227-228). These images are important to reflect on people's sense of self and of their participation in the broader social learning systems. Alignment as a mode of belonging means ensuring that people are properly aligned with the required processes so that they can be effective beyond their own engagement. Each of these modes of belonging, contribute an important aspect to social learning systems to ensure that they function efficiently (Wenger, 2000).

Communities of practice form the foundation of a social learning system as they provide such systems with the necessary coherence and competences. As further expounded by Wenger (1998), coherence and competences of communities of practice are achieved through *mutual engagement*, i.e. through members interacting with one another, establishing norms and relationships of mutuality. Secondly, members are bound together by an understanding of a sense of *joint enterprise*. Thirdly, communities of practice produce a *shared repertoire* of communal resources. For Wenger (1998) communities of practice are important places of negotiation, learning, meaning, and identity. This conceptual framework is an appropriate tool for analysing teachers' development, particularly through cluster-based training.

In spite of constructivism having originally been developed for schooling learners in mind, there are certain points of intersection between constructivism and adult learning characteristics. For example, Knox's ideas complement those of Piaget's constructivism. Knox (1980) believes that adults learn continually as they adjust and adapt to changing roles and other conditions in life. Piaget had earlier argued that learners learn by assimilation and accommodation, which involves construction of new knowledge from their experience, i.e. by assimilating new experience into already existing one, whilst modifying existing experience to fit new experiences. This is particularly true in the context of changing curricular, where teachers find themselves learning new material and assuming new roles with constantly evolving curricular.

3.4 Adult learning theories

a. Andragogy

There seem to be a number of parallels between constructivism and the needs of adult learners (Thompson, 2001). As discussed above, the key principles of constructivism include self-regulated learning, prior knowledge and authentic learning tasks for meaningful learning to occur. Similarly, in viewing adult professional development Knowles (1970) proposed a concept of andragogy which is aligned with the theory of constructivism. Knowles' Andragogical model distinguishes adult learning from pre-adult learning and is grounded on the following assumptions (Knowles, 1998: 64-68; Merriam, 2001: 5):

- *The need to know*. Adults need to know why they need to learn something before they undertake it.
- *The learner's self-concept*. An adult learner has an independent self-concept and can direct his or her own learning.
- *The role of the learners' life experience.* An adult learner comes into an educational activity with a great volume of experiences which becomes a rich resource for learning.

- *Readiness to learn.* An adult learner has learning needs closely related to changing social roles.
- *Orientation to learning.* An adult learner is problem-centred and interested in immediate application of knowledge.
- *Motivation.* An adult learner is motivated to learn by internal rather than external factors.

Knowles (1968) derived the idea of self-directed learning in adults from the perspective that adults manage other aspects of their lives, and are therefore capable of directing, or at least assisting in planning their own learning (Merriam, 2001). The notion of self-directed learning in adult learners has also been expressed by Simpson (as cited in Trotter, 2006) noting as one of the traits of adult learners, the autonomy of direction of learning. As articulated by Trotter (2006: 11), *functional theorists* such as Simpson, believe that ‘adults prefer to plan their own educational paths, and most generally choose educational topics and subjects that they could directly apply in their own classrooms’. Similarly, Daloz (1999) asserts that adult learners need to plan their own educational paths based on their interests and their classrooms. Trotter (2006) contends that teachers should be given latitude to form their own professional development, dealing with what interests them and what they feel they need to learn for effective learning.

Carlson (1989) related Knowles’ seven step process for working with adult learners: cooperative learning climate, mechanisms for mutual planning, diagnosis of learner needs and interests, formulation of learning objectives based on the diagnosed needs and interests, sequential activities for achieving the objectives, selection of methods, materials, and resources, and evaluation of learning (Thompson, 2001:19).

Gibb (as cited in Trotter, 2006) earlier developed what is now called the ‘functional theory’ of adult learning. In this theory, Gibb observed adults learning, and later proclaimed that their learning should be problem-centred and meaningful. It is against this backdrop that Knowles reiterated the key assumptions about adult learning being problem-centred, where adult learners are interested in immediate application of knowledge. Adult learners are motivated to learn if the subject matter is relevant to their current role and transition period (Brundage & Mackeracker, as cited in Trotter, 2006).

Adult learners also use experience as the main resource for learning (Knowles, 1968). This proposition has been backed by many scholars including early functional theorist Linderman, Brundage, & Mackeracker; Smith, and Knox (as cited in Trotter, 2006). Another key assumption made by Knowles was that related to the role of teachers' experience when participating in a learning programme. In Knowles' perspective, an adult learner has learning needs related to changing social roles. Teachers of Life Sciences in this study are a case in point. As a result of ongoing curriculum reform, teachers continuously develop new learning needs related to their new teaching roles.

b. Adult motivation to learn

Motivation is required to stimulate learners to want to participate in learning, and is also needed throughout the process of knowledge construction (Palmer, 2005: 1855). In Palmer's view, constructivist theory includes motivation as a 'necessary prerequisite and co-requisite for learning' (p. 1855). In the opinion of Barlow (2002), teachers who have an intrinsic need to learn are likely to be satisfied.

Teachers' motivation to engage in professional learning can be viewed within the context of Maslow's theory of human motivation which is based on satisfying a hierarchy of needs (Bennett, 1994; Barlow, 2002). The teachers' desire to participate in professional development may be seen as a way to satisfy their development needs. Whilst Maslow's levels of needs include physiological needs; safety needs; belonging needs; esteem needs; and self-actualization needs, it is likely the higher levels, i.e. belonging need, esteem needs and self-actualization needs that relate to teachers' development needs. For example, collaborations with other teachers of Life Sciences where practical solutions to teaching challenges may be shared are pivotal. This sense of belonging would include teachers' affiliation to different teacher-social structures such as Cluster groups (teacher networks/learning communities), where there is expected interaction and information-sharing. At a higher level of need, teachers generally desire to acquire content-related knowledge and overall pedagogical content knowledge which is linked to the development of their self-esteem and confidence to implement the new curriculum. Hence the need to increase one's scope of knowledge may well fit into Maslow's esteem needs category. At the highest level of hierarchy, i.e. self-actualisation, adults develop an urge to solve complex problems, a sense of autonomy and self-directedness, an outcome of which is well developed individuals.

Self-reflection is important in determining motivation to learn. As noted by Bandura (1986), self-reflection i.e. intrinsic reinforcement, influences learning and behavior which then brings some form of internal reward and a sense of accomplishment once learning has taken place. Through self-reflection, is self-efficacy belief i.e. people's judgments of their capabilities to execute courses of action required to attain desired types of performances (Bandura, 1997: 391). Self-efficacy beliefs form the basis for human motivation and personal accomplishment (Bandura, 1997). Teachers' beliefs about their competences are thus likely to determine their engagement in continuous learning.

Motivation is important not merely because it improves learning but because it also mediates learning (Wlodkowski, 1999). Learners who complete a learning experience feeling motivated about what they have learned are more likely to have a continuing interest in and to use what they have learned (Wlodkowski, 1999). The inference drawn here is that motivation arises intrinsically from the learner and extrinsically from the learning experience.Whilst Knowles (1968) considered an adult learner to be intrinsically motivated, Tough, in Knowles (1998: 68) established through his research, that adult intrinsic motivation to learn is often hindered by barriers such as inaccessibility of learning opportunities, time constraints, and programs that disregard principles of adult learning. Empirical studies have shown that other factors such as lack of finance, workload, etc., often deter adult learners from participating in continuous learning. Clearly, the intrinsic as well as the extrinsic motivation to learn reinforce each other for successful learning.

More often than not, it is the deep social responsibility, i.e. need for competence and being effective at what one does that drives learning among adults (Wlodkowski, 1999). During any curriculum change, teachers feel externally propelled into learning. For successful learning however, the extrinsic goal to learn needs to be self-endorsed and adopted with a sense of volition (Ryan & Deci, 2000: 55). Contextual factors such as the quality of learning programmes and the personal will to learn may either hinder or promote motivation. In essence, there has to be a balance between intrinsic and extrinsic factors which motivate teachers to learn. Individual teachers that develop internal motivation to engage in continuous learning need support from relevant authorities to ensure that external factors that are likely to impinge on teachers' enthusiasm to learn are eliminated.

3.5 Pedagogical content knowledge

Literature suggests that teachers' pedagogical content knowledge was affected by the constructivist view (Geddis, 1993). For many teachers the transition toward the constructivist-based teaching practices has been challenging (Wildy & Wallace, 1995). Drawing on the discourse on the domains of teacher knowledge under the literature review, this study also uses PCK as one of the underpinning conceptual frameworks of the study. With the study contextualized in the field of Life Sciences, specific attention will be paid to Science PCK.

Shulman's (1986, 1987) construct of PCK has been widely accepted as a significant domain in teachers' knowledge. PCK has however been construed differently by various scholars. With different models of PCK having been developed, the ongoing dialogue has been whether PCK should exist as a separate construct from other knowledge domains. Gess-Newsome (1999) conceptualised the nature of PCK, recognising two different epistemological views: an *integrative* and a *transformative* view. An integrative view considers PCK as part of teacher knowledge as a whole, comprising subject matter knowledge, knowledge of pedagogy, knowledge of curriculum, and other knowledge domains. The integrative model PCK is conceived as the overlapping of three constructs: subject matter, pedagogy, and context (Karaman, 2012). The integrative model has no defined boundaries between knowledge domains. The transformative model on the other hand considers PCK as a distinct knowledge which arises from the act of transforming other domains of knowledge such as the subject matter knowledge through experience, which develops into a new form of knowledge (Appleton, 2008).

Shulman's model is seen to be transformative because he viewed PCK as a special domain since it is a unique knowledge for teachers to deliver successful teaching. Whilst Grossman (1990) proposed a transformative PCK model with four components and Magnusson et al., (1999) a five-component model, they followed Shulman's transformative model explicitly. Advocates for the transformative model consider PCK as a distinct knowledge which arises from the act of transforming other domains of knowledge such as the subject matter knowledge through experience for the purpose of teaching, which develops into a new form of knowledge (Appleton, 2008). Magnusson et al. (1999) and other proponents of transformative models reason that other knowledge domains such as the knowledge of subject matter; pedagogy; curriculum; school context; educational aims, etc., all act as prerequisites for the transformation process. Similarly, Appleton (2006) contends that when developing their science PCK, teachers draw on these various knowledge domains.

The position taken in this research study is that of transformative PCK, drawing largely on Shulman and Magnusson's models. PCK is an applied competence, founded on foundational knowledge, one of which is the subject matter knowledge. Teachers with underdeveloped subject matter knowledge for example lack deep and connected understanding of the subject. They are unlikely to present developed PCK, that which Shulman expressed as "useful forms of representation of ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations-in a word, the ways of representing and formulating the subject that make it comprehensible to others" (Shulman, 1986: 9). Hence, this study argues that professional development activities aimed at teachers need to equip them with as much knowledge from various domains such as subject matter knowledge to enable teachers to develop their PCK for successful teaching.

Integrative models reflect mostly initial teacher education programmes since they often present a wide range of components (Kind, 2009). Transformative models of PCK on the other hand tend to focus on subject-specific PCK and are more appropriate for already practising teachers (Kind, 2009). This research study is also concerned with development of PCK for practising Life Sciences teachers and that is why it is aligned with the transformative model.

a. Subject matter knowledge

It has long been argued that the development of teachers' pedagogical content knowledge is influenced by their subject-matter knowledge (Shulman, 1986, 1987; Rollnick et al., 2008). As a result of the science curricular reforms, which demand a shift towards teaching for understanding, teachers have had to grasp deep and highly structured content knowledge and conceptual understanding. It is this sound content knowledge and rich conceptual understanding that allows the teacher to transform the subject matter to produce representations that are pedagogically powerful (Shulman, 1987) to improve student learning. Strengthening subject-matter knowledge thus contributes to the development of stronger PCK. Expanding on the description of subject matter knowledge, Carlsen (1999) included the ‘nature of science and technology’ as a component of subject matter knowledge which relates to Specific Aim 3 of the South African Life Sciences curriculum. As discussed above, there is a need to strengthen Life Sciences teachers’ knowledge and skills of conducting investigations/practical work so that teachers can effectively teach these process skills.

Since transformative models support subject-specific PCK, it is important that teachers possess good command of content-specific subject matter knowledge. Shulman (as cited by Rollnick et al., 2008) earlier raised concern about the fading of discipline-specific subject matter from programmes of teacher education in the USA. Rollnick et al. (2008: 1366) explain that the disappearance in content was largely shaped by the notion that pedagogy was a ‘content-free skill’, which the assumption that teachers had adequate content preparation during their training. Limited content background may lead to teachers’ over-reliance on transmission methods of teaching and superficial use of content, which has occurred in South Africa (Rogan, 2004). Subject matter knowledge and in particular, discipline-specific knowledge is an important domain that needs special attention, especially in view of the content changes taking place in science curricular, within the broader curriculum reform in South Africa. A teacher’s PCK becomes challenged when teaching specific content that he/she has little familiarity with (Loughran et al., 2006, 2012), restricting the art of transforming SMK into successful PCK. The teacher’s content knowledge must be strong and coherent in order for a teacher to use PCK.

Research is ongoing to find the best practice on how science teachers can successfully transform SMK and develop their PCK through professional development programmes. For example, Loughran et al. (2008, 2012) developed a framework that can be used during teacher development programmes such as workshops to elicit science teachers’ PCK. This PCK framework has two elements, the CoRes (Content Representations) and the PaP-eRs (Pedagogical and Professional –experience Repertoires). The CoRe presents an overview of the particular content taught when teaching the topic (Loughran et al., 2004, 2008, 2012). The CoRe includes aspects such as what students have to learn (content to be taught); how the concepts fit within other; and why it is important for students to learn that material.

The PaP-eRs, which are narrative accounts of teachers’ PCK, are designed to unpack a teacher’s thinking and actions in teaching specific aspects of science content. Loughran’s PCK tool has presented a framework to help teachers define PCK for teaching each specific topic in their subjects. This approach has been used by other researchers including some from South Africa (Rollnick et al., 2008; Ratcliffe, 2008).

b. Pedagogical Knowledge

Whilst SMK plays a much dominant role in the development of teachers' PCK, other knowledge domains also contribute. Shulman (1987:8) defined pedagogical knowledge as broad principles and strategies of classroom management and organization that appear to transcend subject matter. In line with a transformative view of PCK Magnusson et al. (1999) views this domain as the *Knowledge of Instructional Strategies and Representations for Teaching Science*. This domain comprises two sub-domains: knowledge of subject-specific strategies and knowledge of topic-specific strategies (Magnusson et al., 1999). Subject-specific strategies deal with approaches for teaching a science subject, such as inquiry-based approach (Park & Oliver, 2008). Topic-specific strategies on the other hand include specific approaches for representing concepts of particular topics (Magnusson et al., 1999; Park & Oliver, 2008).

c. Knowledge of learners

Magnusson et al. (1999) assert that a teacher needs knowledge of learners' understanding and beliefs about science in order to be able to present a specific topic. This knowledge domain, according to Magnusson et al. (1999) includes knowledge of the requirements or prerequisite ideas and skills that students will need to learn a specific scientific topic. This also includes teachers' knowledge of different approaches that students will use to learn specific content. According to Magnussson et al. (1999) effective teachers should recognize the varying needs of their students and have knowledge of an appropriate strategy for a particular type of learner in a specific subject area. In this knowledge domain, Magnusson et al. (1999) also included the 'knowledge of areas of student difficulty', which includes teachers' knowledge of content areas that students will find difficult to learn. Consistent with Magnusson et al. (1999), Park and Oliver (2008:265) affirm that to effectively put PCK to use, teachers need to possess knowledge about 'students' conceptions of particular topics, learning difficulties, motivation, and diversity in ability, learning style, interest, developmental level, and need'.

d. *Curriculum knowledge*

Although Shulman (1986) considered curricular knowledge to be separate from PCK, he acknowledged its contribution to teachers' PCK. In this category Shulman included aspects of knowledge about curriculum materials available for teaching particular subject matter as well as about both the horizontal and vertical curricular for a subject, a concept that was later accentuated by Grossman (1990). From a science perspective, Magnusson et al. (1999) refer to this category as 'knowledge and beliefs about science curriculum'. This component can be further divided into two sub-domains: mandated *goals and objectives* and *specific curricular programs and materials*. Magnusson argued for inclusion of curricular knowledge PCK citing that it is knowledge of the curricular materials that divide the content specialist from the pedagogue, which is a defining factor of PCK.

Goals and objectives: includes knowledge of and the ability to articulate goals and guidelines. This includes knowledge of relevant standards, district, state or national and also includes knowledge of the vertical position of their subject within the progression of student learning (Magnusson et al., 1999).

Specific Curricular Programs and Materials: This includes the knowledge of programs and materials for teaching that are specific within a domain and also the specific relevant sub topics within that domain. Teachers must be more than aware of certain programs or instructional supports; they must also be knowledgeable of the learning goals of these programs in order for the effective implementation of the programs.

e. *Knowledge of Educational context*

Knowledge of educational contexts is knowledge of schools, classrooms and all settings where learning takes place (Shulman, 1986). According to Turner-Bisset (1999) there are contextual factors that have a significant impact on teaching performance affecting the development and classroom performance. Turner-Bisset found a range of contextual factors that affected teaching performance such as the type and size of school; the class size; the level and quality of support for novice teachers; the quality of relationships in the school, and other pertinent factors (Nichol & Turner-Bisset, 2006:46). Ernest (2006:19) included such contextual factors as knowledge of other teachers; departmental and school location of teaching resources; knowledge of assessment systems and policies; knowledge of the school ethos, and of the school and departmental expectations concerning the role of the teacher. This knowledge 'extends beyond the school, to the knowledge of its broader social, cultural, ethnic and geographic contexts' Ernest (1989:19). Knowledge of school context is therefore among the most powerful determinants of the classroom approach employed by the teacher. In South Africa, where there is such diversity of culture, religion, socio-economic status and language, it is particularly important for teachers to be aware of such diverse contextual factors in order to develop the full potential of each individual learner.

f. Knowledge of Educational Ends, Purposes and Values

Shulman included in his list, knowledge of educational end, purposes, and values, and their philosophical and historical grounds. The South African curriculum has laid down a number of educational ends, purposes and values for both its learners and teachers. It envisages teachers who are qualified and competent, who will act as mediators of learning amongst many roles. It envisages a teacher who creates a confident, independent, multi-skilled lifelong learner who has respect for the environment and has the ability to participate in society as a critical and active citizen. With each school subject outlining purposes related to the development of knowledge specific to the subject, teachers are envisaged to be the key facilitators for the development of this knowledge (DBE, 2011c).

In summary, the theories discussed above were used to frame the study as follows:

Adult learning theories were used to frame some of the open ended questions as well as closed-ended items of the questionnaire. Data obtained from these questions will also be analysed using adult learning theories. These questions in the questionnaire dealt with aspects such as teachers' preferred methods of learning during professional development as well as their motivation to learn. Because teachers are adult learners, it is envisaged that gathered data will shed light on how teachers construct their learning, for example, whether the surveyed teachers exhibited the features of adult learners such as self-directed learning. Communities of practice as a complementary conceptual framework will be used for analysing data pertaining to learning that takes place in teacher clusters. Teacher clusters provide a platform for shared learning, and can thus be appropriately analysed using 'Communities of learning' as a framework.

Data on teachers' content and pedagogical needs will be analysed using PCK as a conceptual framework. This framework is envisaged to demonstrate the extent to which teachers surveyed had developed their content and pedagogical knowledge, which shapes their overall PCK.

3.6 Conclusion

From a constructivist perspective, learning in adults is self-regulated and thus mediated by a number of factors such as the intrinsic motivation to learn, self-efficacy beliefs, social interactions, and learning needs. These factors affect the level of learning teachers may attain in any professional development opportunity. Contextual factors such as program factors also have an impact on teacher learning. Because learning is contextual, the development of teachers' PCK is influenced by such knowledge as subject matter, pedagogy, learner characteristics, curriculum, contexts and educational values.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

The purpose of this chapter is to describe and justify the methodological approaches and the methods selected to explore and understand Life Sciences teachers' engagement with, and learning through professional development programmes. The following methodological aspects are presented:

- The approach and design of the study
- Data collection strategies and procedures
- Data analysis
- Validity, reliability, ethical issues and study limitations.

To summarize, the study explores Life Sciences' teachers' engagement with ongoing learning through professional development programmes. More specifically, the associated sub-questions explored are:

1. How do Life Sciences teachers engage with learning in continuous professional development programmes? i.e. what methods of professional development programmes do they use?

2. Why do Life Sciences teachers engage in ongoing learning through continuous professional development programmes? i.e. what are teachers' attitudes and motivation towards learning through professional development programmes?

3. What are Life Sciences teachers' perceived professional development needs in terms of subject matter and pedagogical knowledge and skills?

4. What gains in knowledge in skills are achieved through engaging in continuous professional development programmes?

4.2 Research approach

To answer the critical questions of this study, a mixed methods research design was adopted. The central premise of mixed methods as argued by Creswell and Plano Clark (2007) is that blending quantitative and qualitative approaches provides a deeper understanding of research problems than either approach alone. Many research questions are best and most fully answered through mixed research solutions (Johnson & Onwuegbuzie, 2004: 18). Whilst the mixed methods approach to data collection may have been used for many years before, the actual concept is fairly recent in social science research (Cresswell & Plano Clark, 2007). As such there has been an extensive dialogue in an effort to conceptualize mixed methods, with diverse definitions and descriptions suggested (Tashakkori & Teddlie, 2010). Scholars such as Guba and Lincoln (1994); Tashakkori and Teddlie (2003) emphasize a methodology orientation and reduce the emphasis on the philosophical assumption, which includes everything from the worldview, including the whole research process from the beginning to the end (Tashakkori & Teddlie, 2010). The 'methods' perspective on the contrary focuses on the procedures of data collection, data analysis, and possibly, interpretation (e.g., Creswell, Plano Clark, Gutmann, & Hanson, 2003; Onwuegbuzie & Teddlie, 2003; Tashakkori & Teddlie, 2003).

Against the backdrop of these divergent views, Tashakkori and Teddlie (2010) suggest a more inclusive way of conceptualizing mixed methods research, one which recognises that some researchers will operate from a 'methods' orientation, others from a 'methodology' orientation, whilst others may take a philosophical orientation. Johnson, Onwuegbuzie, and Turner (2007) have since reviewed their earlier definition and proposed a composite description of the mixed methods research. Johnson et al. (2007: 123) view mixed methods research as that in which elements of qualitative and quantitative approaches are combined with the aim to increase the breadth and depth of understanding the research problem and enable corroboration. This is achieved by use of qualitative and quantitative viewpoints, data collection, analysis and inference techniques (Johnson et al., 2007). Similarly, Creswell and Plano Clark (2007) consider a mixed methods research design within philosophical assumptions but also within a 'methods' orientation, defining it as follows:

> 'Mixed methods research is a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative

> and quantitative approaches in many phases in the research process. As a method, it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone' (Creswell & Plano Clark, 2007: 5).

The underlying argument for this all-encompassing definition has been to merge the divergent views for better understanding of mixed methods as a research process. With all these views amalgamated, Tashakkori and Teddlie (2010) nonetheless caution against a broad conceptualization of mixed methods which can potentially raise the problem of the 'misappropriation of other designs as mixed methods'.

A pragmatic approach was adopted for this study. Pragmatism enables the use of mixed and multiple methods to meaningfully generate information to address the research questions (Morgan, 2007). To Patton (2002: 72), a pragmatic approach in research allows for 'methodological appropriateness'. In expounding this notion, Tashakkori and Teddlie (2010: 132) posit that a pragmatic standpoint 'has no set methodological requirements for social inquiry, but rather has a consequential action-knowledge framework to guide inquiry'. Hence, a pragmatic inquirer may select any method based on its aptness to the situation at hand. Instead of focusing on a set of methods, emphasis has been placed on the research problem using all the approaches available to understand the problem in this research.

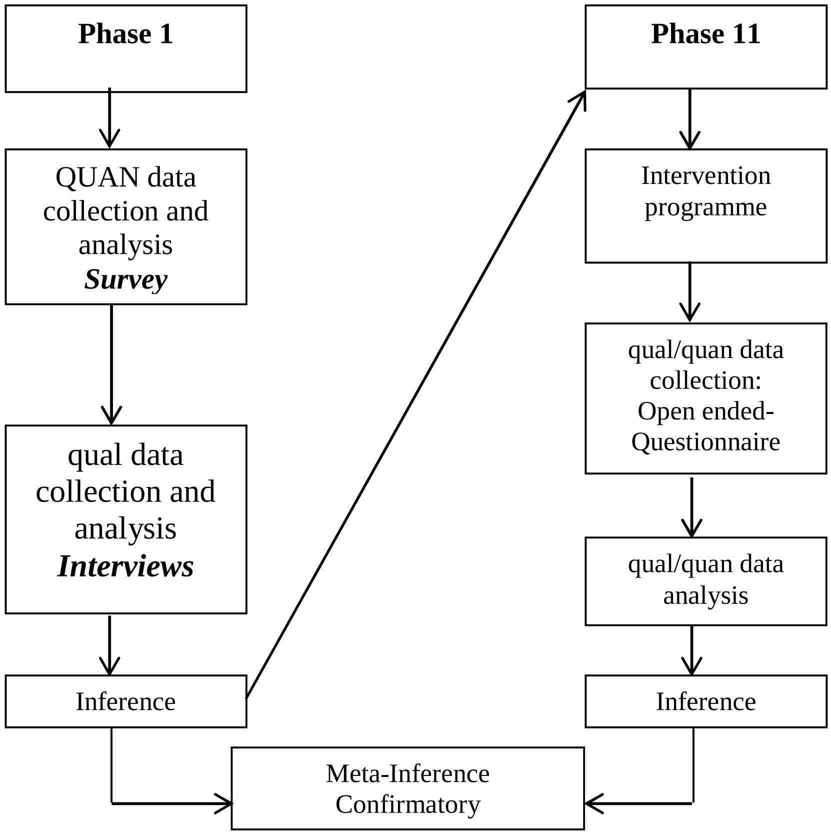
The results of pragmatic inquiry are viewed as assertions that become acceptable in terms of their transferability in different situations (Tashakkori & Teddlie, 2010). So, from a pragmatic stance, the researcher works backward and forward between specific results and their general implications (Morgan, 2002). A mixed methods approach operating within a pragmatic paradigm thus becomes an 'active and iterative process of establishing warranted assertions as they are applied in new experiences' (Tashakkori & Teddlie, 2010: 132-133). This process was evident as the process of enquiry unfolded, which is elaborated on in the sections below.

4.3 Research design

Data was collected through a survey using a questionnaire. The questionnaire comprised closed-ended questions (dominant) and open-ended questions. In-depth interviews were later conducted with Subject Advisors. The subsequent in-depth, semi-structured interview instrument consisted of questions intended to explore some of the teachers' responses as well as standard questions exploring Subject Advisors' general perspectives on teacher continuous professional development.

There are several key principles that researchers consider as they navigate the complex process of mixing methods during research, (Creswell, 2009). One of these principles as noted by Creswell (2009) is determining whether the mixed methods design is fixed and/or emergent. In fixed mixed methods designs, the use of qualitative and quantitative approaches is pre-set and planned beforehand. In emergent mixed methods designs, the use of mixed methods emerges during the research process (Creswell, 2009). A fixed mixed methods design was initially planned for the study. However, some significant trends emerged from the first set of data which necessitated further examination. The study subsequently added emergent aspects to the design, however with the greater part of data collection leaning more towards the fixed mixed methods design, (Creswell, 2009).

Within each of the mixed methods research design types, the procedure or timing for data collection may be concurrent, sequential, or parallel (Onwuegbuzie & Johnson, 2006). As indicated above, responses from teachers' questionnaires were explored further thorough interviews with Subject Advisors. In addition, intervention programmes were designed to address some of teachers' concerns highlighted in the questionnaire. More data was collected during these interventions. Data collection was therefore sequential in nature. In the sequential approach, the first data is collected (qualitative or quantitative), and the results inform the second form of data collection. The procedure enables the researcher to elaborate on the findings of one method with another method (Creswell, 2009). The following diagrammatic representation shows a summary of the design process.



Source: Adapted and modified from Tashakkori & Teddlie (2003: 668)

Figure 4.3.1: A Sequential Mixed Method Design for the study

As presented in figure 4.3.1., there was a sequential mixing of quantitative and qualitative approaches where the quantitative was predominant over the qualitative design (indicated as QUAN/qual). Findings from this first phase influenced the collection of further data during the second phase.

Mixed methods research may include the embedded, triangulation, exploratory or explanatory research design types (Creswell & Plano Clark, 2007). This research study employed a triangulated mixed method design. The purpose of the triangulation is to gather independent but complementary data on the same topic to best understand the research problem (Morse, as cited in Creswell & Plano Clark, 2007). The design is used as a way to compare and contrast quantitative statistical results with qualitative findings or confirm, cross-validate, or corroborate findings within a single study (Creswell et al., 2003). The triangulation design included both the aspects of 'validating' variant of triangulation as well as 'multilevel' model of triangulation. As described by Creswell and Plano Clark (2007) the validating model is used when the researcher wants to validate and expand on the quantitative findings from a survey by including a few open-ended qualitative questions carefully embedded within the quantitative instrument. These qualitative responses together with in-depth interviews provided data that was used to validate and elaborate the quantitative survey findings. The multilevel model of triangulation used in this study, where data was sought from teachers as well as Subject advisors who are at different levels of hierarchy, served to address different levels within a system (Creswell & Plano Clark, 2007). Findings from each level (teachers and Subject advisors) were merged together during interpretation to better understand the phenomenon.

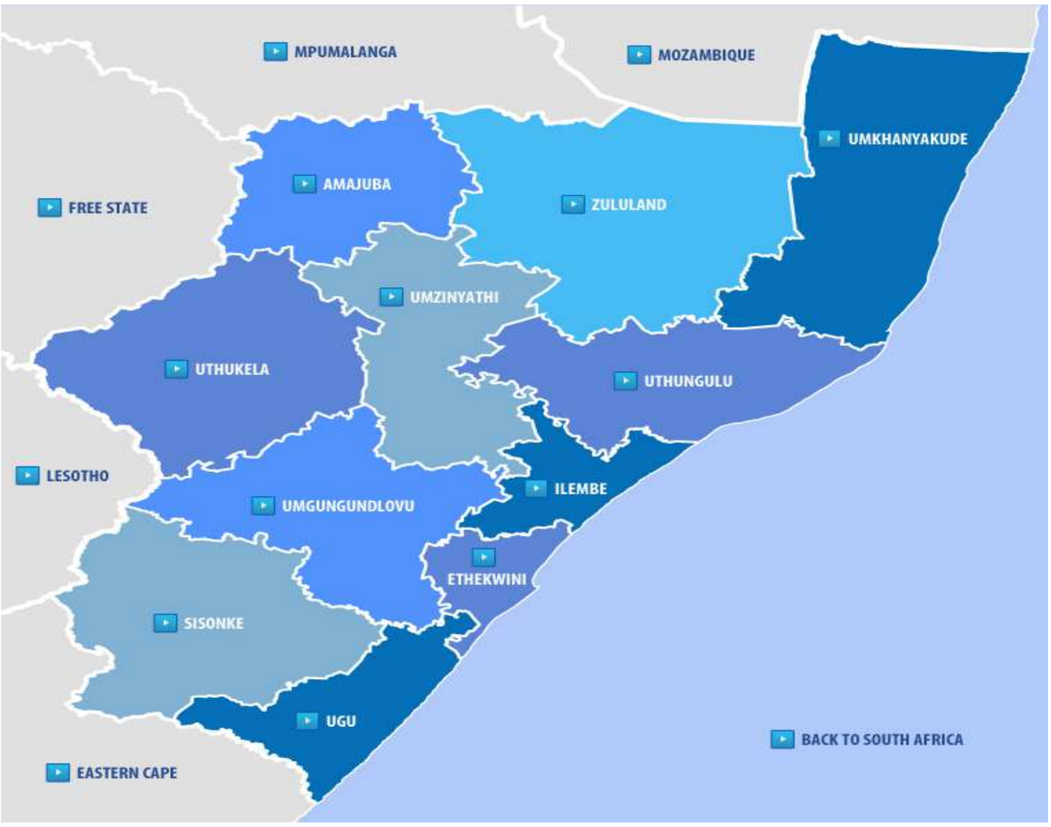
The main purpose of this study was to explore the nature of learning and development through Professional Development programmes for teachers of Life Sciences. Teacher learning through professional development programmes is a multifaceted process. In exploring this complex construct, I sought to understand: the general perception around CPD programmes; motivation for such learning; the perceived level of need for development in specific knowledge domains and skills; different CPD opportunities available and pursued by teachers; and the perceived growth as a result of engaging in such programmes. With such a range of factors to explore, it was fitting to take a pragmatic approach using both qualitative and quantitative methods sequentially to allow for a robust enquiry, taking advantage of the strengths of each of the approaches.

4.4 Sampling procedure

Tashakkori and Teddlie (2010: 356) define sampling as ‘a process of selecting a subset or sample unit from a larger group or population of interest’, with its purpose to answer the research questions. In this research, I needed a representative sample of teachers from KwaZulu-Natal province from which I could generalize. The KwaZulu-Natal Department of Education is divided into twelve districts as shown in Table 4.4.1 below. Of the twelve districts, eight are rural. Three are largely rural, with a fair mixture of urban areas. Only one district is considered predominantly urban. A total of three districts were selected for the study, two rural and one with a rural-urban split. ‘Rural’ schools in this study included all those situated in Traditional Authority areas i.e. in primarily community owned land, as well as those in the commercial farms. ‘Urban’ schools included those in the metropolitan areas and well as those in the peri-urban, i.e. in townships and informal settlements.

Table 4.4.1: Districts in KwaZulu-Natal province and their geographical form

District Name	Rural/Urban
a. Pinetown	Predominantly urban
b. Ugu	Rural/Urban - predominantly rural
c. Ilembe	Rural
d. Umlazi	Rural/Urban - predominantly urban
e. Sisonke	Rural
f. Othukela	Rural
g. Umzinyathi	Rural
h. Umgungundlovu	Rural
i. Amajuba	Rural/Urban
j. Uthungulu	Rural
k. UMkhanyakude	Rural
l. Vryheid/Zululand	Rural



Source: http://www.cohsasa.co.za/institution-district/umdm (eThekwini combines Pinetown and Umlazi)

Figure 4.4.1: Map showing the districts in KwaZulu-Natal

The three districts sampled for the study were coded District 1, District 2 and District 3 for purposes of keeping them anonymous. Districts 1 and 2 were completely rural whilst District 3 had an urban/rural mix. Sampling of these districts was purposive. According to Johnson and Christensen (2008: 239), in purposive sampling, the researcher specifies the characteristics of a population of interest. In addition to being rural, districts 1 and 2 had been the lowest- performing in the National Examinations for Grade 12 in the year preceding collection of data for this research study (District 2 being the worst performing and District 1 was second worst performing). Life Sciences was one of the subjects in which learners were performing poorly. One of the key objectives of this study was to examine teachers' needs for professional development in Life Sciences knowledge and skills. In view of these development needs, this study aimed to explore ways in which teachers were developed professionally on an ongoing basis, and whether teachers perceived these PD efforts to be effective. These districts therefore potentially possessed rich and valuable information that would answer these critical questions of the study. Although not poorly performing, District 3 had a rural/urban mix which would have potentially provided a different dynamic from the two completely rural districts. In essence, both purposive and convenience sampling were used in selecting these districts. Although convenience samples are not the best way to go (Johnson & Christensen, 2008), it was necessary to ensure representivity in terms of demographics by selecting at least one rural-urban district (District 3) for the study.

During the second phase of the study, the sample was narrowed down to include only District 2. As indicated above, district 2 had been flagged as the worst performing for the Grade 12 National Matriculation examination results. De Vos, Strydom, Fouche, and Delport (2005: 328) elucidate that in purposive sampling a particular case is chosen because it illustrates some feature or process that is of interest for the study. Participants are selected because of the data they hold (Creswell, 2010). Tashakkori and Teddlie (2010: 358) describe this type of sampling as a 'critical case' sampling scheme with the technique involving selection of groups or individuals, based on 'specific characteristics because their inclusion provides the researcher with compelling insight about the phenomenon of interest'. Whilst the majority of the teachers from District 2 who participated in the second phase of the study had completed the first survey questionnaire, a few had not been part of the first set of data collection, i.e. had not completed the questionnaire. Termed by Johnson and Christensen (2008: 256), this mixed method sampling procedure is a 'parallel sample relation criterion'. According to Johnson and Christensen (2008) a parallel sample relation indicates that the samples for the quantitative and qualitative components of the research are slightly different but drawn from the same population.

Macmillan and Schumacher (2010) point out that a judgment can be made about which subjects to select to provide the best information to address the purpose of the research. The choice of District 2 was informed by the need to contribute to the development of Life Sciences teachers' knowledge and skills. Having obtained findings from the first phase highlighting great need for development in certain specific knowledge domains, the purpose of the second phase was to obtain first-hand data on benefits achieved through participation in a professional development programme. Hence, CPD programmes in the form of training workshops were designed for teachers based on their expressed needs. As indicated above, the choice of District 2 for further study was to a large extent informed by poor learner performance in the district. Therefore any potential benefit that would be derived from participation in a CPD programme was directed at these teachers.

4.5 Profile of the districts

District 1

District 1 is a rural district with a total of 661 public schools. About 70% of the schools have a quintile ranking of 1 and 2 (DBE, 2013b). A quintile is a school ranking system that assigns a poverty score based on the relative poverty of the community around the school based on the unemployment rate, income and level of education. The quintile score ranges from quintile 1 to 5, with quintile 1 being the poorest of the poor, and quintile 5 being schools that are affluent. In terms of the performance in National Certificate examinations, this district had been the second worst performing in the year preceding data collection (DBE, 2011a, 2012). Because of poor learner performance, this district was targeted for intervention by the KZN Department of Education which was set to continue until the results improved (KZN DoE, 2012).

This district had been without a Life Sciences Subject advisor for up to three years at the time of data collection. Subject Advisors from District 2 were the custodians of District 1 as they were geographically in close proximity with each other. These Advisors were entrusted with organising and conducting Continuous Professional Development programmes such as training workshops, and other pertinent forms of teacher in-service training. Access to District 1 was therefore obtained through these Advisors.

District 2

District 2 is also rural. There are 537 public schools in the district, 90% of which are from Quintile 1 and 2 (DBE, 2013b). This is the only district in the province with no quintile 5 schools, indicating that is was largely rural. As indicated above, this district had been the worst performing in National Senior Certificate (NSC) examinations during the time of data collection. There were two Life Sciences Subject Advisors in this district therefore access to the district was sought without difficulty. In the year preceding this study, this district had been the worst performing in the province in the overall Grade 12 NSC pass rate. Whilst it still remained the worst-performing in the year following data collection, the district had recorded a 9.9% improvement in the pass rate (KZN DoE, 2013).

District 3

Whilst District 3 is also largely rural, there is a small percentage of urban schools. There are 492 public schools in the district and about 75% of those have a quintile ranking of 1 and 2 (DBE, 2013b). District 3 ranked number 7 out of the 12 districts in the province in terms of NSC pass rates in the year preceding data collection for this study (KZN DoE, 2012). This district had been without a Life Sciences Subject Advisor for at least 18 months at the time of data collection. Access to the district was sought through a caretaker Subject Advisor. Being a Subject Advisor for a different subject meant that this advisor was not a specialist in Life Sciences. Continuous Professional Development programmes in the form of training/cluster workshops were led by 'facilitators/cluster leaders' i.e. senior teachers of Life Sciences. The research questionnaire was therefore distributed during CAPS workshops that were facilitated by two senior teachers who were also cluster leaders. From informal conversations with one of the only two facilitators, there was poor coordination of training workshops, and hence, few teachers attended the workshops.

4.6 Sample size

Achieving an adequate sample size is critical in increasing the 'trustworthiness of the findings' and the 'transferability of the study's conclusions' (Tashakkori & Teddlie, 2010: 361). As indicated above, three districts were selected from a total of twelve in the province of KwaZulu-Natal. The timing for the distribution and collection of data through the survey questionnaire was done during training workshops which were conducted in cluster groups in each of the districts. Teachers convene in cluster groups which are geographically close to each other. Generally, one teacher per subject per school attends a subject-cluster meeting or a training workshop. Similarly, on average, only one Life Sciences teacher per school attended the cluster meeting or workshop during data collection. Questionnaires were therefore handed out to all the teachers that attended the cluster meeting or a workshop. The turnout in some of the districts was poor, particularly in District 3 where motivation seemed low because of the absence of the Advisor. Representivity of the total population of Life Sciences teachers was thus difficult to attain. Based on a 95% confidence interval, a projected sample size of 206 teachers from an average total population of about 450 teachers of Life Sciences in three districts was therefore not achieved. Instead, 152 teachers completed the first survey, which constituted 30% of the total number of Life Sciences teachers in the three districts. Fifty nine teachers completed the survey from District 1, which constituted 39% of all the Life Sciences teachers from that district. Fifty one teachers completed the questionnaire from District 2, making up 34% of all the Life Sciences teachers from this district. Thirty nine teachers completed the questionnaire from District 3, which constituted 26% of the population of teachers from this district.

4.7 Data Collection process

Data collection in the first phase of research was done largely through a survey using a questionnaire. Survey research provides a quantitative description of trends, attitudes, or opinions of a population by studying a sample of that population (Babbie, 1990; Creswell, 2009: 12). The purpose of a survey is to generalize from a sample to a population so that inferences can be made about some attitude or behaviour of the population (Babbie, 1990). Similarly, the aim of the research was partly to collect data on Life Sciences teachers' need for continuous professional development; their attitudes, opinions and motivation (or lack thereof) towards professional development; the different methods of professional development they engage in and the associated benefits thereof. The purpose for the use of a survey was to be able to obtain this data from a large number of teachers so that findings could be extrapolated to the wider population of Life Sciences teachers with similar demographics. The survey design has a number of strengths including that of rapid turnaround in data collection (Creswell, 2009); accuracy in measurement which is enhanced by quantification and replicability (Marshall & Rossman, 2006:126). Results can also be generalised to a larger population within known limits of error (Marshall & Rossman, 2006).

The largely quantitative survey questionnaire was supplemented with a few open-ended questions which allowed for collection of qualitative data. The quantitative items in the first phase questionnaire sought to answer research question (1): what are Life Sciences' teachers professional development needs in terms of knowledge and skills. The questionnaire thus comprised items relating to all the content in Life Sciences as well as an exhaustive list of skills required to teach the subject (including practical work skills). The questionnaire also included items to explore methods used by Life Sciences teachers during their ongoing professional development their reasons and motivation (or lack of) for engaging in such professional development programmes. These items thus sought answers for the second and third critical questions: (2) how teachers were engaging in ongoing learning through PD programmes, and (3) why they engaged in PD programmes. Further, items on teachers' perceived gains from participating in the PD programmes were included, seeking answers for research question (4): what gains in knowledge and skills were achieved through engagement in the PD programmes. Open-ended questions were included to enable teachers to elaborate on their quantitative responses.

A questionnaire instrument was also used to gather data in the second phase of the study i.e. during the intervention programme in the form of teacher training. As indicated above, the design, and in particular, the content of the training workshops had been informed by the findings from the first phase of data collection. The first questionnaire in the second phase was an audit of Life Sciences' practical work skills. The results of this audit provided detail on teachers' development needs, in particular, the type of practical work skills they (the teachers) considered priority, which then assisted in the design of the intervention workshops.

The second questionnaire was designed as an evaluative tool to determine the effectiveness of the training workshop. This evaluation was useful in that it helped in answering research question (4) which dealt with gains achieved through engagement in professional development activities.

This questionnaire also was used as a means to triangulate information obtained from the questionnaire distributed during the first phase of data collection. This included data pertaining to opportunities for teacher learning, and precisely the relevance of CPD activities that Life Sciences teachers generally engage in and the extent to which they benefit from such programmes.

Data through surveys was collected during CAPS training workshops organised by districts through Subject Advisors. In districts 1 and 3, where there were only care-taker Subject Advisors, the questionnaire was distributed through a single workshop conducted at a central venue. In district 2, where there were two permanent subject advisors, workshops were conducted in four different centres with at least 15 schools represented in each workshop. The questionnaire was distributed and collected during these workshops. The custodians of district 1 were Life Sciences specialists and therefore they also conducted the workshops. As a result, attendance in these workshops was good. In total, 60 teachers completed the questionnaire in full in district 1. In district 2, the questionnaire was completed by 53 teachers.

In district 3, the care-taker Subject Advisor was not a specialist in Life Sciences. Workshops for Life Sciences in this district were therefore conducted by senior teachers who were also 'facilitators' in their clusters. Attendance at the single workshop that was organised by the care-taker Subject advisor was poor. Many teachers left long before the workshop ended, seemingly discontent with the level of facilitation. Many of the teachers did not complete the questionnaire which was distributed at the end of the workshop. A significant number of teachers only filled in demographic data which was not useful on its own. Only 39 teachers completed the questionnaire in full.

4.8 Instruments

a. Survey

Survey research generally involves the use of either a cross-sectional or a longitudinal design (Babbie, 1990). A cross-sectional survey collects data to make inferences about a population at one point in time (Creswell, 2009), contrary to the longitudinal survey where data is collected at several different times (Marshall & Rossman, 2006). A cross-sectional design was used in collecting data during the first phase of research.

A self-administered questionnaire with structured response categories (predominant) and a few closed-ended questions was used when collecting data. The questionnaire was developed and modified partly from the *Science Teacher Inventory of Needs for Limpopo Province (STIN-LP)* by Laugksch, Rakumako, Manyelo, and Mabye (2005). The original *Science Teacher Inventory of Needs* instrument had been developed by Zurub and Rubba (1983). Although the *STIN-LP* instrument was developed for use in Limpopo province, it had been adapted for use in the South African education context in general. *STIN-LP* was used for identifying teachers' professional development needs relating largely to general pedagogic skills of teachers of Mathematics, Biology and Physical Sciences. The questionnaire for this study was specific to Life Sciences and therefore necessitated adjustment to suit the context. In addition to general pedagogic categories, specific content categories were included in this study's survey instrument. The development of Life Sciences content-specific categories was entirely informed by the latest CAPS version of the Life Sciences curriculum. The development of other categories such as those relating to teacher motivation as well as the perceived benefits derived from engaging in various CPD programmes were constructed through the review of pertinent literature. Once developed, the instrument was scrutinised by various experts and later piloted with various groups of teachers. The piloting of the instrument is explained under validity and reliability.

The teacher questionnaire (Appendix 1) was divided into four sections. Section 1 sought biographical information, including data pertaining to teachers' academic level of education in Biological/Life Sciences; the number of years they have been teaching the subject; and their specialization, i.e. the subjects they were trained to teach in their formal qualifications. This information was necessary to establish the trends for enrolment in further (or even initial) qualification programmes by already practising teachers. Thus, Section 2 dealt with teachers' engagement with professional development programmes. In this section teachers were probed on their participation in both qualification and non-qualification CPD programmes. Also included in the latter part of this section were items pertaining to teachers' attitudes, motivation and perceived development as a result of engaging in qualification programmes. Equally, other items in this section sought reasons for teachers' non-participation in CPD programmes.

For all the data collected from items in section 2, respondents were asked to indicate their responses by checking one of five response categories with varied from "completely true" to "completely false", or "to a very great extent" and "to no extent at all" or "very high development and "no development at all". Open-ended question were included to allow teachers to give detailed explanations of their opinion of CPD programmes, their perceived development through these programmes as well as their proposals on how the programmes could be improved to benefit teachers maximally. With South Africa being a multilingual country, it was indicated to the teachers that they could express themselves in any of the official languages.

Section 3 dealt with teachers' general pedagogic needs. As in Laugksch et al. (2005), these needs were grouped into seven categories. Within the seven categories, 33 items were included. The seven categories were:

- **Improving personal competence** (3 items). This category included items such as 'update subject matter knowledge' and 'update knowledge of teaching strategies'.

- **Specifying objectives for instruction** (4 items). This category included items such as 'Identifying learning objectives which specify knowledge needed by learners in Life Sciences'.
- **Diagnosing and evaluating learning** (6 items). This category included items such as 'Developing skills in recognising and correcting learners' common misconceptions', and 'Developing learners' language skills by including it as part of the assessment'.
- **Planning instruction** (5 items). This category included items such as 'Develop lesson plans', 'Select appropriate resources for Life Sciences'.
- **Delivering instruction** (8 items). This category included items as 'Doing practical demonstrations'.
- **Managing instruction** (3 items). This category included items such as 'Appropriate use of group work'.
- **Administering instructional facilities and equipment** (4items). This category included items such as 'Use of media and everyday resources appropriately in teaching'.

Respondents were asked to indicate their level of need by checking one of three response categories from "greatly needed" to "not needed".

Section 4 was designed using the latest CAPS document listing all the topics of the Life Sciences curriculum in the FET band (Grade 10-12). These topics are categorized into four Knowledge Strands:

- *Knowledge Strand 1*-Life at molecular, cellular and tissue level (6 items)
- *Knowledge Strand 2*- Life processes in plants and animals (9 items)
- *Knowledge Strand 3*- Environmental studies (6 items)
- *Knowledge Strand 4* - Diversity, change and continuity (9 items)

As with Section 3, the respondents were asked to indicate their level of need by checking one of three response categories from "greatly needed" to "not needed".

Open-ended questions were also included in the questionnaire where respondents were allowed to elaborate on their needs, providing specific detail on both pedagogic and subject matter related needs.

A second questionnaire (Appendix 2) was designed and administered to UKZN ACE Biological Sciences teachers (students). This questionnaire also included closed and a few open-ended questions. The questionnaire sought teachers' perceived development in both content and pedagogic knowledge.

b. Interviews

In addition to the survey, in-depth interviews were conducted with Subject Advisors. An interview was conducted with one Subject Advisor from District 2 and another Advisor from another district which did not form part of the study. The reason to include a second advisor was to allow for triangulation of facts from at least two sources of the same professional and occupation level. As a caretaker for District 1 for at least three years, the interviewed Advisor from District 2 had full insight into professional development programmes related to Life Sciences in that district. A decision was taken to not include the caretaker Subject advisor from District 3 as the interview protocol consisted of questions specific to Life Sciences curriculum. As indicated earlier, in this district, senior teachers were taking turns in facilitating the training workshops.

An interview schedule with a set of pre-determined open-ended questions (Appendix 3) was prepared in order to engage the participant (de Vos et al., 2005). The interview questions included questions directly related to the role of Subject advisors in teacher professional development. Other questions in the interview schedule had already been explored with teachers in the first questionnaire. These questions sought information on teachers' development needs; their motivation for engaging in CPD programmes; how the learning is conducted during CPD programmes such as workshops, clusters, as well as challenges associated with such; the perceived development as a result of participation in CPD programmes. The purpose of posing similar questions to the different participants such as the teachers and advisors in this case, was to triangulate data sources. Triangulating information from different sources helps to build a coherent justification for themes during analysis (Creswell, 2009). When themes are established based on converging different perspectives from participants, this can be viewed as adding to the validity of the study (Creswell, 2009).

4.9 Validity and Reliability

In quantitative research, the standard of validity and reliability is important (Creswell, 2009). There are a number of aspects to reliability. One of these is the reliability of a measurement instrument, i.e. the degree to which the instrument generates the same results when used repeatedly (Terre Blanche, Durrheim, and Painter, 2006). To increase the validity and dependability of the instrument, it was piloted with teachers registered for an ACE programme. A further piloting was done with a group of teachers registered for PGCE. All the teachers in the ACE group were working fulltime as school teachers. The PGCE group comprised of prospective teachers and also those already practicing on a fulltime basis. At the time of piloting, the PGCE teachers had already completed their teaching practice modules, with experience in classroom teaching and thus familiar with the curriculum. Following the analysis of the pilot results, some items were amended to better align them with the research questions. A few items that yielded inconsistent results were removed from the instrument as a way of increasing consistency. The instrument was further subjected to an internal consistency test, details of which are discussed in the next subtopic.

To further improve the validity of the scale in the questionnaire, content validity was established. The validity of a scale refers to the degree to which it measures what it is supposed to measure (Terre Blanche et al., 2006). According to Terre Blanche et al. (2006), content validity is particularly important for tests of knowledge and is therefore achieved by determining the extent to which a measure reflects a specific domain of content. To achieve content validity for the questionnaire items dealing with content knowledge, the CAPS handbook specifying the topics covered in the FET phase of Life Sciences was used.

In qualitative research, reliability and validity of research is rather spoken about as trustworthiness. As stated by Guba and Lincoln (1994), trustworthiness is evidenced by the *transferability* (the generalizability of findings to other contexts), *dependability* (ability of repeating the study and getting similar findings), *confirmability* (objectivity and the control of researcher bias) and *credibility* of data (believability of the findings). The activities used to increase the credibility of the qualitative findings in this study included triangulation and member checking (Guba & Lincoln, 1994). Triangulation involved the use of multiple sources for gathering data, i.e. teachers and subject advisors. It also involved the application of different research methods, i.e. quantitative and qualitative methods to address similar research questions. Once the data had been analysed, interpretations and conclusions were tested with the participants (in this case, subject advisors) from whom the data was collected (Guba & Lincoln, 1994). This was critical in establishing credibility of the findings. The Subject advisors were given the opportunity to react to the findings and verify that the data accurately reflected the interview.

Dependability is achieved through obtaining credibility of the findings (Guba & Lincoln, 1994). Hence, achieving credibility in the findings of the study was sufficient to establish its dependability. Similarly, if a study demonstrates credibility, it is also said to possess confirmability (Guba & Lincoln, 1994). Because the study used a large survey design, where representativeness was achieved when sampling the participants, the generalizability of the findings to other similar contexts was attained.

4.10 Internal Consistency

Another important aspect in quantitative research is internal consistency. Internal consistency is the degree to which items in a scale correlate with each other (Terre Blanche et al., 2006). Because the instrument had been adapted from previous research where issues of validity and reliability had been established, the questionnaire for the study was partly valid and reliable. However, to increase the internal consistency for the new items that were added, a further reliability test was conducted. One of the most reliable indicators of internal consistency is Cronbach's alpha coefficient. According to Field (2003), the ideal Cronbach's alpha coefficient of a scale should be above 0.7. In this study reliability was achieved by determining the value of Cronbach's alpha on all the questionnaire items in each scale. The alpha values are presented below.

As indicated earlier, the instrument consisted of four sections. Section 1 sought information on teachers' demographic characteristics. Section 2 consisted of a total of 35 items pertaining to teachers' perceived motivation for engaging in both structured formal and non-qualification professional development programmes; reasons for non-participation in such programmes as well as the perceived development as a result of participation in such programmes. These items were grouped into categories depending on the type of information they were addressing. Each of the items constituted a statement with a five-point Likert scale ranging from (5) completely true to (1) completely false, or (5) to a very great extent to (1) no extent at all, or (5) very high development to (1) no development at all. Reliability of the items was assessed by using Cronbach's Alpha internal consistency approach. Table 4.10.1 below shows a summary of the items and their alpha values.

Table 4.10.1: The distribution of items for participation/non-participation in CPD programmes and alpha values

Category	No. of items	Alpha coefficient
1. Motivation for engaging in structured formal PD programmes	8	0.976
2.Perceived development as a result of participation in qualification PD programmes	5	0.991
3. Reasons for non-participation in qualification PD programmes	8	0.990
4. Perceived development as a result of participation in training workshops	5	0.909
5.Perceived development as a result of participation in various non-qualification PD programmes	3	0.500
6. Motivation for engaging in non-qualification PD programmes	5	0.820

All items in categories 1 to 4 had an alpha value of 0.9 which suggested a very good internal consistency amongst items in each category. Similarly the alpha value for items in category 6 was 0.820 which was also acceptable. There were only 3 items in category 5 as shown in table 2.1 above. Generally if there are less than 5 items in a category, the reliability of the alpha coefficient is also reduced.

Section three consisted of 39 items relating to Life Sciences teachers' needs for development in pedagogical skills. These needs were grouped into seven categories as discussed above, and also shown in table 4.10.2 below.

Table 4.10.2: The distribution of items for teachers' development needs in pedagogical skills and their alpha values

Category	No. of items	Alpha coefficient
1. Improving personal competence	5	0.832
2. Specifying objectives for instruction	4	0.862
3. Diagnosing and evaluating learning	5	0.862
4. Planning instruction	5	0.859
5. Delivering instruction	9	0.912
6. Managing instruction	4	0.866
7. Administering instructional facilities and equipment	7	0.911

All the items in the above categories had a Cronbach's Alpha value above 0.8, indicating a good internal consistency in the items.

Section four comprised 29 items relating to teachers' needs for development in content knowledge. These items were grouped into four *Knowledge Strands*, Each of the statements on sections three and four were placed on 3-point Likert scale ranging from (3) greatly needed to (1) not needed. Table 4.10.3 shows a summary of the items.

Table 4.10.3: The distribution of items for teachers' development needs in content knowledge and their alpha values

Category	No. of items	Alpha coefficient
1. Life at molecular, cellular and tissue level	6	0.941
2. Life processes in plants and animals	9	0.962
3. Diversity, change and continuity	6	0.941
4. Environmental studies	8	0.934

Items in the above categories had a Cronbach's Alpha value of 0.9, suggesting very good internal consistency reliability for the scale in these items.

4.11 Ethical Considerations

There are number of ethical considerations that must be observed when doing research with humans, which are generally invasive and complex (de Vos et al., 2005). The following is the discussion of the ethical issues that were considered important for the study.

a. Ethical clearance

Ethical clearance was sought with the University through which the research was conducted prior to collecting the data.

b. Permission to conduct research

An application requesting permission to conduct research was sent to the KwaZulu-Natal Department of Education office a few months preceding the research. A written permission was granted (Appendix 3). The names of districts were removed to maintain anonymity.

c. Informed consent

An informed consent letter was drafted and attached as a covering memo to the questionnaire. The informed consent outlined the information pertaining to the purpose of the investigation, the procedures that were to be followed during the investigation, the possible benefits, the credibility of the researcher, and the right to not participate in the study (de Vos, 2005). Another letter of consent was sent to Subject advisors, requesting their participation in the research project. Both informed consents are attached as appendices.

d. Anonymity and confidentiality

As stated by de Vos et al. (2005), information given anonymously ensures the privacy of subjects. Although there was no foreseeable harm to the participants, there are various undertakings that were considered to ensure the confidentiality of the subjects. Teachers were not asked to disclose any of their personal identification in the questionnaire, such as their names and the names of schools where they taught. The only identifying information requested was the district in which they taught. Once the data was collected, the districts were labelled as District 1, 2 and 3 to ensure their anonymity. The names of the Subject advisors were also kept anonymous. To ensure confidentiality, data mainly in the form of questionnaires was kept in a safe place, where only the researcher had access.

4.12 Data analysis approach

A concurrent mixed data analysis approach was used in the first phase of the study. Both content and discourse analysis was used to analyse qualitative data obtained through interviews with subject advisors and open-ended questions from teacher questionnaires. The analysis of quantitative data was both descriptive and inferential. Although data was collected from two different sources, i.e. the teachers and the subject advisors, it was essential to draw the information together to present a single integrated finding. The understandings from both forms of data were combined into meta-inferences, leading to convergent results.

Because the collection of data was skewed towards quantitative data, priority was given more to quantitative analysis. The descriptive analysis of quantitative data which was both numerical and graphic for the quantitative data focused on applying SPSS statistical tools to find frequencies, means and standard deviation. Whilst the researcher conducted the actual statistical analysis, a statistician was consulted to determine the appropriateness of the statistical applications used.

A univariate descriptive analysis was used largely to describe teachers' demographic profile, their trends in participation in continuous professional development programmes over the years. Frequency distributions were also used to determine teachers' development needs for different categories of content and pedagogical knowledge and skills.

Inferential analyses such as bivariate correlations were then conducted to explore relationships between certain variables of interest. For example tests were conducted to establish relationships between registration for CPD programmes and completion rates. A few additional variables were explored using the bivariate correlation approach, such the participation rate in CPD programmes by age and per district. Chi square (and Fischer's exact) tests were conducted to test for significance in these relationships. In depth explanations for these relationships came largely from interviews with subject advisors and from open-ended questions in teacher questionnaires.

Multivariate statistics such as the logistic regression analysis were employed to establish if any combinations of explanatory variables described the variation in the perceived dependent variable. Multiple regression analysis was also undertaken to establish whether teachers' demographics such as their qualifications, their academic level in Life/Biological Sciences and their experience teaching Biology/Life Sciences influenced their professional development needs.

In analysing qualitative data from interviews and open-ended responses from the questionnaires, thematic analysis was used. Themes were isolated and integrated with the quantitative results, providing richer explanations for quantitative data that would otherwise have be left unsubstantiated. Data is presented and discussed in chapter 5.

4.13 Limitations on the Research methodology

As indicated earlier in this chapter, the presence of Subject Advisors in districts largely influenced the attendance of teachers in training workshops which were used for distributing the questionnaire. This impacted on the number of teachers completing the questionnaire in district 3. Completion of questionnaires in this district was also affected by poor attendance as well as the lack of interest in some teachers.

4.14 Conclusion

In this chapter, the methodology and the research design is presented. Data was collected using both quantitative and qualitative approaches such as the survey questionnaires and interviews. Data analysis approach also using mixed methods approach was presented. Ethical issues as well as validity and reliability were discussed. Results are presented in the next chapter.

CHAPTER 5

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

Phase One[3]

5.1 Introduction

This chapter presents data gathered during phase one of the research study. At the outset, the chapter presents a brief history of teacher qualifications in South Africa which was useful for interpreting the results of the study. The profile of Life Sciences teachers in three districts of KwaZulu-Natal province in South Africa then follows. In presenting the profile of Life Sciences teachers demographic variables such as the age, gender, formal qualifications, school location, highest academic level in Life/Biological Sciences, and experience in teaching Life/Biological Sciences will be describes. This profile provides the context for subsequent trends in participation in continuous professional development programmes and benefits of such programmes presented afterwards. Furthermore, an examination of Life Sciences teachers' development needs is presented. In light of these development needs, data gathered through an intervention programme designed and implemented with a selected group of teachers is presented.

5.2 A brief history of teacher qualifications in South Africa

As noted in the preceding chapters, prior to 1994, the system of teacher education in South Africa was very diverse. Majority of prospective teachers attended training colleges where they spent two years training and exited with a Primary Teachers' Certificate (PTC) or a Secondary Teachers' Certificate (STC). Prospective teachers could enrol in the colleges having passed only up to Grade 10. Later, all teachers were required to have a 3-year diploma to be considered qualified. The two-year PTC thus later became the three-year Primary Teachers' Diploma (PTD); and the STC became the Secondary Teachers' Diploma (STD),

[3] Some of the findings presented in this chapter have been accepted for publication as a paper in *Teacher Development: An International Journal of Teachers' Professional Development*.

and in some cases, it became the University Education Diploma (UED), (CHE, 2010). Some colleges distinguished between Junior Primary Teachers' Diploma (JPTD), Senior Primary Teachers' Diploma (SPTD), Junior Secondary Teachers' Diploma (JSTD) and Senior Secondary Teachers' Diploma (SSTD).

Teacher training colleges mainly trained primary school teachers whilst the training of secondary school teachers was done largely by the universities and a few colleges of education, which resulted in an oversupply of primary teachers (DBE & DHET, 2011). Hence, a substantial number of currently practicing teachers with qualifications such as the PTD and STD are likely to be senior Biology (Life Sciences) teachers. They are qualified teachers, and they may have studied some Biology in the PTD, but not in any depth.

A four-year diploma called a Higher Diploma in Education (HDE) offered in some colleges later replaced the STD (CHE, 2010). A fourth-year HDE was later offered for teachers with a three-year PTD or JSTC. A Further Diploma in Education (FDE) was later offered which improved the qualification status of teachers to REQV 15. The FDE was the first major intervention to provide teachers the opportunity to re-skill or upgrade their initial qualification in teaching (CHE, 2010). The FDE also allowed for specializations such as School Leadership and Management. When the college sector was closed down in 2000/2001 and the Norms and Standards for Educators were implemented, the FDE was renamed the Advanced Certificate in Education (ACE) (CHE, 2010).

With the closing down of the college sector, teacher education was placed in the university sector, and meant that intending teachers had to have passed their Senior Certificates with "matric exemption[4]" (now called a Bachelor's pass) to enroll for initial teacher education. The PTD/STD/HDE route was replaced by the four-year Bachelor of Education (B Ed) degree. The Post Graduate Certificate in Education (PGCE) has always existed, although its name changes regularly (CHE, 2010). It is a one-year full-time professional qualification following a three-year general degree, such as a B A or B Sc.

In 2000, the South African Qualifications Authority introduced short-term qualification programmes that provided teachers with opportunities to upgrade their qualifications and

[4] A legal requirement for first-degree study at a South African university

teaching skills and specialize in certain subjects (DBE & DHET, 2011). For example, to allow for the large number of teachers who still had a two-year teaching qualification (REQV 12), a National Professional Diploma in Education (NPDE) was introduced for a limited period, but it continued far beyond its projected lifespan. It was also expanded to allow teachers who were on REQV 11 to upgrade to REQV 13 (the previous benchmark in terms of teacher qualifications). The Advanced Certificate in Education (ACE) replaced the HDE and the FDE, to allow teachers with the old STD or PTD to upgrade to REQV 14 status (DBE & DHET, 2011). It was also a vehicle for re-training teachers, e.g. those who wanted to change their teaching subjects. Universities introduced different specializations of ACE such the ACE Biological Sciences which would comprise content modules, education modules, as well as pedagogic content knowledge modules. Although this qualification was studied at university level, it was not equivalent to a major in a B Sc degree (CHE, 2010).

The B Ed Honours programme was originally a qualification that was available to graduates only, but during the 1990s it was opened to any student who had an REQV 14 qualification, i.e., it could be an HDE or an STD + ACE. A B Ed Hons specifically for Science teachers was offered by some universities. The focus was on teaching and learning science, and there was no advanced study of the discipline. The general purpose of the B Ed Hons was not to specialize in any subject, but was intended to initiate students into academic research (DoE, 2000; DHET, 2011).

5.3 The Profile of Life Sciences teachers in Kwazulu-Natal province

The demographic profile of Life Sciences teachers from three districts of KwaZulu-Natal is presented and discussed in this section. This profile provides the context for understanding teachers' professional development needs and their participation in professional development programmes.

Table 5.3.1: Overview profile of Life Sciences teachers in three KZN districts *(n=number of responding teachers per variable)*

		Frequency	%
Gender(n=152)			
	Female	93	61.2
	Male	59	38.8
Age (n=141)			
	20-29	24	17.0
	30-39	50	35.5
	40-49	49	34.8
	50-59	16	11.3
	>59	2	1.4
Formal qualifications (n=149)			
	Grade 12	8	5.4
	Diploma/Cert	86	57.7
	Bachelor's degree	34	22.8
	Postgrad degree	21	14.1
Highest academic level in Biological Sciences (n=148)			
	Std 10	34	23.0
	1st year University/College	6	4.1
	2nd year University/College	21	14.2
	3rd year University/College	81	54.7
	Honours and higher	6	4.1
Majors (n=146)			
	Biological Sciences	124	81.6
	Other	22	18.4
Experience teaching Biological Sciences (n=137)			
	1-5 years	51	37.2
	6-10 years	32	23.4
	11-15 years	31	15.3
	16-20 years	22	16.1
	21-30 years	10	7.3
	More than 30 years	1	0.7
School location (n=152)			
	Urban/peri-urban	16	10.5
	Rural	136	89.5

5.3.1 Gender, age, teaching experience, and formal qualifications of Life Sciences teachers in three KwaZulu-Natal districts.

The profile in table 5.3.1 indicates that the gender distribution is skewed, with more females (61.2%) than males. This data however corresponds to the latest survey conducted by the KZN Department of Education, which showed that 70% of the educators in the public schools were female; with a ratio of female to male at 2.34:1 (KZN DoE, 2011). A large proportion (70%) of the teachers was between 30 and 49 years, i.e. they were mid-career teachers. Seventeen percent of the teachers were below 30 years of age (early career), whilst 13% were over 49 years of age (late career). This means the results are dominated by mid-career teachers. As presented and discussed in Chapter 3, about two thirds of the districts in KZN province are considered completely rural, whilst a quarter have an urban-rural split. Only one district is exclusively urban. The majority (about 90%) of teachers in this study said they were practising in rural schools.

Table 5.3.2 explores the relationship between teachers' age and years of teaching experience in Biology / Life Sciences. Just over 60% of the teachers reported more than five years of experience teaching Biological/Life Sciences, while 37% of the teachers had less than five years' experience in teaching Life Sciences. In the 30-39 age group, more teachers had 6-10 years of experience, as expected, but almost as many had 1-5 years of experience, indicating a change of subjects during the teaching career. The majority of 40-49-year-olds reported 16-20 years of experience of teaching Life Sciences/Biology, but many teachers in this age group reported less than 16 – 20 years of experience. The same trend is found in the age group 50-59 years, where the largest number of teachers have 21-30 years of experience, but several in this age category reported shorter periods of time.

Overall, there was a positive relationship between teachers' age and their experience in teaching Biological/Life Sciences ($r=.583$, $p<0.001$). However, the cross-tabulation indicates that many teachers have apparently changed subjects, since they have fewer years' of teaching experience in Biology / Life Sciences than expected based on their ages.

Table 5.3.2: Percentage of teachers in different age groups and their experience in teaching Biology/Life Sciences *(n = 135)*

			Teaching experience Biology/Life Sciences (%)						
		n	1-5 years	6-10 years	11-15 years	16-20 years	21-30 years	More than 30 years	Total
Age	20-29	24	16.8	0.7	0.0	0.0	0.0	0.0	17.5
	30-39	50	11.7	13.1	9.5	2.2	0.5	0.0	36.5
	40-49	49	6.6	8.8	5.1	12.4	1.5	0.0	34.3
	50-59[1]	16	2.2	0.7	0.7	1.5	5.8	0.7	11.7
Total			37.2	23.4	15.3	16.1	7.3	0.7	100.0

[1]Only two teachers were over 59 years of age, and were omitted from this analysis.

5.4 Life Sciences teachers' professional training, academic level and experience

Teachers' professional qualifications, academic level, and teaching experience are all considered important variables when examining the overall profile of teachers. Moreover, these are key variables that need to be considered during teachers' professional development. Below is the exploration of each of the following variables: Life Sciences teachers' level of professional training, highest academic level in Biological Sciences as well as teaching experience.

a. Professional training

A teacher's qualification levels may not necessarily translate into teacher quality, but there is an expectation that higher levels of qualification will be associated with better quality of teaching and learning. Figure 5.4.1 below shows the summary of qualification levels for Life Sciences teachers in the three participating KZN districts.

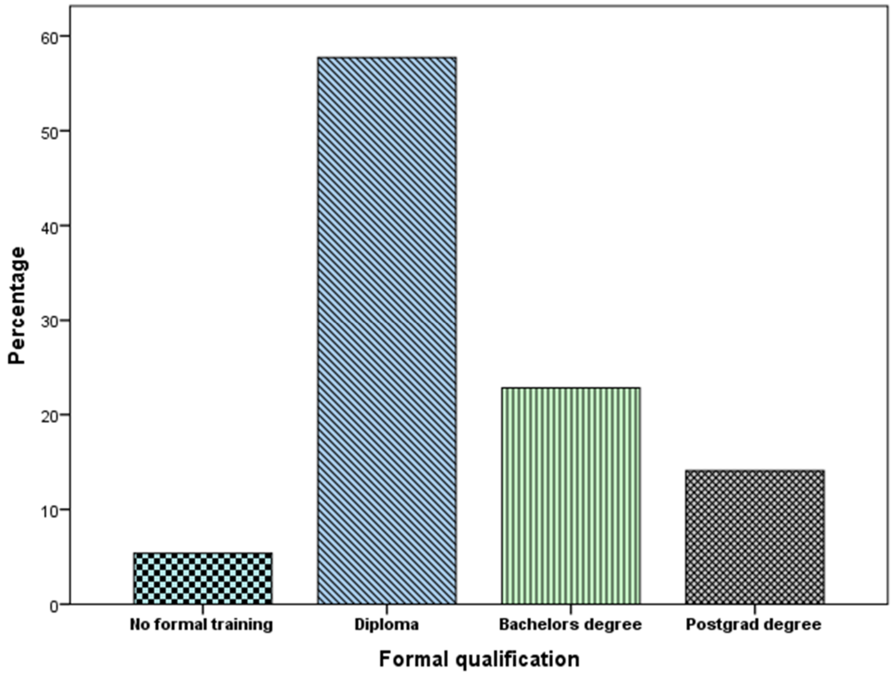


Figure 5.4.1: Percentage of Life Sciences teachers in different qualification categories (*n = 149)*

As shown in Figure 5.4.1, only about 5% of the participating teachers were without a formal professional qualification. These teachers need to attain REQV 14 qualification which is the minimum required level for teaching. Although the NSE lifted the minimum qualification requirements for all new teachers to REQV 14, teachers already in the system that had REQV 13 were considered qualified (DoE, 2006). About 58% of the teachers in this study had a Diploma or certificate as the primary qualification. The majority of these teachers had a Secondary Teachers Diploma (STD), whilst a few teachers had a range of other qualifications such as the JSTC (Junior Secondary Teachers Certificate) and SPTD (Senior Primary Teachers' Diploma). About 23% had obtained a Bachelor's degree and 14.1% had an Honours degree. Half of the degreed teachers (including Honours) had a BSc/BSc Honours or a B Ed or a B Paed (a previous 4-year initial teacher education qualification) degree. These figures for degreed teachers are higher than the national statistics, which indicate that while 89% of the teaching corps have a professional teaching qualification, only 18% are graduates i.e. have a four-year Bachelor of Education (B Ed) or a degree plus Post Graduate Certificate in Education (PGCE) or its equivalent, (DBE & DHET, 2011: 30).

About 5% of the teachers had a BA degree. The remaining 14% of the teachers who had a degree had B Ed Honours. Most of the teachers with B Ed Honours had not done a

Bachelor's degree as an initial qualification. They had completed their honours after diploma studies such as STD + ACE.

As shown in this study, the majority of teachers have a 3 year diploma in teaching, which was previously offered by Colleges of Education. Colleges of Education were phased out or incorporated into universities from 2001. All newly qualified teachers since 2001 have a Bachelor's degree, either a four-year B Ed, or a general bachelor's degree and a PGCE. However, as explained in the introduction, a large number of teachers have, since 2001, attained qualified teacher status through the NPDE. The relatively high proportion of teachers with Honours degrees is explained by a window of opportunity provided after the publications of the NSE in 2000 (DoE, 2000), when entrance to the B Ed Honours degree was opened to teachers who had a four-year diploma in education as well as degreed teachers. Many teachers took the opportunity to further their studies to Honours level. However, based on the Policy on the minimum requirements for teacher education qualifications, as from 2014 no student with a Diploma in Education followed by an ACE will be allowed to progress to a B Ed Honours degree (DHET, 2011). All prospective students intending to enrol for a B Ed Hons degree will require a B Ed or a Bachelor's degree capped with a teaching qualification. Trends are therefore likely to change in the next few years.

Reading from table 5.4.3 below showing cumulative frequency, about 63% of the participating teachers were without a Bachelors' degree, whilst 86% of the teachers were without an Honours degree. However as noted above, only about half of the teachers with a degree appeared to have the appropriate Biological Sciences qualifications.

Table 5.4.3: Percentages of formal qualification for Life Sciences teachers from three KZN districts *(n=149)*

		Frequency	Percent	Cumulative Percent
Professional training (n=149)	No formal training (Grade 12 only)	8	5.5	5.5
	Diploma/Cert	86	57.7	63.2
	Bachelors' degree	34	22.8	86.0
	Postgrad degree	21	14.1	100.0

Whilst only 5% of the teachers were unqualified, the continued appointment of unqualified teachers particularly in the KZN province only exacerbates the situation of poor quality teaching happening largely in rural schools.

Districts 1 and 2 had low performance in the National Senior Certificate examinations, while district 3 had better performance. To determine whether there was a difference in the teacher qualification levels per district a crosstab using Fisher's exact test[5] was performed. The test indicated that there was no statistically significant difference between teachers' formal qualifications in the three districts (p = 0.645.) This suggests a comparable distribution of teacher qualifications across the three participating districts, and that teachers' general qualifications were not related to NSC results.

Table 5.4.4 Life Sciences teacher qualifications across three KZN districts *(n = 149)*

			District			Total
			District 1	District 2	District 3	
Formal qualification	Grade 12	Count	6	1	1	8
		% within formal qualification	**75.0%**	**12.5%**	**12.5%**	
	Diploma/Cert	Count	35	28	22	86
		% within formal qualification	**37.5%**	**35.0%**	**27.5%**	
	Bachelors' degree	Count	12	14	8	34
		% within formal qualification	**35.3%**	**41.2%**	**23.5%**	
	Postgrad degree	Count	6	8	7	21
		% within formal qualification	**28.6%**	**38.1%**	**33.3%**	
Total		Count	59	51	39	149
		% within formal qualification	**39.6%**	**34.2%**	**26.2%**	

b. Academic level in Biological Sciences

Research indicates that knowledge of the subject is an essential attribute in effective teaching and successful learning. Teachers must possess "deep" knowledge of the discipline they teach in order to create meaningful learning experiences. An item was included in the survey questionnaire to determine teachers' academic level in Biological Sciences, which would generally have been obtained through initial teacher education. The level of Biological Sciences training received during teachers' pre-service training is expected to influence the

[5]chi-square test not suitable since the expected values in some of the cells of the contingency table were below 5

teacher's choice of a further in-service qualification programme. For example, the qualifications that would have enabled a teacher with a Secondary Teachers Diploma (STD) to upgrade would have been a Further Diploma in Education (FDE). Post NSE, it would be an ACE. A few teachers might have done a B Ed Honours in Science Education, where they would learn more about teaching science, but no science content knowledge (depending on the institution). The results on teachers' academic level in Biological Sciences are shown in figure 5.4.2 below.

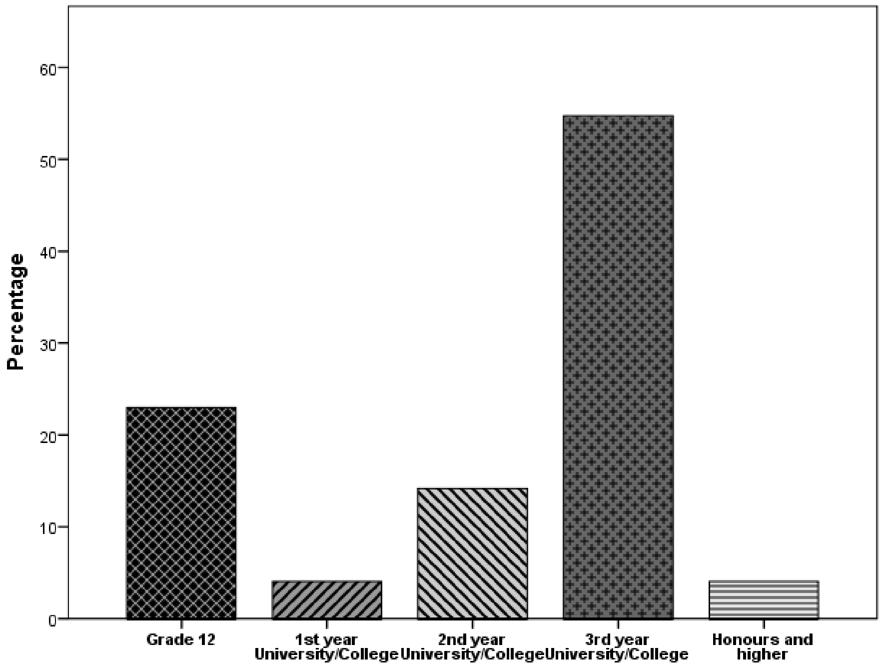


Figure 5.4.2: Teachers' academic level in Biological Sciences

Figure 5.4.2 shows that over a half of the teachers said they had studied Biological Sciences for at least 3 years in their initial training. Once again, it is important to note that the majority (63%) of the responding Life Sciences teachers were without a Bachelor's degree, and in particular, without a B Sc or an equivalent B Ed degree. Many of the teachers had obtained diplomas through the old college system. As a result, although the majority of the teachers claimed to have received up to third level of Biological Sciences training, this level is likely to be lower than those with up to 3rd level of Biology training through a degree. Within the range of diplomas and certificates completed by some of the Life Sciences teachers during their initial training were diplomas suited for teaching at primary and at junior secondary school levels. These included the JSTC (Junior Secondary Teachers Certificate) and SPTD (Senior Primary Teachers' Diploma). These teachers have completed further qualifications; however, these qualifications were still not at the level of a degree in Biological Sciences. It may thus be argued that teachers in this study gave an inflated rating of their level of training in Biological Sciences so that they may be seen to be appropriately qualified. The actual pointer to the level of training in Biological Sciences is the type of initial qualification they completed.

A crosstab was conducted to establish if teachers' formal qualifications reflected their academic level in Biology received during initial teacher education. The results are shown in table 5.4.5 below.

Table 5.4.5: Life Sciences teachers' qualifications and highest level in Biological Sciences (%) (*n=145)*

			Highest level in Biological Sciences					
			Grade 12	1st yr	2nd yr	3rd yr	Hons	Total
Formal qualification	No formal qualification	Count	8	0	0	0	0	8
		% within formal qualification	100.0%	.0%	.0%	.0%	.0%	100.0%
	Diploma	Count	18	6	15	45	0	84
		% within formal qualification	21.4%	7.1%	17.9%	56.6%	.0%	100.0%
	Bachelor's degree	Count	6	0	5	21	0	32
		% within formal qualification	18.8%	.0%	15.6%	65.2%	.0%	100.0%
	Postgrad degree	Count	1	0	1	13	6	21
		% within formal qualification	4.8%	.0%	4.8%	61.9%	28.6%	100.0%
Total		Count	**33**	**6**	**21**	**79**	**6**	145
		% within formal qualification	**22.8%**	**4.1%**	**14.5%**	**54.5%**	**4.1%**	100.0%

The NSE (DoE, 2000) stipulated that the minimum requirement for teaching an FET subject was 32 credits at NQF Level 5 (= first year university) and 32 credits at NQF Level 6 (= second year university). Thus teachers who had not studied Biological Sciences at tertiary level, or who had one year of study in Biological Sciences would not be regarded as qualified to teach Life Sciences in Grades 10-12. Table 5.4.5 shows that a total of 39 of the teachers sampled (about 27%) did not meet the minimum requirements as specified in the NSE (DoE, 2000), and were therefore teaching **out** of their field of specialisation. They need to upgrade their qualifications in Biology through a formal CPD programme.

Eighty five teachers (about 59%) reported that they had studied Biological Sciences for three years or more, and are therefore deemed to be teaching **in** their field of specialisation. They do not need to upgrade their qualifications. The remaining 21 teachers (about 15%) reported that they had studied Biological Sciences for two years, 15 of them within a diploma in education. As indicated in the Integrated Planning Framework for Teacher Education & Development in South Africa (DBE & DHET, 2011) diplomas offered by the various colleges of education were very variable in the quality and level of education offered. Depending on the college attended, two years of study in a subject at a college of education may not equate to two years of study in a Bachelor's degree. In this study, the 15 teachers who had a diploma with two years of study in Biological Sciences were deemed to be teaching **out** of field, while 6 who reported two years of study within a degree were teaching **in** their field of specialisation. Overall, 91 teachers (63%) were judged to be teaching **in** their field of specialisation, while 54 (37%) were teaching **out of** their field of specialisation in their initial teacher education.

Analysing Table 5.4.5 by formal qualification, the majority (58%) of all the teachers sampled had a diploma in education, but only 57% of that group said they had studied Biology to third-year level. Over 20% of the teachers who had a diploma had not studied Biology beyond school level.

Teachers who had a bachelor's degree comprised 22% of all the teachers, and within this group, 65% had studied Biological Sciences to third year level. However, 19% of teachers with a degree had not studied Biological Sciences at tertiary level. Over half of the teachers holding an Honours degree (62%) had studied Biological Sciences for three years, but only 29% had studied Biological Sciences for four years. This supports the finding that the majority of the Honours degrees are general B Ed Hons degrees, which do not include subject-specific content knowledge. Only one teacher with an Honours degree was teaching out of field, i.e., had not studied Biological Sciences beyond Grade 12.

The above analysis shows a considerable number of teachers of Life Sciences teaching out of the area of specialisation, a challenge that was also acknowledged by Subject Advisors in this research study. As noted in the introduction, the actual demands of the South African education system are hidden in aggregated data (SACE, 2010). This combined data fails to capture the extent to which teachers are teaching out of their areas of specialisation and/or reveal the actual levels of training that the teachers in the system received (SACE, 2010; CHEC, 2009).

5.5 Participation in CPD programmes by teachers of Life Sciences in three districts of KZN

Formal, qualification-based Continuing Professional Development programmes are important as they provide teachers with opportunities to strengthen or supplement existing knowledge base. This allows teachers to grow in their careers and become more experienced. In addition to providing knowledge and skills linked to the continuously changing curriculum, participation in qualification CPD programmes is important because it offers teachers an opportunity to learn innovative teaching strategies and technologies, and generally improves teachers' professionalism (Perraton, Creed & Robinson, 2002). Because of the previous teacher education system, there is still a significant proportion of South African teachers eligible for enrolling in qualification-based CPD programmes. The following analysis looks at participation rates in qualification CPD programmes by teachers of Life Sciences in the three districts selected for the study.

a. Trends in registration and completion rates for qualification-based CPD programmes by Life Sciences teachers from three districts in KZN.

Figure 5.5.1 below shows the trends in registration for qualification programmes by teachers of Life Sciences from three participating districts of KwaZulu-Natal.

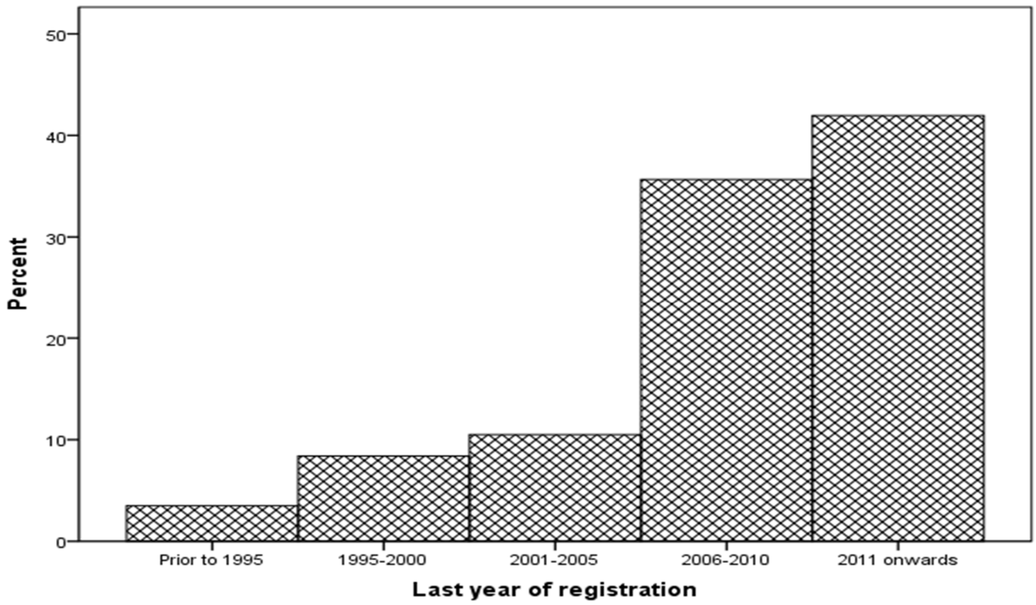


Figure 5.5.1: Trends in registration for qualification-based CPD programmes by Life Sciences teachers in three districts of KwaZulu-Natal

As seen from Figure 5.5.1, the participation in formal qualification CPD programmes by teachers of Life Sciences in this research study only showed significant improvement from around 2006. By 2011 almost half of the teachers in the three districts studied were enrolled in some form of higher education studies. Whilst enrolment trends for CPTD programmes are essential, it is the retention and completion rates in these qualification-based programmes that determine their realisation of teachers' goals.

The rate of completion was determined by exploring the relationship between teachers' last year of registration and their current registration status, i.e. whether they were still registered or had completed an upgrade qualification programme. Despite Table 5.4.1 showing that 16% of teachers did not complete their studies, the overall correlation analysis between registration and completion was significant (p<0.001), suggesting that the retention/completion rate of 84% was adequate.

Table 5.5.1. Relationship between registration and retention/completion rates for CPD qualification programmes by teachers of Life Sciences in three participating districts of KwaZulu-Natal

			Currently registered OR completed an upgrade programme		
			No	Yes	Total
Last year of registration	Prior to 1995	Count	3	2	5
		% of Total	2.1%	1.4%	3.5%
	1995-2000	Count	4	8	12
		% of Total	2.8%	5.6%	8.4%
	2001-2005	Count	6	9	15
		% of Total	4.2%	6.3%	10.5%
	2006-2010	Count	7	44	51
		% of Total	4.9%	30.8%	35.7%
	2011 onwards	Count	3	57	60
		% of Total	2.1%	39.9%	42.0%
Total		Count	23	120	143
		% of Total	**16.1%**	**83.9%**	**100.0%**

b. Life Sciences teachers' preferred methods of qualification CPD programmes

The following figure shows the percentage participation in the different CPD programmes by Life Sciences teachers that participated in the study. This data includes both programmes that teachers were still engaged in and those that they had already completed.

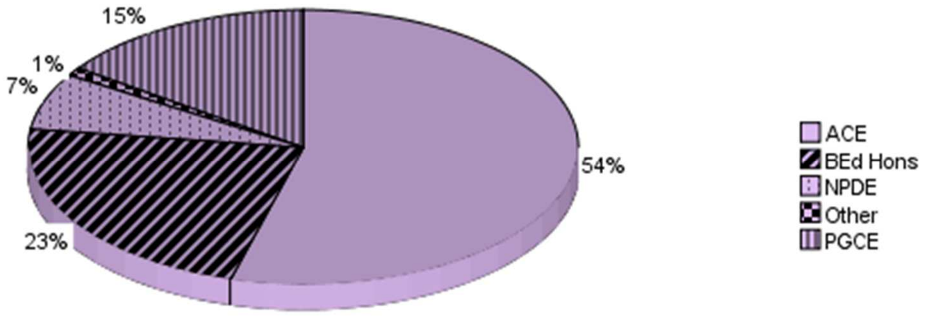


Figure 5.5.2: Percentage enrolment in qualification CPD programmes by Life Sciences teachers *(n = 152)*

The Advanced Certificate in Education (ACE) was the most popular programme among the teachers sampled (54% enrolment). In retrospect, an item on ACE specialisation should have been included in the questionnaire to give more specific results. These results only indicate that majority of teachers of Life Sciences had either completed or were enrolled for an ACE programme. The second most popular programme was the B Ed Hons with 23% either enrolled or having completed the programme. The Postgraduate Certificate in Education (PGCE) was pursued by 15% of the Life Sciences teachers. Consistent with the small number of unqualified teachers in this study, only 7% of the teachers were registered for a National Professional Diploma in Education (NPDE). These results were consistent with the latest national statistical records, which indicated considerable increase in enrolment for ACE programmes, increasing by 20% from year 2008 to 2009. Whilst substantial growth was shown by other provinces from 2008-2009, KZN experienced the lowest growth. Similar trends were observed with enrolments for NPDE. Whilst first-time enrolments in NPDE programmes had declined by 31.1% nationally during 2008-2009, consistent with the decrease in the number of unqualified teachers, KZN had the smallest enrolment even when the qualification was still growing in other regions (DBE & DHET, 2011). Cognisant of the high number of un-and under-qualified teachers, the KZN DoE has been providing bursaries for qualification programmes such as the PGCE, ACE and the NPDE (now terminated). The provision of these bursaries will clearly continue until all teachers are adequately qualified for the subjects they are teaching.

The supply of teachers of science and mathematics in the rural schools has not met the demand. The employment of under-qualified or even unqualified teachers has thus persisted, more so in rural than in urban schools (SACE, 2010). Darling-Hammond and Sykes (2003:3) earlier explained using the United States context that the appointment of unqualified teachers is mainly due to distributional inequities, rather than overall shortages of qualified individuals. This is also partly true in the South African context, where the majority of qualified maths and science teachers opt to teach in urban schools, creating systemic shortages in rural schools (SACE, 2010).

In addition to the bursaries for ACE, PGCE and NPDE it was established that the KZN DoE was also subsidising unqualified temporary employed teachers who meet the B Ed degree requirements. For example, one unqualified teacher in this research study was enrolled for a B Ed degree and indicated that she had received a bursary from the department. This data was however not included in the analysis since a B Ed degree is considered to be an initial qualification. It is not clear how long the provision of this learnership had been continuing and whether it would still continue in future. The data collected for this study could also not clearly discriminate between the teachers who completed the B Ed full-time, as initial teacher education, from those that had been offered on-the-job learnerships to enrol for a B Ed degree.

c. *Life Sciences teachers' participation in qualification-based CPD programmes by age*

Data presented in table 5.5.2 shows that not only did participation differ by age, but that choices of upgrade programmes also varied across different age groups.

Table 5.5.2: Life Sciences teachers' participation in CPD programmes by age

Age		ACE	PGCE	NPDE	Hons	No upgrade	Total
20-29	Count	3	9	3	1	1	18
	% of Total	2.1%	6.4%	2.1%	0.7%	0.7%	17.0%
30-39	Count	26	2	3	9	6	45
	% of Total	18.4%	1.4%	1.4%	5.7%	4.3%	35.5%
40-49	Count	20	3	1	10	12	46
	% of Total	14.2%	2.1%	0.7%	7.1%	8.5%	34.8%
50-59	Count	7	1	0	1	5	14
	% of Total	5.0%	0.7%	0.0%	0.7%	3.5%	11.3%
Total	Count	56	15	7	21	24	123
	% of Total	39.7%	10.6%	4.3%	14.2%	17.7%	100.0%

Participation in qualification-driven CPD programmes was highest in the 30-39 and 40-49 age categories, with ACE being the most popular programme, followed by the Honours programme. The rate of non-participation was also higher for these age categories, more so for the 40-49 than the 30-39 age groups. PGCE was the favourite programme for the 20-29 age category, accommodating young unemployed graduates who had entered the teaching profession. The NPDE enrolments were spread across the first three age categories, indicating possible persistence of unqualified teachers throughout these ages. The highest number of teachers that had not taken up any upgrade programme was in the 40-49 age band, followed by those in the 30-39 and 50-59 categories respectively.

The difference in participation in upgrade programmes by age was significant (p = 0.037). The results also indicated a significant difference between teachers' age and the choice of CPD programmes (p<0.001), also determined using Fisher's exact test. Thus early career teachers prefer the PGCE, mid-career teachers the ACE and B Ed Hons, and late career teachers the ACE. The retirement age in the teaching profession is 65 years.

Teachers between 30-49 years of age who have not participated in any upgrade programmes ought to be encouraged to do so to improve their knowledge and skills, particularly in light of the ongoing changes in the school curriculum, including that of Life Sciences which many teachers find challenging.

d. Life Sciences teachers' participation in CPD programmes by qualification

As shown in table 5.5.3, almost all the teachers with no initial teacher education were enrolled for a qualification programme. A total of 17% of the teachers eligible to enrol for upgrade programmes such as the ACE and B Ed Honours had not taken up any qualification programme beyond their initial training. Teachers with a diploma as their initial teaching qualification were the least likely to participate in an upgrading qualification. All the teachers in the graduate categories were currently upgrading or had already upgraded through the PGCE, ACE or Honours. The association between teachers' participation rate in CPD programmes by initial qualification was investigated using Fisher's exact test. The disparity in participation was found to be significant at $p<0.001$, showing that initial qualification had a strong impact on participation in formal CPD qualifications. The results suggested that it was precisely the teachers with only a diploma that ought to be targeted for further development.

Table 5.5.3 Participation in CPD programmes by qualification levels (n = 149)

			Currently registered OR completed a programme		
			No	Yes	Total
Initial qualification	Grade 12	Count	1	7	8
		% within formal qualification	12.5%	87.5%	100%
	Diploma/Cert	Count	25	61	86
		% within formal qualification	29.1%	70.9%	100%
	Bachelors degree	Count	0	34	34
		% within formal qualification	0%	100%	100%
	Postgrad degree	Count	0	21	21
		% within formal qualification	0%	100%	100%
Total		Count	26	123	149
		% within formal qualification	**17.4%**	**82.6%**	**100%**

5.6 Perceived gains through engagement in professional development programmes

The purpose of any professional development programme is generally to improve teachers' knowledge and skills. According to Villegas-Reimers, (2003), the role of professional development is to assist teachers build new pedagogical content knowledge, thus helping them develop expertise in their fields. Similarly, Van Driel, (2010: 1) views the rationale for CPD programmes as that of advancing teachers' knowledge and practices. This section therefore explores teachers' perceived benefits from engaging in CPD programmes.

5.6.1 Perceived gains from qualification-driven CPD programmes

Teachers in the study were asked to indicate their perceived level of development as a result of engaging in various qualification-driven CPD programmes. The items were however not specific to any one type of qualification programme, but rather, assessing perceived gains from all programmes in general. The CHE review (CHE, 2010) noted that because of the generic nature of many ACE programmes, teachers developed through ACE were less well-prepared to teach a subject than those developed through the B Ed or PGCE programmes (CHE, 2010). The review noted a lack of articulation between the ACE modules and the B Ed or the PGCE modules, especially in relation to subject content level competence (CHE, 2010). According to CHE (2010) the ACE programmes did not cater adequately for updating, enriching and supplementing the teacher's existing subject knowledge; but instead it focused on how the school subject content could be taught more proficiently. Hence, a significant number of Life Sciences teachers in this study are likely to have completed this generic ACE, or even ACE (Management and Leadership) which was popular at the time. As indicated in chapter 2, the new Advanced Certificate in Teaching, which will replace the ACE programme, will focus on subject specialisations.

Similarly the B Ed Honours is a generic degree, not targeting growth in subject matter knowledge of any particular subject. Life Sciences teachers in this study who completed the B Ed Honours degree would not have experienced any significant improvement in content knowledge. Against this backdrop, the results on Life Sciences teachers' perceptions about the benefits of these programmes are interpreted with caution.

As shown in Table 5.6.1, five items were put on a five-point Likert scale, where 'no development at all' was coded as 1, and 'very great development' coded as 5. The table below shows teachers' responses in percentage, mean and standard deviation.

Table 5.6.1 Teachers' perceived development from participation in various qualification CPD programmes

	Percentage of teachers					*Score*	
Items	*To no extent at all*	*To a very little extent*	*To some extent*	*To a great extent*	*To a very great extent*	*Mean*	*Std. dev*
1.My subject matter knowledge is improving/has improved	0.9	1.9	14.8	37.0	45.4	4.24	0.84
2.My knowledge of different teaching strategies is increasing /has increased	0.9	1.9	13.0	50.9	33.3	4.14	0.78
3.My knowledge of assessment strategies is improving/has improved	0.9	2.8	18.5	38.0	39.8	4.13	0.88
4.My knowledge of the curriculum is improving/has improved	0.9	4.7	13.1	42.1	39.3	4.14	0.88
5.I am developing/have developed confidence as a teacher	1.9	1.9	6.5	27.1	62.6	4.47	0.85

Development of 'confidence as a teacher' (item 5) emerged as the main benefit achieved from participating in qualification CPD programmes. This was reflected by 63% of the teachers who indicated development to a 'very great extent'. Generally, teachers should develop confidence as a result of their development in various knowledge domains such as subject matter knowledge, pedagogical knowledge, curriculum knowledge, etc. It can thus be argued that the ultimate development of teacher confidence was linked to development in other areas of teacher knowledge, as evidenced by teachers' responses to items 1 to 4 in the above table. For all these items, the majority of teachers indicated growth at least to a great extent.

Because many of the participating teachers had been enrolled in the ACE programmes at one stage or another, it was necessary to explore the extent at which this qualification in particular was contributing to the advancement of teachers' knowledge and skills. The Subject Advisors believed that Life Sciences teachers, particularly those without Bachelor's degrees (majority of teachers) or with non-Biological Sciences degrees, would benefit the most from ACE qualifications in Biological Sciences.

> *To me teachers of Life Sciences need to register for ACE programmes that will teach content and relevant pedagogy, so that when you meet them at a workshop or visit them at school, you don't have to deal with problems of teachers who lack the content and therefore do not know how to approach it when teaching.* (**Subject Advisor)**

Further remarks from advisors however suggested that it was precisely the ACE in Biological/Life Sciences programme that was relevant, and from which teachers of Life Sciences were benefiting enormously.

> *In my view we need to have Life Sciences teachers registered for university ACE programmes such as the ACE in Biological Sciences offered by UKZN (University of KwaZulu-Natal). This programme is very specific; it upgrades teachers content-wise, and also helps them learn didatics, including assessment. General ACE programmes that are not subject specific do not necessarily address teachers' needs for teaching Life Sciences.* (**Subject Advisor)**

The Subject Advisor became aware of the ACE (Biological Sciences) that was to be offered at UKZN (one of the local universities in KZN province). When a circular came out indicating that teachers of Life Sciences could apply for a bursary to complete an ACE Biological Sciences programme at UKZN, the Subject Advisor requested module templates outlining the curriculum to be covered. From this perspective, this Advisor believed that this kind of ACE specialisation would significantly benefit the teachers of Life Sciences. The Advisor was adamant that the generic ACE programmes that many Life Sciences teachers had completed fell short in addressing teachers' classroom needs.

The first (and only) cohort of ACE Biological Sciences teachers enrolled at UKZN in 2012. It was therefore worth exploring the impact the UKZN ACE (Biological Sciences) programme had on the needs of teachers. An evaluation was conducted during the second half of 2013, when this cohort was doing the last semester of the programme. There was however a very small cohort of fourteen students because the bursaries had not been awarded on a massive scale as promised by the KZN DoE. Only two of the fourteen teachers were DoE funded, the rest of the teachers were self-funded.

As indicated in the discussion of instruments in the methodology section, the evaluation took the form of a questionnaire which included closed and open-ended questions on teachers' perceived development in both content and pedagogic knowledge. Thirteen ACE students responded to the questionnaire. Whilst data was collected from a small sample of thirteen students, legitimate inferences could still be drawn from the data considering that nearly all the students (13 of the 14 registered) from the 2012 cohort responded to the evaluation.

Table 5.6.2 below shows the results on students' perceived development in specific content areas. Three out of four Knowledge Strands identified in the National Life Sciences curriculum had been completed at the time of the evaluation, viz: Life at molecular, cellular and tissue level (Knowledge strand 1); Life processes in plants and animals (Knowledge strand 2); and Diversity, change and continuity (Knowledge strand 4). The module covering Environmental Studies (Knowledge strand 3) was underway at the time of the evaluation. The results are presented per Knowledge Strand.

Table 5.6.2: UKZN ACE students' perceived development in Knowledge Strand 1

Topic	*No development*	*Very little development*	*Some development*	*Good development*	*Very good development*	*Mean*	*Std.dev**
1. Chemistry of life	0.0	7.7	7.7	23.1	61.5	4.4	1.0
2. Cells – basic unit of life	0.0	0.0	7.7	7.7	84.6	4.8	0.6
3. Cell division - mitosis	0.0	0.0	7.7	15.4	76.9	4.7	0.6
4. DNA – the code of life	0.0	0.0	7.7	0.0	92.3	4.8	0.6
5. Meiosis	0.0	0.0	7.7	23.1	69.2	4.6	0.7
6. Genetics & inheritance	0.0	7.7	0.0	23.1	69.2	4.5	0.9

* Standard Deviation

Results displayed in table 5.6.2 above suggested that this cohort of students (which were practising Life Sciences teachers) were satisfied with their development of content knowledge in Knowledge Strand 1. Exceptional development was observed for the topic: DNA: the code of life'. Only one student (7.7%) indicated 'very little development' for two topics 'chemistry of life' and 'genetics and inheritance'. A close examination of the demographic information showed that this teacher had majored in English and Biblical studies during initial teacher education. Ordinarily, learning new content altogether would have been a challenge for this teacher. It is therefore not unusual that he/she did not experience the same level of development as the other teachers who had background knowledge in Biological Sciences content. As highlighted by one of the advisors, the system has displaced a few teachers by making them teach subjects they were not trained to teach. These teachers typically have to learn the Life Sciences content *ab initio*, which is obviously an arduous task. It was encouraging to note that through enrolment in this ACE programme, the said teacher improved her 'confidence' to teach. The following comment captured this benefit.

> *I have benefited a lot from doing ACE Biological Sciences because it's brought me some confidence when teaching the subject. Now I know some topics which I did not understand at all before. Things are now clearer and understandable.* **(ACE student)**

As seen from the above excerpt, this teacher was cautious saying things were 'clearer' to suggest a developmental learning process.

As presented in Table 5.6.3, there were clear patterns of growth in teachers' knowledge of 'Life processes in plants and animals' (Knowledge strand 2), with the majority of the teachers indicating 'very good development' for many of the topics. The results of the first survey on Life Sciences' teachers' content needs (results of this study presented later in 5.8 of this chapter) showed that 'Energy transformations to sustain life' was the most sought topic in this strand. Consistent with these needs, UKZN ACE teachers' perceived development in this topic varied from 'very good' (53.8%) to 'good' (23.1%), and to 'some development' (23.1). This may imply that a number of Life Sciences teachers perhaps find the topic challenging.

Development for 'Support & transport systems in plants' was particularly noted by one of the ACE students as encapsulated in the following extract.

> *I am whole lot confident to teach Life processes in plants. The plant section used to be the most challenging for me. On my first year of teaching Life Sciences I actually skipped it. Now I am a whole lot confident to teach it.* **(ACE student)**

Table 5.6.3: UKZN ACE students' perceived development in Knowledge Strand 2

Topic	*No development*	*Very little development*	*Some development*	*Good development*	*Very good development*	*Mean*	*Std.dev*
1. Plant and animal tissues	0.0	0.0	7.7	38.5	53.8	4.5	0.7
2. Support & transport systems in plants	0.0	0.0	0.0	53.8	46.2	4.5	0.5
3. Support & transport system in animals	0.0	0.0	7.7	46.2	53.8	4.5	0.5
4. Energy transformations to sustain life	0.0	0.0	23.1	23.1	53.8	4.3	0.9
5. Animal nutrition	0.0	0.0	7.7	7.7	84.6	4.8	0.6
6. Gaseous exchange	0.0	0.0	15.4	0.0	84.6	4.7	0.8
7. Excretion in humans	0.0	0.0	7.7	15.4	76.9	4.7	0.6
8. Reproduction in vertebrates	0.0	7.7	0.0	15.4	76.9	4.6	0.9
9. Human reproduction	0.0	0.0	7.7	0.0	92.3	4.8	0.6
10. Responding to the environment	0.0	7.7	7.7	23.1	61.5	4.4	0.9
11. Human endocrine system	0.0	7.7	15.4	15.4	61.5	4.3	0.9
12. Homeostasis	0.0	0.0	7.7	7.7	84.6	4.8	0.6

Knowledge strand 4 had been the most sought according to the results of the survey on Life Sciences teachers' needs presented in the following section. Table 5.6.4 below points out to greater development in 'evolution by natural selection' and 'human evolution'. Improvement in the knowledge of 'history of life' was also fairly good. Teachers may have experienced these notable gains because there was adequate time for them to learn and understand evolution concepts. Stears (2012) asserts that more time needs to be allocated to evolution modules so that sound conceptual understanding can be developed.

Table 5.6.4: UKZN ACE students' perceived development in Knowledge Strand 4

Topic	*No development*	*Very little development*	*Some development*	*Good development*	*Very good development*	*Mean*	*Std.dev*
1. Biodiversity and classification of microorganisms	0.0	0.0	7.7	46.2	46.2	4.4	0.7
2. Biodiversity of plants	0.0	0.0	7.7	38.5	53.8	4.5	0.7
3. Reproduction in plants	0.0	0.0	0.0	38.5	61.5	4.6	0.5
4. Biodiversity in animals: Inverts	0.0	0.0	15.4	23.1	61.5	4.5	0.8
5. History of life on Earth	0.0	0.0	15.4	30.8	53.8	4.4	0.8
6. Darwinism and natural selection	0.0	0.0	7.7	15.4	76.9	4.7	0.6
7. Human evolution	0.0	0.0	7.7	23.1	69.2	4.6	0.7

Overall, there appeared to be a perceived significant improvement in Life Sciences teachers' content knowledge as a result of participating in the UKZN ACE Biological Sciences programme.

The UKZN ACE Biological Sciences students were positive about their growth in pedagogic knowledge and skills. As shown in Table 5.6.5, more responses were on the affirmative side. Consistent with the results of the first survey (Table 5.5.1), the most significant benefit was that of 'development of confidence as a Life Sciences teacher', with a resounding 84.6% of respondents articulating this. Similar findings were reported by Bertram, Mthiyane, and Mukeredzi (2012) in their study of learning experiences of PGCE students. Once again, this response may illustrate the commonly-held view that South African teachers lack confidence. Hence, learning new knowledge and skills is seen as an opportunity to improve their confidence.

Table 5.6.5: UKZN ACE students' perceived development in Pedagogic knowledge

Item	*To no extent at all*	*To a very little extent*	*To some extent*	*To a great extent*	*To a very great extent*	*Mean*	*Std. dev*
1. Confidence in teaching difficult topics	0.0	0.0	15.4	15.4	69.2	4.5	0.8
2. Improved knowledge of teaching strategies	0.0	0.0	7.7	23.1	69.2	4.6	0.7
3. Improved knowledge of assessment strategies	0.0	0.0	7.7	38.5	53.8	4.5	0.7
4. Improved knowledge of CAPS	0.0	0.0	15.4	53.8	30.8	4.2	0.7
5. Improved practical work skills	0.0	0.0	23.1	46.2	30.8	4.1	0.8
6. Made changes to my own teaching	0.0	0.0	15.4	53.8	30.8	4.2	0.7
7. Engage learners in higher order thinking	0.0	0.0	7.7	61.5	30.8	4.2	0.6
8. Apply skills in my classroom teaching	0.0	0.0	16.7	25.0	58.3	4.4	0.8
9. Developed interest in Life Sciences	0.0	0.0	7.7	23.1	69.2	4.6	0.7
10. Improved confidence as a teacher	0.0	0.0	7.7	7.7	84.6	4.8	0.6
11. Selecting materials for teaching	0.0	0.0	7.7	30.8	61.5	4.5	0.7
12. Designing learning according to context	0.0	0.0	15.4	23.1	61.5	4.5	0.8
13. Integrate diff. cognitive levels in assessment	0.0	0.0	7.7	30.8	61.5	4.5	0.7
14. Integrate indigenous knowledge	0.0	0.0	15.4	38.5	46.2	4.3	0.8

In line with development of confidence, teachers' interest in Life Sciences as a subject had been greatly enhanced. Looking at other pertinent skills, it appeared that this cohort was also advancing their knowledge of teaching strategies through the programme, with about 69% of the respondents indicating ‘development to a great extent’ in this regard. It was also particularly noteworthy that teachers indicated progression in their skills of ‘selecting materials for teaching’; ‘designing learning according to context’ and ‘integrating indigenous knowledge’. The least perceived improvement was on ‘practical work skills’. This was logical as explained by one of the UKZN ACE tutors because the last module was to cover explicitly, the teaching of practical skills. Whilst teachers had conducted practical work during the course of the study, the pedagogy of imparting the skills to the learners was to be taught in the last module.

On the whole, the cohort of UKZN ACE students appeared to be benefiting immensely from the programme. Through open-ended questions, students highlighted specific topics where they advanced their content knowledge. They also noted improvement in pedagogic skills such as dealing with students’ misconceptions; handling diversity in classrooms; learning new teaching strategies; learning how to conduct practical work/experiments.

5.6.2 Perceived development through participation in training workshops

With training workshops being the most utilised non-qualification method of continuous professional development of teachers in South Africa, items were included in the questionnaire to examine the sampled teachers’ perceptions of their development through such workshops. In contrast to the documented lack of impact of these workshops, teachers in this study responded affirmatively. As seen from the table below, the sampled teachers of Life Sciences unanimously believed that workshops were assisting them in various aspects of their development such as learning relevant subject matter and new teaching strategies, and so forth. Open-ended responses to the same questions, answered by the same teachers however revealed a conflicting view. Their comments upheld the widely supported consensus that training workshops were not adequately addressing teachers’ development needs. The quantitative results were therefore treated with restraint. More credibility was by far, given to qualitative responses as they were further substantiated by feedback from Subject Advisors.

Table 5.6.6: Teachers' opinions of training workshops showing percentage, mean and standard deviation

Items	*SA (%)*	*A (%)*	*N (%)*	*D (%)*	*SD (%)*	*Mean*	*Std. dev*
1. We learn subject matter that is directly relevant to what we have to teach.	78.6	15.2	3.4	1.4	1.4	4.68	0.73
2. We learn how to help our learners answer exam questions better.	74.1	20.4	3.4	0.7	1.4	4.65	0.71
3. We learn new ways of teaching subject matter.	69.2	25.3	4.8	0.0	0.7	4.62	0.64
4. We enrich our knowledge of the subject matter.	72.5	20.8	4.0	0.7	2.0	4.61	0.78
5. We learn new ways of including practical work in our teaching	61.2	25.2	10.9	1.4	1.4	4.44	0.84

SA = strongly agree; A= Agree; N= neutral; D= disagree; SD = strongly disagree

The ambiguity in teachers' responses can be seen from the following comment made by one of the teachers who had selected 'strongly agree' for all the items above:

> *In 3 years, workshops have been of NO value at all. Had there been workshops like before, these would be my answers (indicating strongly agree for all five items).* **(Teacher)**

This teacher then elaborated on the questionnaire indicating that they used to have workshops run by 'experts', most likely suggesting people from outside the department of education, people with possible links to higher learning institutions. The idea of bringing experts into training workshops was reiterated by other teacher respondents. For example one of the teachers argued that *'bringing experts on the subject at least once every year to mass workshops'* would ensure that teachers '*see the need to not only to attend workshops but to check if they are really updated and clued up with current information on the subject'*.

A closer observation of data showed that the comments about experts came largely from district 3. As indicated in chapter 3, this district had been without an Advisor for at least 18 months. Workshops were conducted by cluster leaders. It is likely therefore that the comment came against this background.

Other excerpts from open ended responses of the same item in the questionnaire revealed a scenario of training workshops that fail to adequately address the immediate needs of teachers. The following extract for example, clearly suggested a fair degree of dissatisfaction with the duration of the workshops, a position that has been argued strongly in many research studies.

> *Workshops must at least take 3 days for teachers to get time to discuss all aspects. One day workshop is meant to flood teachers with information and becomes futile.* (**Teacher**)

From teachers' accounts, it is not merely the duration that renders workshops somewhat ineffective, in addition there were issues of regularity of these workshops. The following extracts from different teachers illustrate the point.

> *I wish workshops would be conducted each and every term so that I can be developed in different areas of each term. Two workshops a year are not enough…*(**Teacher**)

> *I would like to see a lot more content workshops conducted for capacity building and follow up rather than one day workshops which don't help us much.* (**Teacher**)

> *We need more regular workshops that will start at the beginning of the year and continue through the year, not just one workshop a semester.* (**Teacher**)

A number of teachers shared this sentiment, appealing for more workshops that would focus mainly on content, with some teachers calling for *'greater degree of content workshops'*; *'rigorous discussion of Life Sciences content during workshops'*; *'more focus on content during workshops'*.

Teachers also linked these content workshops to teaching strategies.

> *Workshops need to deal directly with content and skills….methods of delivery.* (**Teacher**)

> *We need workshops that deal with most difficult content problems and to be empowered with a variety of methods of teaching those problem areas.* (**Teacher**)

Essentially, the question of what exactly is covered in these training workshops was a matter of concern for the majority of the teachers. Training of teachers through workshops to a large extent rests with Subject Advisors. Subject advisors themselves are aware of these shortcomings. The following comment from one of the Subject advisors clearly outlined the challenges they face.

> *At the beginning of the year we conduct workshops called Orientation workshops. Then in the middle of the year, we again call them (teachers) for another workshop, the Content workshop. But these workshops run only for one day. So it becomes very difficult, almost impossible to say you'll be doing content and also how to teach it because in fact you have three hours. We are told that workshops must start at 12pm and end around 3pm. So really what can you do in 3 hours? If you have two sessions, one at the beginning of the year and another in the middle of the year, each for 3 hours…really there is nothing much you can do to capacitate teachers.* **(Subject Advisor)**

Similar problems were experienced in training teachers for CAPS. Whilst some form of training was done for the curriculum revision in 2007 for the implementation in 2008 in Grade 10, the curriculum was then revised again to produce CAPS, which was implemented in Grade 10 in 2012. The advisors explained that they did the same kind of workshops, that is, the Orientation workshop at the beginning of the year (2012) and the Content workshop in the middle of the year to train teachers for CAPS. There was obviously nothing additional done to capacitate teachers for CAPS.

> *There was nothing more to prepare them in terms of content. What assisted us was that some of the content that was now in Grade 10 of the new CAPS curriculum was previously in Grade 12. Some of the teachers that were teaching Grade 12, were also teaching Grade 10 & 11 and those teachers already know the content. But in big schools where there are many teachers teaching different grades, there was not enough training for the Grade 10 teachers in terms of content. As I said, it was just a day training where we just advised them on what was in the CAPS curriculum. There was no time to go deep into the content. We just focussed on the logistics. We definitely need more time for content.* **(Subject Advisor)**

It was clear that Subject Advisors had very limited contact time to conduct training workshops that would make meaningful impact on teachers' classroom practices.

Another important aspect that had been at the centre of this research was the identification of teachers' needs prior to engaging them in training workshops. A number of comments from the teachers clearly indicated that the relevance of training workshops was important. The following quotations were extracted from teachers' open-ended responses:

> *We would like to be asked what we need to be work-shopped on, before we come to workshops.* **(Teacher)**
> *Subject Advisors are supposed to get from the educators areas to be treated in workshops; areas which give us educators difficulties.* **(Teacher)**

As discussed in the theoretical framework of this study, one of the assumptions on which Knowles 'theory of Andragogy is grounded is *'the need to know'*. According to Knowles (1968), adults need to know why they must learn something before they undertake it. As expounded by Merriam (2001), Knowles' idea of 'self-directed learning' in adults comes from the perspective that adults manage all aspects of their lives, and are thus likely to direct and plan their own learning. Functional theorists such as Daloz, (1986) and Trotter (2006) backed Knowles' theory arguing that adults prefer to plan their own educational paths, where they can select educational topics that they could directly apply in their own classrooms. As these theorists assert, teachers should be given autonomy to plan their own professional development, dealing with what they feel they need to learn. Comments from teachers in this study clearly revealed the need for autonomy in deciding on their learning. Their needs should therefore be surveyed prior to embarking on any training workshop, if meaningful learning is to be achieved.

The analysis of teachers' qualitative responses together with interview comments from subject advisors revealed that a great deal of effort was required to improve the impact of training workshops on teachers in general, and on teachers of Life Sciences in particular. In line with previous research studies, to improve the development of teachers through training workshops, the duration and frequency of the workshops has to be increased. Again, as with previous research, focusing on teachers' immediate needs such as dealing with content and teaching strategies seems to go a long way in ensuring that meaningful learning on the part of teachers takes place.

To a very large extent the mandate for the improvement of teacher training workshops, in particular those organised through education districts, lies with the provincial and national departments. A unique outcome of this study is that districts need not do this singlehandedly; they need to bring in experts to train teachers in complex and new areas of content and associated pedagogy. This seems to be of utmost value to teachers and therefore this idea should be taken forward to improve the impact of these training workshops. Also important for teachers is the assessment of their needs prior to planning any training workshop.

5.6.3 Participation in cluster-based CPD and perceived benefits.

In the midst of school curriculum changes in South Africa, other non-qualification based CPD models such as teacher clustering, school-based PD and mentoring & coaching have also gained momentum. Table 5.6.7 below shows that of the three approaches, teacher clustering was widely used by 94% teachers of Life Sciences, followed by School-based PD at 80%. Just over half (53%) of Life Sciences teachers indicated that they have mentors or coaches.

Table 5.6.7: Percentage participation in Cluster-based CPD, School-based CPD and Mentoring or coaching

	Teacher clusters (%)	*School-based PD(%)*	*Mentoring & Coaching (%)*
Yes	94	80	53
No	6	20	47

a. Participation in clusters

Following the analysis of teachers' qualitative responses, it was not quite clear what the cluster group meetings were used for other than assessment, which many of the teachers referred to as 'moderation'. Subject Advisors were then probed on the objectives of cluster group meetings. The following explanation was given by one of the advisors.

> *Cluster groups are set to look at continuous assessment which is part of the 25% that we assess during the course of the year. In the clusters, teachers set common tasks and they generate a database of questions which they go back and use in their schools. We believe that when they (teachers) are together they prepare much better assessment tasks than when they are on their own.* **(Subject Advisor)**

In the absence of advisors, cluster coordinators carry the responsibility of leading the groups to ensure that assessment tasks are completed. This, as one of the advisors explained, is achieved by way of selecting senior or experienced teachers, or even good-performing teachers. As the advisor elucidated, criteria for selecting the coordinators are not restrictive.

> *We take senior teachers or experienced teachers or well-performing teachers as cluster leaders. There is a long criteria (list of) but we consider anything associated with being good. We train them by way of giving guidelines on what to do as a cluster coordinator. Because of good Cluster Coordinators, some clusters are therefore quite viable.* **(Subject Advisor)**

As the advisor alluded, the viability of these clusters is largely dependent on the competence of the cluster coordinators. According to Jita and Ndlalane (2009) one of the factors that determine the success of teacher clusters is the competence of the facilitator/s. A comment from one of the teachers supported this assertion, as it suggested that their motivation to attend cluster meetings was to a certain degree influenced by the competence of the facilitator.

> *We need facilitators that are clear with the subject matter. When the facilitator is not clear that demotivates us to come to cluster workshops where we gain nothing. Subject Advisors need to visit clusters to see for themselves these problems with some facilitators.* **(Teacher)**

It emerged from the qualitative data obtained from the teachers that Subject advisors were not always able to attend these meetings. In seeking clarity, advisors indeed confirmed that they were unable to visit all cluster groups and offer advice on-site largely because there were too few advisors.

> *We do visit clusters but not all of them because of time constraints. We've always wanted to be there when they develop tasks but we only meet them when they have already developed the tasks and when they come for moderation. So when they meet for the first time we're not there. Imagine if you have 150 teachers and there are between 5 and 10 teachers in a cluster, it means that there will be up to 50 clusters so you cannot see all of them. In most districts there are is only one advisor or two at the most.* **(Subject Advisor)**

Bearing in mind that some districts were without advisors, it was essential to determine whether this influenced teacher participation in cluster meetings. Fisher's exact test suggested a statistically significant difference in participation between the three districts, *($p<.001$).*

Participation trends per district presented in the table below indeed indicated that some districts were more active than others.

Table 5.6.8: Life Sciences participation in cluster-based CPD programmes by district

District		*Participation in teacher clusters*		
		No	**Yes**	**Total**
District 1	Count	**0**	**54**	**54**
	% within District	**0.0%**	**100.0%**	**100.0%**
District 2	Count	**2**	**50**	**52**
	% within District	**3.8%**	**96.2%**	**100.0%**
District 3	Count	**6**	**26**	**34**
	% within District	**17.6%**	**82.4%**	**100.0%**
Total	Count	**8**	**132**	**140**
% within District		**5.7%**	**94.3%**	**100.0%**

p<.001

Nearly all teachers responded to this item. The results show that the participation by teachers from Districts 1 and 2 was slightly higher (between 96%-100%) than that of District 3, where participation levels were just over 80%. It was not entirely clear why there was a difference in participation. However, the absence of the Life Sciences advisor for almost two years in District 3 may have contributed to the lower levels of participation. Whilst District 1 was also without a dedicated Life Sciences advisor, the caretaker advisors from District 2 were actively ensuring the establishment and functionality of cluster groups in this district.

b. Perceived development through cluster-based CPD programmes

Due to the difference in participation levels by district, teachers' perceived development per district through cluster-based CPD was also determined. In respect of the activities (mostly assessment) that teachers engaged in during cluster meetings, teachers were asked to rank their perceived level of development, on a scale of 1 to 5, where 1 represented 'no development at all' while 5 represented 'very high development'. Analysis of data on development per district was done. The following results were obtained.

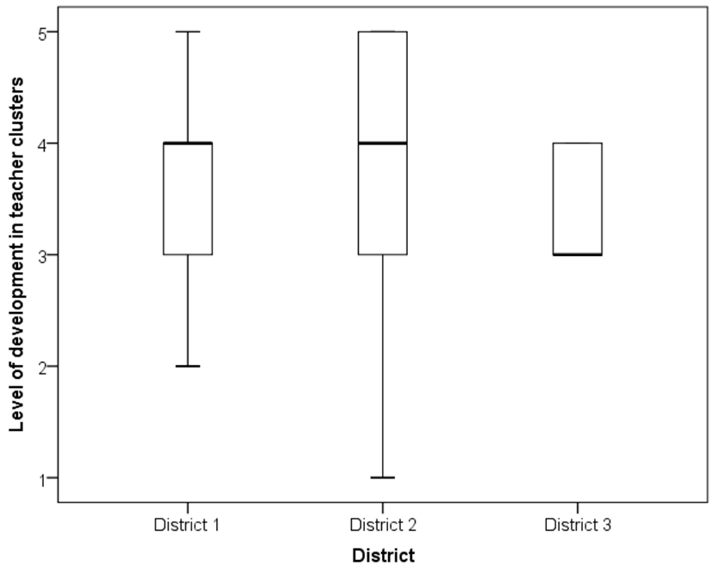


Figure 5.6.1: Life Sciences teachers' perceived level of development through cluster-based CPD programmes per district

Development was highest in Districts 1 and 2 (median= 4). However, teachers from district 2 demonstrated the greatest variability with some teachers indicating "very high development" whilst others only experienced 'some development'. Overall, teachers from districts 1 and 2 appeared to be benefiting marginally higher than those from District 3. Teachers from District 3 experienced only 'some development', with a median of 3.

Asked whether they were aware of any problems relating to teachers' participation in cluster meetings, advisors indicated that some teachers played a very passive role during cluster meetings.

> *We know that some teachers don't participate maximally. For example, you find that a cluster has a task to complete, and the task is only completed by 3 out of 10 people.* **(Subject Advisor)**

Probing whether there were mechanisms in place to ensure maximum participation in clusters by all teachers, the advisors indicated that they encouraged rotational cluster coordination. Nevertheless, advisors explained that this was difficult to achieve as some clusters resisted changing their coordinators. As the advisors elucidated, many of the teachers resisted largely because they did not feel confident to lead.

Confidence in teachers usually develops once they master subject matter knowledge, including competence in pedagogic knowledge and other related knowledge areas (Shulman, 1987; Evans, 2008). So, it may be that some teachers are truly lacking in their knowledge and skills, preventing them from participating to their maximum. Until all teachers of Life Sciences are competent, this will likely remain a challenge.

Whilst cluster groups have great potential to be utilised for wide-ranging development of teachers, it became obvious from these results that their scope was limited to developing teachers in only one area, i.e. assessment. Subject advisors attested to this citing time constraints. This may suggest that the school curriculum is assessment-driven, which may hamper teacher learning efforts. Teachers' remarks however signalled a great need to expand these networks to include development in other areas of teaching. Teachers indicated willingness to use cluster meetings for more inclusive professional development rather than confining them to assessment-related activities. As seen in the following excerpts, a number of teacher participants shared their ideas on how cluster groups could be used as a platform to share content knowledge, teaching strategies, and other pertinent skills.

> *Teacher Clustering must be officially authorised so that it can play an active role in developing teachers in terms of new content, especially difficult content.* **(Teacher)**
>
> *Clusters must be used for sharing new teaching strategies, not only for moderation.* **(Teacher)**
>
> *I would like to see us teachers in the clusters develop one another in terms of teaching and improving the subjects especially Life Sciences.* **(Teacher)**
>
> *Clusters groups can work together in drafting preps (lesson plans) that can be uniform - this will ensure proper completion of syllabus topics in all schools.* **(Teacher)**

It is evident from the above quotes that teachers see the need to utilise this social learning network opportunity to its maximum. As relayed by one advisor, this determination was demonstrated by a ward in one of the districts, where cluster groups go beyond merely sharing assessment-related knowledge and skills. Teachers in this cluster share content knowledge and pedagogic skills such as teaching strategies related to such content.

> *There is ward/circuit in my district whereby teachers capacitate each other. They don't only meet for assessment but also meet to share content information and teaching strategies. They have different cluster groups where each group has an expert in a particular topic in Life Sciences. For example, one teacher may be an*

> *expert in Evolution, another in Genetics, etc. So these experts move around in these groups and they share their expertise.* **(Subject Advisor)**

Clearly there are great potential benefits from such information-sharing platforms as further explained by the advisor.

> *This is a very good structure to support the curriculum because when you can't be there as the Advisor, you know that something is happening, teachers are learning from each other. That ward actually produces good results. When clusters work effectively like in that ward, teachers benefit. It increases the encounter that teachers have with the content, especially because the only encounter some have with content is when we have workshops. If all teachers can go an extra mile like what they do in this ward, they would benefit. So I think this is something we need to explore, put to work in a manner that will benefit everyone.* **(Subject Advisor)**

As one of the teachers pointed out, cluster groups ought to be formally endorsed as programs for inclusive continuous development for teachers. This idea was supported by one of the advisors.

> *We are told by the department that we cannot take teachers out of class. So if teachers can agree to meet on their own outside teaching time as they do in this ward (where teachers meet to discuss content), then they can develop more. For example if teachers can be motivated to do this on a monthly basis, this would really help.* **(Subject Advisor)**

Teacher clusters are still at an experimental phase in South Africa. Whilst these teacher networks or communities of learning (as commonly referred) are used widely in other countries, it remains unclear what they focus on, and how they develop teachers (Lieberman & Grolnick, 1996; Jita & Ndlalane, 2009). Similarly, in South Africa it appears that they remain only a potential and possible strategy to improve teacher learning. From the above accounts however, it is clear that teachers have great potential to capacitate themselves, and expand their knowledge through such learning networks. These results clearly demonstrate eagerness on the part of teachers to affiliate in meaningful learning social networks where expertise on teaching can be shared. The notion of 'learning communities' or 'communities of practice' put forward by Wenger (1998) needs to be supported to improve teachers' continuous learning. Learning Communities as articulated by Wenger (1998) are important places of negotiation, learning, meaning, and identity. The principles of 'Communities of learning' are guided largely by the theory of Social Constructivism. Focusing on social interactions between members of a group, sharing an understanding of a specific circumstance, social constructivists recognize the interplay between the personal and the social aspects for meaningful learning to take place. Teachers in this study clearly articulated the need to use clusters as platforms to negotiate and share knowledge associated with teaching Life Sciences.

As proposed by Vygotsky (1978) social interaction plays a central role in the development of cognition. Vygotsky described how learning is mediated by social interaction, using the 'Zone of Proximal Development' concept. In this concept Vygotsky argued that a high level of cognitive development (the zone of proximal development) is attained when one engages in social learning. Vygotsky theorised that in order to bridge the gap between what the learners know (in this case, teachers) and what they ought to know, they need to utilize the social support system. Learning according to Vygotsky does not occur in isolation, but it is a complex process that occurs as a result of association with significant others. Social learning is also associated with Maslow's 'Belonging needs'. As articulated by Maslow, most people want to belong to a group that will give them a sense of belonging, such as working with colleagues to support each other. Teachers in the study clearly expressed the need to formally affiliate to viable social learning structures where there would be interaction and information-sharing at an advanced level.

Teachers thus need be encouraged and supported to participate maximally so that they can benefit from these social learning networks. A certain degree of personal investment and opening up on the side of teachers is required to make these clusters effective (Jita & Ndlalane, 2009). Hence, Jita and Ndlalane (2009) argue that if clusters or networks are to be considered for large-scale development of teachers, they need not be mandatory as they risk being viewed as a bureaucratic requirement. The same perspective is supported in this study. The idea of using cluster groups or establishing 'Professional Learning Communities' (PLCs) as endorsed by the DBE, for inclusive development of teachers should not be imposed; instead, teachers should be encouraged and supported to participate voluntarily for their own personal growth and development.

5.6.4 Participation in school-based CPD programmes per district.

It is necessary for every school to determine its in-service teacher training needs and plan for the continuing professional development of its teachers. In South Africa, each school has to develop its own School Improvement Plan (SIP) based on individual teachers' needs for development (Professional Growth Plan), and also based on the report on the Whole School Evaluation. Whilst the SIP is used to measure school's progress through a process of ongoing self-evaluation, emphasis is placed on continuous professional development. Hence, professional development of teachers is linked to the evaluation of individual teachers as well as the school evaluation.

Table 5.6.9 below indicates consistent participation in school-based CPD activities across the three districts. About 80% of the teachers indicated some form of school-related professional development.

Table 5.6.9: Participation in School-based Professional Development per district

		Participation in School-based PD		
		No	Yes	Total
District 1	Count	**11**	**39**	**50**
% within District		**22.0%**	**78.0%**	**100.0%**
District 2	Count	**8**	**43**	**51**
% within District		**15.7%**	**84.3%**	**100.0%**
District 3	Count	**8**	**26**	**34**
% within District		**23.5%**	**76.5%**	**100.0%**
Total	Count	**27**	**108**	**135**
% within District		**20.0%**	**80.0%**	**100.0%**

To determine whether these school-related CPD activities had any impact on teachers, items were put on a similar scale used for cluster groups where teachers indicated their perceived level of development. The following graph shows that teachers of Life Sciences from Districts 1 and 2 were benefiting more than those from District 1, with medians of 4 (high development) and 3 (some development) respectively. The level of development in school-based PD approach was overall towards the upper end of the scale. School-based method of teacher development clearly has a role to play in capacitating teachers and should be expanded to all schools so that all teachers benefit.

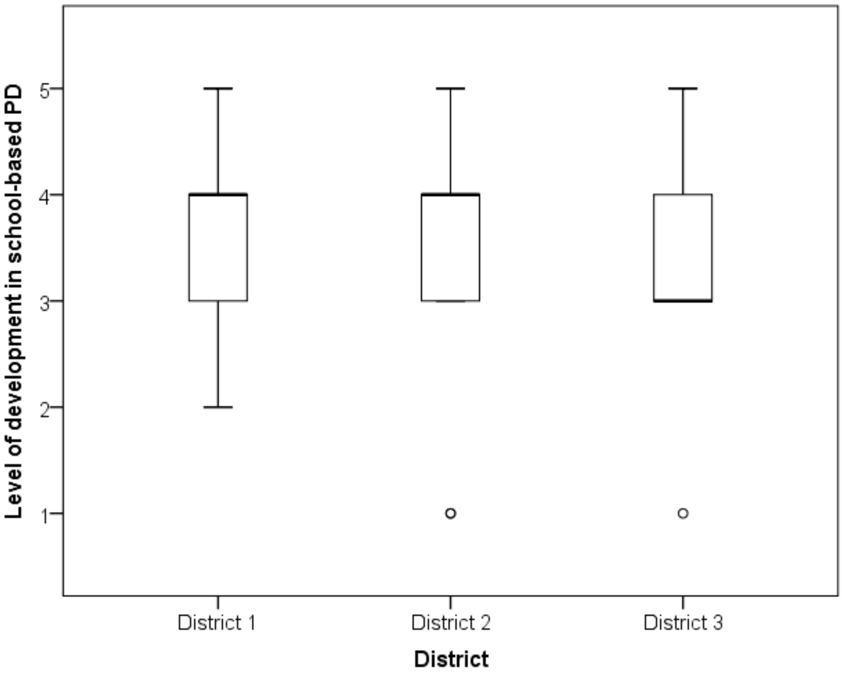


Figure 5.6.2: Life Sciences teachers' perceived level of development through school-based CPD per district.

As outlined in the KZN School Management Team (SMT) handbook, mentoring and support falls under the auspices of the IQMS. The IQMS provides for the establishment of a number of structures including the Development Support Group (DSG). The DSG comprises the teacher, the immediate supervisor and a peer selected by the teacher on the basis of appropriate phase/learning area/subject expertise (KZN DoE, 2003). The main purpose of the DSG is to provide mentoring and support. The DSG is responsible for assisting the teacher to develop his/her Professional Growth Plan (PGP). In addition, through appraisals, HoDs have a responsibility to ensure that teachers, especially inexperienced teachers, are assisted in problem areas through coaching and other forms of in-service training where necessary.

5.6.5 Participation in Mentoring and Coaching

As shown in table 5.6.9, overall, only 53% of Life Sciences teachers indicated that they have mentors or coaches. Table 5.6.10 indicates that there was no variation by district in participation in mentoring or coaching related forms of development. Participation was around 50% for all three districts.

Table 5.6.10: Participation in mentoring and coaching per district

		Participation in Mentoring & Coaching		
		No	Yes	Total
District 1	Count	**25**	**26**	**51**
% within District		**49.0%**	**51.0%**	**100.0%**
District 2	Count	**22**	**29**	**51**
% within District		**43.1%**	**56.9%**	**100.0%**
District 3	Count	**17**	**17**	**34**
% within District		**50.0%**	**50.0%**	**100.0%**
Total	Count	**64**	**72**	**136**
% within District		**47.1%**	**52.9%**	**100.0%**

Whilst participation in mentoring and coaching was far lower than participation in cluster-based and school-based CPD, teachers of Life Sciences perceived the gains from this type of teacher development to be just as great. Figure 5.6.3 below shows that all three districts had a median of 4 indicating high level of development for many of the participating teachers.

As highlighted in the following excerpt, there was a strong desire to have a mentor or a coach as that meant they would have someone to share expertise with them.

> *I think what can help me improve as a Life Sciences educator is getting other teachers who are more experienced that me to help me and guide on other strategies on how to deliver the lessons to learners.***(Teacher)**

It is clear from these findings that senior teachers should be encouraged to take on the role of mentors and coaches for novice teachers. Currently, mentoring and coaching of inexperienced teachers by senior teachers is voluntary. These findings point to the fact that this is potentially a highly valuable system of developing novice teachers, and therefore consideration should be given to making it mandatory to induct novice teachers into the profession through a mentoring relationship with an experienced teacher.

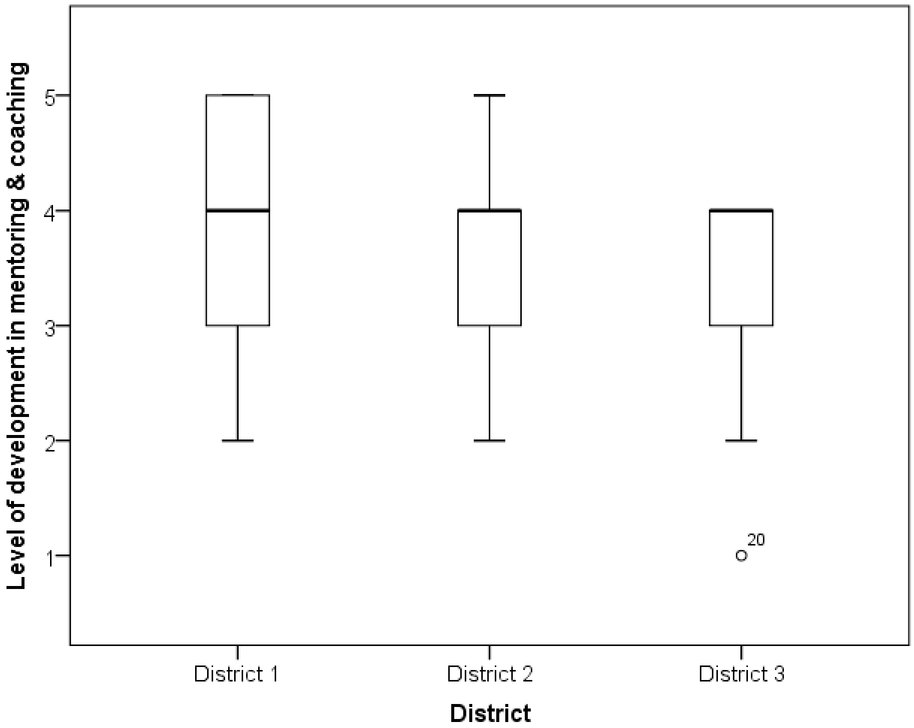


Figure 5.6.3: Life Sciences teachers' perceived level of development through mentoring and coaching per district

5.7 Teachers' motivation for engaging in qualification-driven CPD programmes

Teachers' motivation to engage in professional development is considered to be one of the most influential determinants of teacher change, (Bell & Gilbert, 1994; Smith & Gillespie, 2007) and has a direct influence on teachers' classroom practices (Anderson, 2002; Guskey, 2002). So investigating teachers' personal desire and motivation to enhance their professional lives is an important aspect in teachers' professional development (Grundy & Robison, 2004). In examining Life Sciences teachers' perceived motivation for participating in various qualification-driven upgrade programmes, eight items were put on a five-point Likert scale, where 1 represented 'completely false' and 5 represented 'completely true'. Teachers' responses are summarized in table 5.7.1 below.

Table 5.7.1: Perceived motivation for pursuing qualification-driven CPD programmes in percentage, mean and standard deviation

Items	*Percentage of teachers*						
	SD	***D***	***N***	***A***	***SA***	***Mean***	***Std. dev***
1. Improve subject matter knowledge	0.9	0.0	1.9	8.5	88.7	4.84	0.54
2. To get an accreditation	2.9	1.0	4.9	21.6	69.6	4.54	0.88
3. To get promotion	32.4	9.8	20.6	23.5	13.7	2.76	1.46
4. Received a bursary from Department	73.1	1.1	3.2	3.2	19.4	1.95	1.63
5. To keep up to date with curriculum changes	4.8	1.0	1.0	21.2	72.1	4.55	0.95
6. To take responsibility for my own learning	4.0	2.0	6.9	16.8	70.3	4.48	1.00
7. To upgrade my knowledge and skills	0.0	1.0	0.0	8.7	90.4	4.88	0.40
8. To be a better Life Sciences teacher	1.0	0.0	1.0	6.7	91.3	4.88	0.50

For the majority of the participants, taking up CPD courses was intrinsically driven. As shown in Table 5.7.1 above, teachers' responses to the items on the scale indicated a strong internal desire and motivation to engage in continuous learning. 'Becoming a better teacher' was of high importance for the teachers, with 91% of teachers strongly articulating this. The need to upgrade knowledge and skills for Life Sciences teaching was another influencing factor when teachers register for upgrade programmes, with 90% of the teachers expressing this strongly.

Consistent with the DoE's acknowledgement of teachers' poor subject matter knowledge, 'Improving subject matter knowledge' was another motivating factor for teachers to sign up for higher studies, indicated strongly by about 89% of the teachers. The need to improve content knowledge was further affirmed by teachers when responding to the content-specific needs which are presented in the next section. The need to improve curriculum knowledge was a compelling reason for teachers to take up higher education studies.

About 70% of the teachers claimed that they enrolled for structured CPD programmes because they believed that learning is part of their professional responsibility.

The variation (*standard deviation =1.46*) in teachers' responses to item 3 'To get promotion', suggested that whilst some of the teachers may have been seeking promotion following completion of qualification upgrade programmes, others were not. Similarly, teachers were not driven by any monetary incentives when they registered to higher institutions because only a handful of teachers (about 20%) were recipients of the subsidy from the Department of Education.

It was also evident from teachers' responses that there was a strong requirement for many of them to get certification. About 70% of the teachers acknowledged strongly that that they needed accreditation, and that teacher unions were playing an important role in motivating teachers to get qualifications.

> *Teacher unions usually advise teachers that are not qualified to register so that they are not taken out of the system. As few of these teachers are really intrinsically motivated and usually take long to complete their studies, just as long as they can show that they are registered and so that they do not have to leave the system.* **(Subject Advisor)**

Whilst Subject Advisors had no direct mandate in getting teachers to register for qualification programmes, as seen from the extract below, some of them were also taking the initiative to encourage teachers to improve their knowledge and skills.

> *Although we don't really have much influence in getting teachers to engage in continuous professional development such as to register with institutions, but we show them the good side of studying. As Subject Advisors we tell teachers about the importance of having knowledge first. Teachers need to register for themselves because one of the seven roles of the educator is that they must be a lifelong learner. We can easily support someone who is also supporting themselves.* **(Subject Advisor)**

Whilst some of the Life Sciences teachers were driven by external forces to register for higher studies, the bulk of teachers had an intrinsic determination to advance their knowledge and skills. With the majority of the teachers indicating the desire to become better teachers, an inference may be drawn that these teachers have reached Maslow's level of 'esteem needs'. As articulated by Maslow, 'esteem needs' develop as a result of people seeking to improve their self-confidence. As stated by Wlodkowski (1999), it is the deep social responsibility, i.e. need for competence and being effective at what one does that drives learning among adults. Aspirations of becoming 'better teachers' thus clearly suggested teachers' desire to improve their confidence and competence in teaching the new curriculum. This also implied that majority of the teachers have reached the 'self-actualisation' level of

Maslow hierarchy, suggesting a sense of autonomy and self-directedness on the part of teachers. The South African Council for Educators (SACE) also has a mandate to support the system in developing autonomous and confident teachers by way of allocating Professional Development points for any self-initiated professional development, school-initiated and externally initiated professional development activities. At the time of writing, principals and deputy principals as the first cohort were going through the CPTD orientation and sign-up process to start earning professional development points. The second cohort comprising teachers is to follow at a later stage. Having teachers that exhibit an intrinsic impetus to engage in continuous professional development, coupled with incentives to take up CDP courses will go a long way in ensuring the development of an autonomous teaching force.

5.8 Non-participation in qualification-driven professional development programmes

As discussed in chapter 2, KwaZulu-Natal province had the highest number of unqualified teachers at the time of writing (2013). It was thus fitting to interrogate reasons for non-participation in qualification-based CPD programmes. Also looked into, were possible non-participation levels within each district.

5.8.1 Non-participation by district

Table 5.8.1 below shows that an overall 17% of the respondents had not participated in any form of upgrade programmes. From the results, District 2 accounted for 46% of all the teachers in the study that were neither engaged nor had completed any form of upgrade programme. Districts 1 and 3 contributed 27% equally. Whilst a Chi-square test indicated no significant difference in teachers' participation in CPD programmes by district (p = 0.138), reasons for non-participation were nonetheless explored.

Table 5.8.1: Non-participation in qualification-driven CPD programs in three KZN districts

			District			
			District 1	District 2	District 3	Total
Registered/ completed a programme	**No**	**Count**	7	12	7	26
		% within registered/ completed a programme	26.9%	46.2%	26.9%	100.0%
		% of Total	4.6%	8.2%	4.6%	17.4%
	Yes	Count	53	41	32	123
		% within registered/ completed a programme	43.1%	31.7%	25.2%	100.0%
		% of Total	34.9%	25.7%	20.4%	80.9%
Total		Count	60	53	39	152
		% within registered/ completed a programme	39.5%	34.9%	25.7%	100.0%
		% of Total	39.5%	34.9%	25.7%	100.0%

5.8.2 Reasons for non-participation in qualification CPD programmes

For those teachers who specified that they were neither registered nor had completed any upgrade studies, four items were put on a 5-point Likert scale (strongly disagree = 1 to strongly agree =5) to establish their reasons for such. As shown in the table below, possible barriers ranged from lack of financial support to not being aware of available upgrade opportunities. For analysis purposes, the categories ‘strongly agree’ and ‘agree’ were collapsed into a single category of ‘agree’ and ‘strongly disagree’ and ‘disagree’ were collapsed into a single category of ‘disagree’. The neutral category remained unchanged.

Table 5.8.2: Reasons for non-participation in qualification CPD programmes

	Percentage of teachers		
Items	***Agree***	***Neutral***	***Disagree***
1. I do not have financial means to study further.	67.2	8.2	24.6
2. I have too much work at school and so I can’t make time to study.	41.7	13.3	45.0
3. The universities are too far and inaccessible.	32.8	8.2	59.0
4. I am not aware of options available for me to improve my qualifications.	20.3	10.2	69.5

The results in table 5.8.2 shows that lack of financial support was the highest contributor to non-participation in qualification CPD programmes by teachers, with 67% of the teachers indicating this. There was no agreement on workload as a constraint in enrolling for qualification CPD programmes, with virtually the same percentage of teachers responding either affirmatively (42%) or negatively to the statement (45%). These responses indicated that workloads for individual teachers were not necessarily equivalent, therefore suggesting that teachers were affected differently.

A fairly large percentage (59%) of teachers believed that universities were within reach and did not see this as an obstacle to attaining further qualifications. So, only a third of the teachers attributed their non-enrolment for CPD programmes to inaccessibility of higher learning institutions. Similarly, the majority of the teachers (70%) appeared to be aware of upgrade opportunities, with a mere 20% citing lack of information as a holdup for signing up for qualification upgrade programme.

In a different set of items seeking explanations for non-engagement in qualification-driven CPD activities, teachers were asked whether they believed that they were qualified and competent enough, or had acquired adequate teaching or it was mere lack of motivation that kept them from enrolling for further studies. Teachers' responses are presented in the table below.

Table 5.8.3: Reasons for non-participation in qualification CPD programmes showing percentage, mean and standard deviation

	Percentage		
Items	***Agree***	***Neutral***	***Disagree***
1. I have acquired enough teaching experience.	20.9	8.1	71.0
2. I simply have no motivation to study further.	11.3	8.1	80.6
3. I am competent in content knowledge and therefore do not need to study further.	8.3	5.0	86.7
4. I believe that I am qualified enough and thus do not need to engage in any further studies.	4.9	4.9	90.2

The results in the table above clearly show that a large proportion of the teachers neither perceived themselves to be highly qualified (90%) nor did they believe that they were highly competent in content knowledge (87%) to not engage in further studies. By the same token, a significant fraction of the teachers neither believed that they had acquired adequate teaching experience (71%) nor did they lack motivation (80.7%) to take up qualification programmes. From these results it became evident that the key factor that prevented teachers the most from enrolling in qualification CPD programmes was lack of financial support, rather than motivation to study further.

A further analysis was performed to determine how lack of finance in particular, as a perceived barrier for non-participation in qualification PD programmes affected teachers differently in different districts. A radar chart below illustrates how lack of finance in particular affected teachers from each district. A point closer to the centre on the chart indicates a less significant factor, whilst a point near the edge represents a more significant factor.

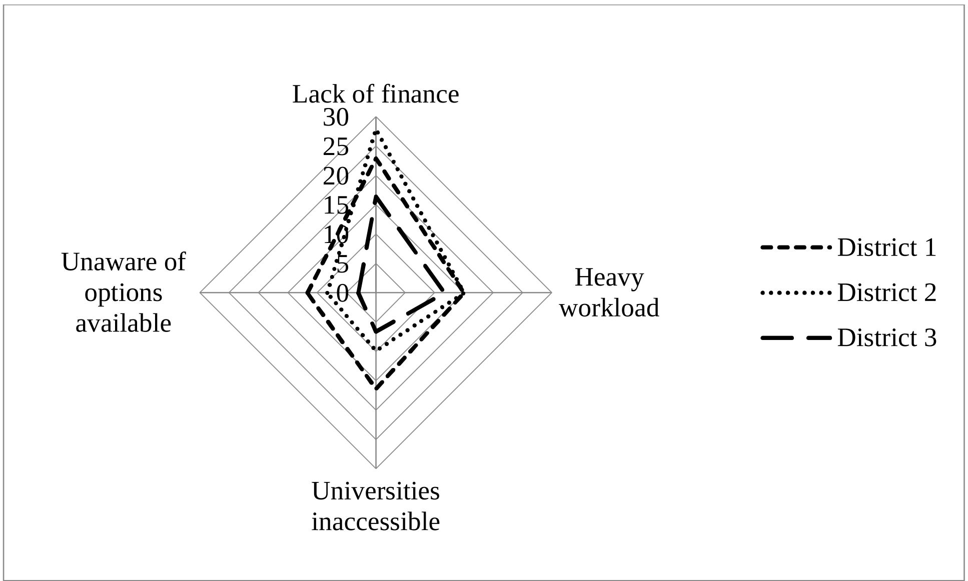


Figure 5.8.1: Lack of finance as a barrier for participation in CPD programmes per district

Teachers from all three districts were affected mostly by lack of finance, albeit with a difference of about 5% between each district. As noted by the Subject Advisor, it is largely the teachers from rural districts that mostly require financial support.

> *There are a lot of teachers who could benefit from department subsidies, especially those from deep rural districts. To me if these teachers could be motivated to take up CPD programmes and be assisted financially by the department, really we would see change. Universities are the centre of knowledge so if teachers take up these courses they would be empowered. But that needs to be done on a wider scale.* **(Subject Advisor)**

Generally, during any curriculum change, teachers feel externally propelled into learning. Whilst learning needs to be self-endorsed, extrinsic factors such as the lack of financial support may hinder teachers' motivation to register for higher studies. There has to a balance between intrinsic and extrinsic factors which motivate teachers to learn (Smith et al., 2003). Individual teachers that develop internal motivation to engage in continuous learning need support from relevant authorities to ensure that external factors do not interfere with teachers' enthusiasm to learn. Therefore targeting teachers eligible for upgrading through higher education studies and providing them with a subsidy will go a long way in ensuring that the pool of South African teaching corps engaged in higher learning activities is increased. Research shows that people learn best when they are self-regulated (Knowles, 1998; Bell & Gilbert, 1994; Merriam, 2001; Thompson, 2001); therefore subsidies have to be accompanied by intrinsic willingness to learn on the part of teachers. Through informal conversations with the UKZN ACE Biological Sciences students, it became evident that despite many teachers not having received the DoE bursaries, they remained highly motivated. It is this calibre of teachers that need to be targeted for further development. As pointed out by many scholars, a more learned teaching force benefits not only the teachers but brings about improved learner outcomes (Fullan, 1991; Guskey, 2000; Borko, 2004).

The provincial departments also need to pay attention to possible discrepancies when bursaries are provided for teachers to enrol for higher education studies. Teachers from rural districts are undoubtedly the neediest because of their low levels of qualification and would benefit from intentional targeting for qualification upgrading by way of providing subsidies. It is worth noting here that during data collection efforts were made by the KZN DoE to intensify registration of teachers for upgrade programmes by way of providing bursaries. A circular on various subsidies was released, inviting teachers to submit applications so that they could register for qualification programmes. The channels of communication when these circulars were released were unclear. For example, when the call came out, it appeared that subject advisors were not necessarily involved or even informed. It is important to ensure that such crucial information reaches the targeted audience especially teachers in rural districts. Proper communication with service providers is also critical in this regard. Because the timing of the release of the circular was not negotiated with the affected providers, serious delays have been experienced in universities receiving payment of bursaries from the DoE on time.

5.9 Life Sciences teachers' professional development needs

For teachers' professional development to be effective, it must commence with an understanding of teachers' needs, to specify explicitly what form of training is required (Moeini, 2008). A needs analysis was conducted with teachers of Life Sciences to identify their needs for development in subject matter knowledge and the associated pedagogical knowledge and skills.

5.9.1 Content needs

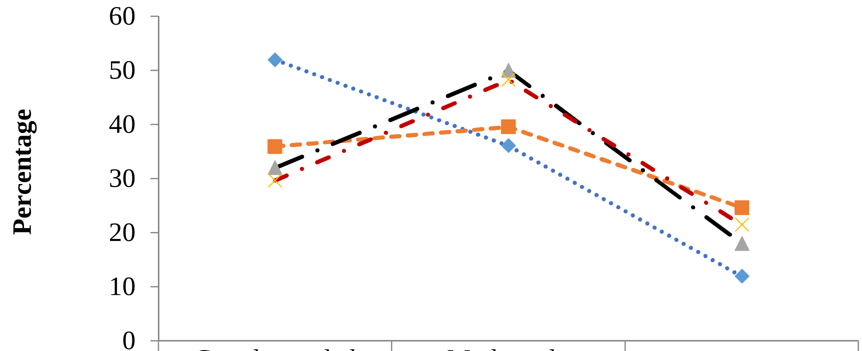
Life Sciences teachers' content needs were organised using the CAPS document, which groups content topics into four Knowledge Strands namely: Life at molecular, cellular, and tissue level; Life processes in plants and animals; Environmental studies; Diversity, change and continuity. Table 5.9.1 shows the main topics within these strands as well as concept and content progression by Grade.

Table 5.9.1: Life Sciences topics showing concept and content progression by Grade

Strands	Life at molecular, cellular, and tissue level	Life processes in plants and animals	Diversity, change and continuity	Environmental studies
Grade 10	• Chemistry of life • Cell – unit of life • Cell division (mitosis) • Plant and animal tissues	• Support and transport in plants • Support and transport systems in animals	• Biodiversity and classification • History of life on Earth	• Biosphere to ecosystems
Grade 11		• Energy transformation to sustain life • Animal nutrition • Energy transformations: respiration • Gas exchange • Excretion	• Biodiversity and classification of microorganisms • Biodiversity in plants • Reproduction in plants • Biodiversity in animals	• Population ecology • Human impact on environment
Grade 12	• DNA code of life • RNA and protein synthesis • Meiosis • Genetics	• Reproduction in vertebrates • Human reproduction • Nervous system • Senses • Endocrine system • Homeostasis	• Darwinism and Natural Selection • Human evolution	• Human impact on environment – current Grade 11

Source: Department of Education: FET CAPS (Life Sciences) from www.education.gov.za Accessed July, 2013

To identify teachers’ perceived professional development needs, a Likert scale with 3 categories (greatly needed = 3; moderately needed = 2 and not needed = 1) was used. The following graphic representation provides a summary of teachers’ needs for development in content/subject matter knowledge. For purposes of analysis, if teachers’ responses for any category were more than 50%, that particular category was considered the strongest.



	Greatly needed (%)	Moderately needed (%)	Not needed (%)
Diversity, change and continuity	52	36	12
Life at molecular, cellular and tissue level	36	40	25
Environmental studies	32	50	18
Life processes in plants and animals	30	48	21

Level of needs

Figure 5.9.1: Life Sciences teachers’ level of needs for development in subject matter *(n = 147)*

As illustrated in figure 5.8.1, support in content knowledge was mostly needed for the Diversity, change and continuity strand. Just over half (52%) of the respondents indicated a great need for development in this knowledge strand. Over a third (36%) of the teachers expressed a moderate need. The results displayed in figure 5.9.1 showed that overall, the majority of the Life Sciences teachers moderately needed development for the remaining three strands. About one-third (36%, 32% and 30%) of the teachers required great support for Life at molecular, cellular and tissue level; Life processes in plants and animals; and Environmental studies knowledge strands respectively. About half of the teachers indicated moderate needs (40%, 50% and 48% respectively). The results also show that in the area of most need, i.e. Diversity, change and continuity, a mere 12% of the participating teachers were satisfied with their subject matter knowledge. Furthermore, only 25%, 18% and 21% of the teachers did not require any form of development in the three other knowledge strands. These results clearly indicate lack of confidence in all the topics.

a. ***Percentage need for development in Knowledge Strand 1- Life at molecular, cellular and tissue level***

There was a greater demand for development in 'Genetics and inheritance' in comparison with other topics in this strand, as 58% of the teachers indicated a great need, whilst only 27% specified a moderate need. Only 15% said they did not need help with this topic. The total need for development in this topic was expressed by 85%, further suggesting an overwhelming necessity to support teachers in this area. Genetics topics introduced over two decades ago formed part of the previous Biology syllabus. Whilst there have been some inclusions of new information, the greater part of the genetics content featured in the NCS has not deviated from the old Biology syllabus. Teachers' needs for development in this area can thus not be influenced the change in the curriculum.

Whilst the overall need for development in the remaining topics was still high, hovering between upper sixty and eighty percent, a larger percentage of the teachers specified a rather moderate need. Support was least needed for topics such as Cell division and Cell - the basic units of life, with about a third of the teachers indicating competence in knowledge of these topics.

Table 5.9.2. Percentage need for development in Knowledge Strand 1

Topic	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Genetics and inheritance	57.9	27.1	85.0	15.0
2. RNA and protein synthesis	39.9	40.6	80.5	19.5
3. DNA: the code of life	37.9	41.4	79.3	20.7
4. The chemistry of life	35.6	42.1	77.7	23.3
5. Plant and animal tissues	33.8	48.1	81.9	18.0
6. Meiosis	29.3	45.7	75.0	25.0
7. Cell division - mitosis	28.6	39.8	68.4	31.6
8. Cell: the basic units of life	26.3	41.4	67.7	32.3

Many of the teachers viewed Genetics as one of the ‘problematic areas’ to teach. Comments such as the following were made by the teachers:

> *Some of the more scientific in nature knowledge areas are Genetics and Evolution. These areas are most difficult and problematic to teach. I will be glad to receive assistance on those areas.* **(Teacher)**

Other teachers specified areas within the Genetics topics.

> *I need development on presenting certain topics like Polyploidy. I also need support on pedigree diagrams including examples of activities that I can give to learners for practice.* **(Teacher)**

Subject Advisors were also cognisant of the challenges associated with teaching Genetics which they claimed was demonstrated by poor learner performance in Grade 12 examinations. Because Grade 12 examinations are moderated nationally, the problem of teaching Genetics is across the board, seemingly affecting many teachers of Life Sciences nationally. After moderation of Grade 12 end-year examinations, the DBE releases diagnostic reports to identify topics that were poorly answered by learners in that exam, and the possible reasons for poor responses. These reasons usually range from ‘concepts that are incorrectly presented to learners and hence wrongly responded to in the examination’, to ‘aspects of the curriculum that are not effectively presented to candidates, thus leaving learners inadequately prepared’ (DBE, 2011a). Both the 2011 and 2012 diagnostic reports reported poor learner performance in the Genetics section, clearly demonstrating that the topic remains a challenge to both the teachers and the learners. In these reports teachers are usually advised to ‘broaden their knowledge and practical experience’ in this topic. Advisors in particular, are identified as central to supporting teachers in this content area. Subject advisors are expected to design workshops to address inadequacies in the content knowledge related to topics such as genetics (DBE, 2013c).

Advisors were fully conscious of their role in supporting teachers, particularly in the areas identified through national examinations.

> *The examination reports tell us exactly where the learners have performed poorly. For example in Life Sciences learners fail Evolution and Genetics. This shows that learners do not have grasp of those topics. So this means that teachers themselves*

have problems in those areas. When we support teachers we therefore focus on these topics. **(Subject Advisor)**

Nonetheless, as pointed out earlier by the advisors, the level of support that they provide is not very effective, since contact with teachers is insufficient to provide significant improvement on the part of teachers. The problem of poor learner performance in Genetics therefore persists.

b. *Percentage need for development in Knowledge Strand 2- Life processes in plants and animals*

Whilst the overall need (total % need) for topics in this strand was articulated by between 75 and 85% of teachers, the need was by far, moderate, and does not vary much across the topics. Teachers needed development the most in 'Energy transformation to sustain life (which refers to photosynthesis)', (overall 85% of teachers conveying this need). The least needed topic for development was 'Gaseous exchange', but even so, only 25% of teachers indicated that this topic was not needed.

Table 5.9.3: Percentage need for development in Knowledge Strand 2

Topic	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Energy transformations to sustain life	39.4	44.7	84.7	15.9
2. Homeostasis in humans	31.6	52.1	83.7	16.3
3. Human endocrine system	30.7	52.9	83.6	16.4
4. Responding to the environment: plants	29.5	51.8	81.3	18.7
5. Responding to the environment: humans	31.4	49.3	80.7	19.3
6. Support and transport systems in plants and animals	28.4	49.3	77.7	22.3
7. Animal nutrition	26.0	54.2	80.2	19.8
8. Excretion in humans	27.7	45.4	73.1	26.9
9. Human reproduction	25.7	50.0	75.7	24.3
10. Gaseous exchange	24.6	50.8	75.4	24.6

c. *Percentage need for development in Knowledge Strand 3 - Environmental studies*

Teachers' need for development in this Knowledge Strand was also moderate. Whilst the overall need for development in this strand was articulated by a large percentage (about 80%)

of teachers, about half of the teachers required only moderate support. Only about a third of the teachers expressed a great need to strengthen their knowledge in this area, but only about 20% of teachers were sufficiently confident to say they did not need support in this area.

Table 5.9.4: Percentage need for development in Knowledge Strand 3

Topic	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Population ecology	34.6	49.2	83.8	16.2
2. Biosphere to ecosystems	32.1	47.0	79.1	20.9
3. Human impact on the environment	31.5	46.9	78.4	21.5

d. *Percentage need for development in Knowledge Strand 4 – Diversity, change and continuity*

Teachers' perceived needs for this knowledge strand were much more pronounced in comparison with all the other strands. As illustrated in the table below, support was greatly needed for three topics, viz.: Human evolution, Evolution by natural selection and History of Life on Earth. Nearly 70% of the teachers expressed a great need to improve their knowledge in these topics.

Table 5.9.5: Percentage need for development in Knowledge Strand 4

Topic	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Human evolution	68.6	22.9	91.5	8.6
2. Darwinism and natural selection	67.9	21.4	89.3	10.7
3. History of life on Earth	66.9	23.3	90.2	9.8
4. Biodiversity and classification	46.3	38.1	84.4	15.7
5. Biodiversity in animals	43.4	44.2	87.6	12.4
6. Biodiversity and classification of microorganisms	42.7	45.0	87.7	12.2
7. Biodiversity of plants	42.3	46.2	88.5	11.5
8. Reproduction in plants	37.7	47.7	85.4	14.6

Whilst Evolution had been in the Life Sciences curriculum for at least five years at the time of data collection, it was evident from teachers' accounts that the topic remained relatively new for many of them.

> *More workshops must be organised to deal with new content as a whole, i.e. Natural Selection, Speciation, History of Life, Out of Africa hypothesis, the whole Biodiversity and Classification.* **(Teacher)**

> *History of Life must be targeted for training because it is new to us.* **(Teacher)**

It was also quite apparent from teachers' comments that Evolution placed a high premium on higher-order thinking skills, demanding in-depth understanding on the part of teachers.

> *Evolution is a topic that needs more attention since it is abstract even in the case of us educators. We need training on these new aspects of the curriculum, especially Evolution, Natural selection.* **(Teacher)**

> *This new chapter of Evolution in Life Sciences is highly failed by our learners, because we as the educators have problems understanding it. If training would focus on this chapter, that would develop us to teach better in Life Sciences.* **(Teacher)**

Advisors themselves were mindful of teachers' challenges in teaching this knowledge area and the need to capacitate them.

> *In Life Sciences we need to focus first and foremost on content, looking at specific difficult topics such as Evolution and Genetics. We now know that the entire Life Sciences curriculum is centred around Evolution, so interventions are really needed to drive this knowledge.* **(Subject Advisor)**

The Advisor's comment clearly indicated awareness of the implicit yet known fact that Evolution is Life Science's/Biology's core theme that ties together all the other themes. Because of this framework some concepts of Evolution (History of Life on Earth) that were previously taught only in Grade 12 were moved to Grade 10 in the New Content Framework curriculum implemented in 2009 to allow gradual progression of content to Grade 12. These topics were also kept in Grade 10 in the CAPS curriculum. Teachers who had taught the New Content Framework would thus have had exposure to this content. The interviewed Subject Advisors however felt that when this content was reshuffled, teachers were not adequately supported to effectively implement the changes, both for the New Content Framework and for CAPS.

Whilst it is expected that some teachers would have required re-skilling in Evolution, having the majority of the teachers expressing such a strong need for development, once again suggests that teachers are not taking responsibility for their own learning. Teaching is a lifelong learning profession, thus, emphasis has to be placed on encouraging self-regulated learning (Day & Sachs, 2004; Friedman & Phillips, 2004; Fraser et al., 2007) on the part of teachers rather encourage passive recipients of training. In line with fostering a constructivist approach to teacher learning, there is a need to move away from focusing only at the end result of teaching. As pointed out by one of the advisors the development of teachers has to be all-encompassing rather than focus largely on Grade 12 outcomes.

> *The problem is that the South African education system is driven by examination results. We focus too much on Grade 12 results and we forget to pay attention to what is happening down in the lower grades. For example, in Life Sciences there's much concentration on Grade 12 Evolution, yet Grade 10 & 11 is supposed to get similar attention because that's where you introduce difficult concepts. All the resources are concentrated on Grade 12. I think we need to look at a bigger picture and start paying attention to other grades. We need to intervene in all grades, not just focus on Grade 12.* **(Subject Advisor)**

Table 5.9.6 below (showing all topics ranked by need), illustrates that teachers' greatest need for development is Diversity, change and continuity (Knowledge Strand 4) topics. All eight topics in this strand featured in the top ten most needed areas for support. Genetics ranked fourth in the ten most sought content topics. The mean values for the first ten topics were high, ranging between 2.60 and 2.31 based on 3-point Likert scale. Standard deviations for all these items were ranged between 0.6 and 0.8, showing a narrow spread of ranking around mean values.

Table 5.9.6: Life Sciences teachers' ranked needs showing topic, mean , standard deviation and knowledge strand *(n = 147)*

Rank		Mean	Std. dev.	Knowledge strand
1.	Human evolution	2.60	0.644	4
2.	History of life on Earth	2.57	0.666	4
3.	Evolution by natural selection	2.57	0.680	4
4.	Genetics and inheritance	2.43	0.741	1
5.	Biodiversity in animals	2.36	0.898	4
6.	Biodiversity of plants	2.31	0.669	4
7.	Biodiversity and classification	2.31	0.728	4
8.	Biodiversity and classification of microorganisms	2.31	0.678	4
9.	Energy transformations to sustain life	2.23	0.708	2
10.	Reproduction in plants	2.23	0.688	4
11.	Homeostasis in humans	2.19	0.667	3
12.	Population ecology	2.18	0.691	3
13.	DNA: the code of life	2.17	0.749	1
14.	Plant and animal tissues	2.16	0.705	2
15.	Human endocrine system	2.14	0.674	3
16.	Responding to the environment: humans	2.12	0.704	2
17.	The chemistry of life	2.11	0.755	1
18.	Biosphere and ecosystems	2.11	0.722	3
19.	Responding to the environment: plants	2.11	0.688	3
20.	Human impact on the environment	2.10	0.724	3
21.	Reproduction in vertebrates	2.08	0.720	2
22.	Animal nutrition	2.06	0.677	2
23.	Support and transport systems in plants and animals	2.06	0.713	2
24.	Meiosis	2.04	0.738	1
25.	Human reproduction	2.01	0.710	2
26.	Excretion in humans	2.01	0.742	2
27.	Gaseous exchange	2.00	0.704	2
28.	Cell division - mitosis	1.97	0.778	1
29.	Cells: the basic units of life	1.94	0.766	1

A non-parametric Kruskal-Wallis test was performed to determine if there was a difference in teachers' ranked content needs per district. The test revealed a non-significant difference in teachers' needs across the three participating districts *($p = 0.257$)*.

Table 5.9.7 below shows chi square test results between teachers' content needs and certain demographic variables. A cross tab of these variables revealed that teachers' qualification was the most influential factor.

Table 5.9.7 Chi Square measures of association between teachers' content needs and demographic variables

Knowledge strands and topics	Variable	X^2	*p*
1. Life at the molecular, cellular and tissue level			
1. The chemistry of life	***No significance***		
2. Cells: the basic units of life	***No significance***		
3. Cell division - mitosis	***No significance***		
4. DNA: the code of life	*Qualification*	**13.729**	**0.024**
5. Meiosis	***No significance***		
6. Genetics and inheritance	***No significance***		
2. Life processes in plants and animals			
1. Plant and animal tissues	***No significance***		
2. Support and transport systems in plants and animals	*Qualification*	**12.661**	**0.036**
3. Energy transformations to sustain life	***No significance***		
4. Animal nutrition	*Qualification*	**14.969**	**0.014**
5. Gaseous exchange	***No significance***		
6. Excretion in humans	***No significance***		
7. Reproduction in vertebrates	***No significance***		
8. Human reproduction	***No significance***		
9. Responding to the environment: humans	***No significance***		
10. Human endocrine system	***No significance***		
11. Homeostasis in humans	***No significance***		
12. Responding to the environment: plants	*Qualification*	***15.319***	***0.012***
3. Environmental studies			
1. Biosphere and ecosystems	***No significance***		
2. Population ecology	***No significance***		
3. Human impact on the environment	***No significance***		
4. Diversity, change and continuity			
1. Biodiversity and classification	***No significance***		
2. Biodiversity and classification of microorganisms	***No significance***		
3. Biodiversity of plants	*Qualification*	**12.481**	**0.037**
4. Reproduction in plants	***No significance***		
5. Biodiversity in animals	***No significance***		
6. History of life on Earth	*Qualification*	**13.738**	**0.020**
7. Evolution by natural selection	*Qualification*	**12.756**	**0.031**
8. Human evolution	*Qualification*	**20.113**	**0.001**

Only one item showed significance in Knowledge Strand 1. The need for support in 'DNA: the code of life' was linked to teachers' qualification levels. All teachers with no formal qualification (i.e. with only up to Standard 10) indicated a great need for support in this area, whilst 20% of the overall 37% of teachers that indicated a great need for this item were those with up to a Diploma. The relationship between these variables was significant at $p = 0.024$. The results therefore suggested that development in this area should target novice teachers as well as teachers without specialisation in Life Sciences in their degree studies. This clearly suggests that a comprehensive needs analysis ought to be conducted nationwide, allowing for detailed assessment of teachers' needs.

Whilst the need for advancement in 'Genetics and inheritance' was expressed by a large percentage of teachers, no specific variables were associated with this need. This could have suggested that teachers in general were challenged by this topic, regardless of qualification level, teaching experience, and so forth. The Genetics topic indeed has long been in the South African Life Science/Biology curriculum, however, challenges in teaching the topic still persist.

In the 'Life processes in plants and animals' knowledge strand, only two topics yielded a statistically significant relationship with the demographic variables. The topic: Support and transport systems in plants and animals', was needed greatly by teachers with no formal qualification and those with a Diploma. Although the results yielded a significant relationship at $p = 0.036$, there was an error in the listing of topics on support and transport systems. The topics should have been listed separately as 'Support and transport systems in plants' and 'Support and transport systems in animals'. So the results presented here do not explicitly indicate which of these two topics were most needed. Nonetheless, looking at the UKZN ACE results (table 5.6.3) where the two topics were separated, there is an indication that more development needs would have been required for 'Support and transport systems in plants'. The need for development in the topic 'human endocrine system' was expressed largely by novice teachers. The difference in the need between the teachers with different teaching experience was significant at $p = 0.009$. Also significant in the strand was the relationship between teachers' need for development in the topic 'responding to the environment: plants' and their formal qualifications at $p = 0.012$. To the extent where formal qualification was a significant variable, teachers with up to Diploma level expressed more of this need. A total of 22% of the 29% that indicated this need were indeed those with no formal qualification together with the Diploma holders. Yet again here, teachers with a B Ed Honours degree pronounced a greater need than the teachers with a Bachelors' degree. These findings reinforce the point discussed above that the B Ed Honours degree has a general purpose, and does not necessarily address content-specific needs.

None of the topics in Knowledge Strand 3 (Environmental Sciences) yielded any significance.

A number of topics in the 'Diversity, change and continuity of life' strand, showed significant association mainly with teachers' qualifications. Of the 41% that greatly needed support in 'Biodiversity of plants' about 30% of the teachers had up to a Diploma. A higher percentage (8%) of postgrads expressed a great need in comparison with only half (4%) of those with a Bachelors' degree. The difference was significant (p = 0.037). Similarly, teachers' needs for development in 'history of life on Earth' were associated with their qualifications. Of the 66 % of teachers that greatly required support, about 47% had up to Diploma. About 10% of each of the Bachelors and Postgrad degree holders articulated a great need. The association was significant (p = 0.020). A similar trend was observed in the last two topics in this strand. Greater need for development was indicated more by teachers with up to a Diploma, followed by Honours then Bachelors' degree holders. All the teachers with no formal qualification greatly needed development in 'evolution by natural selection' as well as Human evolution. About 76% and 80% of the teachers with a Diploma indicated a great need for development in the two topics respectively, whilst only 53% and 43% of the teachers with Bachelor's and Honour's degree respectively expressed a need for support in these two topics. The needs of teachers were significantly different for both topics (p = 0.031 for Evolution by natural selection; and p = 0.001 for Human evolution).

Table 5.9.8 presents a regression analysis performed to determine possible associations between certain groups of demographic variables and teachers' development needs with regard to content knowledge. Content needs were aggregated to obtain a score. Different combinations of demographic variables were then computed to determine their influence on teachers' overall content needs. Table 5.9.8 shows a model containing two independent variables (formal qualifications, highest academic level in Biological Sciences). The overall model predicted 7.1 % of Life Sciences teachers' content needs, which was revealed to be statistically significant, $p<0.05$. An examination of individual variables showed that teachers' formal qualification was the best predictor of their content needs. For example, the needs of the teachers with a Bachelors' degree and Honours were lower than the needs of the teachers with only up to a Diploma qualification (Beta = -0.205, $p<0.05$). Other models containing a different combination of variables (such as teaching experience, formal qualifications and years of study in Biology) did not yield any significant results, indicating that the combination of variables did not influence teachers' needs for development in subject matter knowledge.

Table 5.9.8 Logistic regression predicting teachers' content needs

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Formal_qual			6.440	3	.092	
	Formal_qual(1)	-16.919	14306.530	.000	1	.999	.000
	Formal_qual(2)	-20.311	14306.530	.000	1	.999	.000
	Formal_qual(3)	**-3.319**	**1.594**	**4.333**	**1**	**.037**	**.036**
	Highest_level			7.039	4	.134	
	Highest_level(1)	-1.280	1.790	.512	1	.474	.278
	Highest_level(2)	1.528	1.513	1.021	1	.312	4.610
	Highest_level(3)	**2.650**	**1.241**	**4.559**	**1**	**.033**	**14.159**
	Highest_level(4)	-.430	2.398	.032	1	.858	.651
	Constant	17.755	14306.530	.000	1	.999	51404901.907

a. Variable(s) entered on step 1: Formal_qual, Highest_academic level.

Data presented above suggests that majority of Life Sciences teachers have a relatively low perception of their command of content knowledge. If the content needs presented here are an indication of Life Sciences teachers' level of subject matter knowledge, a complete re-training of teachers would be needed. However, this study did not measure teachers' actual levels of content knowledge and therefore the results are taken to suggest a possible lack of confidence to teach the content. This lack of confidence to teach Life Sciences content may be attributed to a number of reasons. Firstly, when the OBE curriculum was introduced in South Africa, there were problems with the content that was left largely unspecified (Malcolm, 2001; Chisholm et al., 2005). For example in Life Sciences, the curriculum did not contain the concepts necessary to lay a proper foundation for the understanding of Darwinian evolution, and did not provide teachers with strategies to deal with such conceptual gaps (Dempster & Hugo, 2006). It is thus likely that some of the teachers would have suffered as a result of the dilution of discipline-specific subject matter which was done in exchange for the teaching of skills and everyday knowledge. As expounded by Rogan (2004), limited content background may lead to teachers' over-reliance on transmission methods of teaching and superficial use of content, which has occurred in South Africa. Therefore teachers' lack of confidence in teaching may be partly attributed to this challenge.

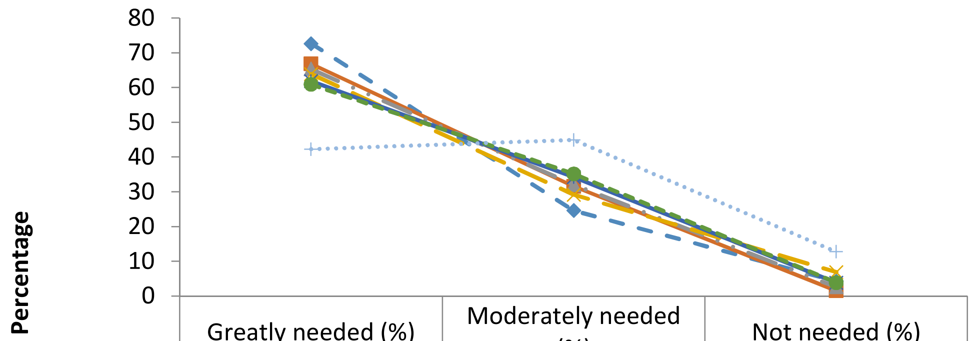
Furthermore, teachers of Life Sciences have not been able to properly adjust to one curriculum. As indicated in Chapter 2, following the first implementation of the National Curriculum Statement at Grade 10 in 2006, the Life Sciences curriculum was revised leading to the formation of the New Content Framework, which was implemented in 2009. Before teachers could adjust to the NCF, it was reviewed again resulting in the release of CAPS and its implementation in 2012. So, Life Sciences teachers have been subjected to three curriculum changes since the implementation of the NCS in 2006. Such instability may have resulted in teachers' diminished levels of confidence to teach the curriculum.

Research shows that confidence in subject matter knowledge does increase confidence to teach (Kind, 2009; Ingvarson, Meiers, & Beavis, 2005). Therefore it is imperative that teachers of Life Sciences strive to improve their subject matter knowledge where it is seen to be lacking. As argued by Bandura (1997), the most powerful source of self-efficacy is personal mastery and mediated experience. To improve their self-efficacy, teachers of Life Sciences need to engage in self-directed lifelong learning. When the teachers in this study were asked to indicate how and where they generally learn 'new information' or information relating to 'difficult topics', a large majority (about 70%) said they relied largely on training workshops and qualification studies. About 35% of the teachers admitted that they rarely engage in 'own reading'. A picture presented here is that of powerless recipients of support who are not self-regulated learners. As pointed out by the Subject Advisors, there are usually only two content workshops in a year that deal with subject-specific content and pedagogic aspects of teaching, with only half-day duration. The onus is on the teachers to ensure that they continuously enhance their subject matter knowledge, especially in view of changing curricular. Continuous professional development programmes, both qualification and non-qualification based, also ought to ensure that subject matter is addressed alongside PCK to enable teachers to develop adequate knowledge that will in turn improve their confidence to teach.

5.9.2 Pedagogical needs

Pedagogical needs were classified into seven categories according to STIN-LP (Laugksch et al., 2003). The seven categories were: (1) Improving personal competence; (2) Specifying objectives for instruction; (3) Diagnosing and evaluating learning; (4) Planning instruction; (5) Delivering instruction; (6) Managing instruction; (8) Administering instructional facilities and equipment.

The figure below provides a summary of Life Sciences teachers' pedagogical needs for development in the seven categories.



	Greatly needed (%)	Moderately needed (%)	Not needed (%)
Improving personal competence	73	25	4
Diagnosing and evaluating learning	67	32	2
Delivering instruction	65	32	3
Administering instructional facilities and equipment	64	29	7
Specifying objectives for instruction	62	34	4
Planning instruction	61	35	4
Managing instruction	42	45	13

Level of needs

Figure 5.9.2: A summary of Life Sciences teachers' pedagogical needs (n = 147)

As shown in figure 5.9.2 above, 'Improving personal competence' was of greatest importance for teachers of Life Sciences, with 73% indicating great need for development. Following this category was teachers' need to improve their skills of 'diagnosing and evaluating learning' expressed by 67% of the teachers. 'Delivering instruction' and 'administering instructional facilities' were the next most needed skills, where 65% and 64% of the teachers respectively pronounced this need. There was also not much difference in terms of development need for ‘planning instruction’ and ‘specifying objectives for instruction’ as these categories were articulated by 62% and 61% of the teachers respectively. A fairly large number of participating teachers indicated a relatively moderate need for improving their skill of ‘managing instruction’, as only 42% indicating a great need of development in this aspect. ‘Managing instruction’ was thus the least sought skill for development.

Within each category were several specific items pertaining to pedagogical skills. Below is the analysis of these specific items for each category. For purposes of analysis, a column representing ‘total need’ was also computed and included in the table. The ‘total need’ column represents the overall percentage need expressed by teachers (i.e. sum of ‘great need’ and ‘moderate need’)

a. *Improving personal competence*

All the needs in this category were found to be very strong, with approximately 70% of the participating teachers expressing a great need for development on all three items in this dimension. The total percentage need for development as presented in table 5.9.9 below shows that nearly all teachers of Life Sciences (99%) needed to update their teaching strategies. An overwhelming 98% needed to improve their skill of integrating different cognitive levels of information when teaching. Similarly, 97% of the teachers needed to update their general subject matter knowledge.

Table 5.9.9: Life Sciences teachers’ needs for improving personal competence (%)

Pedagogical skill	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Update knowledge of effective teaching strategies	72.0	27.3	99.3	0.7
2. Efficiently integrate different cognitive levels during teaching	72.0	26.0	98.0	2.0
3. Update subject matter knowledge in Life Sciences	70.7	25.3	96.0	4.0

Open-ended responses from teachers’ questionnaires also pointed to this need. Teachers of Life Sciences indicated a need to improve their personal competence in various aspects. As discussed in the previous section under content needs, teachers needed to advance their subject matter knowledge. Linked to the need to improve subject matter knowledge, especially difficult concepts, teachers also needed to improve knowledge of different teaching strategies, especially those that would assist them in teaching difficult concepts and topics. Comments such as these were made by the teachers:

> *More workshop time should be spent on the development of teaching strategies especially on different topics.* **(Teacher)**
>
> *We need to participate in activities that help us unpack new teaching strategies which will assist us in teaching problematic topics.* **(Teacher)**

These results are consistent with the results from previous studies which observed teachers' needs from developing countries. Empirical research shows that in-service needs of science teachers from developing countries are more directed towards improving personal competence, generally different from those of science teachers from developed countries. For example, in studies conducted by Abu Bakar and Tarmizi, 1995; Kamariah et al., 1998; Osman et al., 2006; Rakumako and Laugksch, 2010; all showed teachers' needs in developing countries being directed more towards improving one's personal competence.

b. Specifying objectives for instruction

In this category, teachers of Life Sciences needed development the most for 'integration of indigenous knowledge in Life Science teaching' (68.5%) and 'integration of content and practical skills when teaching and during assessment' (67.3%). Identification of learning objectives and integration of Life Sciences knowledge from other subjects were the least greatly needed.

Table 5.9.10: Life Sciences teachers' needs for specifying objectives for instruction (%)

Pedagogical skill	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Integrate indigenous knowledge in Life Sciences teaching	68.5	28.2	96.6	3.4
2. Integrate content and practical skills when teaching and during assessment	67.3	30.0	97.3	2.7
3. Identify learning objectives which specify knowledge needed by learners in Life Sciences	57.3	39.3	96.7	3.3
4. Integrate Life Sciences knowledge with knowledge from other subjects	54.7	39.3	94.0	6.0

The Life Sciences curriculum stresses the importance of teaching science in general, and Life Sciences in particular, in an integrated way in order to enhance the subject and to clarify the relationship between the subject and society, i.e. indigenous knowledge systems (IKS) that relate to a specific topic. The Life Sciences CAPS document goes as far as providing examples of how this knowledge can be integrated during teaching. For example teachers are expected to integrate the knowledge of 'Biodiversity' with the extent of biodiversity and endemism in southern Africa, looking at indigenous and endemic species. The IKS examples in the curriculum documents are however meant to serve as a guide, with teachers expected to supplement this information with other relevant illustrations of IKS relating to specific topics. The results in the table above therefore imply that some of the teachers required further guidance in integrating indigenous knowledge into their teaching.

The skill of integrating content knowledge with practical knowledge was of similar importance for teachers. About 67% of the teachers expressed a great need for development in this aspect of pedagogy, with overall, 97% of them specifying their need for expertise in this area.

Also important was the need to advance skills in helping learners transfer skills by integrating Life Sciences knowledge with knowledge from other subjects, i.e. lateral knowledge (Shulman, 1986). This also involves transfer of knowledge of Life Sciences from previous grades which Shulman (1986) branded as 'vertical knowledge'. This means that teachers of Life Sciences need to be familiar with the topics taught in the same subject area in the preceding and later years in school. In addition the framework of the Life Sciences curriculum is designed around knowledge from various disciplines and teachers of Life Sciences are expected to demonstrate this integration of knowledge. The results therefore clearly suggest that this is a complex task for many of the teachers.

c. Diagnosing and evaluating learning

Assessment is an important pedagogic skill that requires competence on the part of teachers. Whilst teachers use cluster groups as platforms for developing assessment tasks where they are expected to share assessment related expertise, it appeared that many of them were not benefiting as much or that, on an individual basis, they were finding it difficult to develop appropriate and sound assessment activities. As shown in table 5.9.11, training in various forms of assessment was massively required, with over 60% of the teachers expressing a great need.

The comment below from the one of the advisors indicated that assessment remains a challenge for many of the teachers.

> *Assessment is a challenge for many of the teachers of Life Sciences. Some teachers do not know how to assess learners at different levels of complexity. Many of them rely of assessment tasks set by the province. It becomes a problem when they have to set their own tests in schools.* **(Subject Advisor)**

Although cluster-based professional development is used largely for assessment related purposes, it appears that teachers are still grappling with the skill. As indicated by the Subject Advisors, common assessment tasks are developed at a provincial level, seemingly by the Subject Advisors themselves. These common assessment tasks are then used by individual teachers in their schools. This perhaps explains why a number of teachers in this study requested 'exemplar papers' and 'assessment activities'. This may be signalling a certain degree of dependency on the part of teachers, suggesting that teachers do not have confidence in their skills of developing assessment activities. Alternatively, it could be that the system itself is creating this dependency by not giving teachers enough platforms to develop their assessment skills.

Table 5.9.11: Life Sciences teachers' needs for diagnosing and evaluating learning (%)

Pedagogic skill	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Develop skills in recognising and correcting learners' common misconceptions	72.0	25.3	97.3	2.7
2. Develop learners' language skills by including it as part of the assessment	70.5	28.9	99.3	0.7
3. Use various forms of assessment to identify learning difficulties in Life Sciences	69.6	29.1	98.6	1.4
4. Assess knowledge and understanding of investigations and practical work	67.1	32.2	99.3	0.7
5. Efficiently integrate different cognitive levels in assessment	64.2	33.8	98.0	2.0
6. Design assessment items which assess achievement of learning objectives	63.1	34.2	97.3	2.7

This category also includes the knowledge of leaners and their characteristics (Shulman, 1986, 1987: Magnusson et al., 1999). This category, called diagnostic assessment, involves the gathering and careful evaluation of detailed information to understand learners' knowledge and skills in a given learning area. From a teachers' perspective this domain comprises knowledge of prerequisite ideas and skills that students will need to learn a specific scientific topic, and associated with this, teachers need to possess knowledge about 'students' conceptions (or misconceptions) of particular topics, learning difficulties, motivation, and diversity in ability, learning style, interest, developmental level, and need' (Park & Oliver, 2008:265). Consistent with this view, 'developing skills to recognize learners' misconceptions was identified as an area of interest for Life Sciences teachers' development, with 72% of the participating teachers indicated this as a priority need in this category. Literature shows that students' misconceptions in science subjects are a common occurrence, with authors such as Driver and Erickson (1983); Driver, Squires, Rushworth, and Wood-Robinson (1994), leading in this research. There is a body of research-based instructional strategies that have been used successfully at addressing learners' misconceptions, (Driver & Erickson, 1983; Driver et al., 1994; Posner et al., 1982 in Gomez-Zwiep, 2008). The teacher however remains central to the success of such strategies (Gomez-Zwiep, 2008). Teachers' awareness of student misconceptions is a determining factor in implementing conceptual change strategies (Gomez-Zwiep, 2008).

The need to improve ways of developing learners' language skills was also prominent in this category, expressed as a great need by about 71% of the teachers. The Life Sciences curriculum specifies the development of learners' language skills such as reading and writing through reading of scientific texts; writing reports, paragraphs and short essays (DBE, 2011c). The development of language skills remains a challenge in the South African education system because for the majority of learners, the language of teaching and learning is not their home language. By nature Life Sciences/Biology is language-intensive. So accessing the subject presents a challenge for learners whose first language is not English. A number of empirical studies have found a direct correlation between English language competency and performance in subjects that are language-intensive (Stephen, Welman, & Jordaan, 2004; Ramcharan, 2009; Oliver, Vanderford, & Grote, 2012). Many of the teachers of Life Sciences thus find it difficult to develop this skill amongst their learners. Some form of scaffolding of the difficult texts is usually required to improve accessibility of such texts, which may be a complex exercise if teachers did not receive adequate training in this aspect.

Also essential for teachers of Life Sciences was to advance their skills of efficiently integrating different cognitive levels in assessment as well as designing assessment tasks which assess achievement of learning objectives. As seen in the following extract, some of the teachers clearly articulated their inadequacies in this area of assessment.

I need to be helped with an issue of cognitive levels so that I will be able to assess my learners in a correct way that is used by examiners at the end of the year. Especially, I need to learn how to develop assessment activities with questions ranked as higher order questions. **(Teacher)**

The skill of assessing practical work and investigations was equally articulated by 67% of the teachers. This aspect is discussed further in the following section.

d. Planning instruction

The results for planning instruction are presented in table 5.9.12 below.

Table 5.9.12: Life Sciences teachers' needs for planning instruction (%)

Pedagogic skill	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Design and plan investigations/experiments	72.0	26.7	98.7	1.3
2. Design and organize learning experiences according to local circumstances	65.3	33.3	98.7	1.3
3. Select teaching strategies appropriate to learners and contexts	64.0	33.3	97.3	2.7
4. Select appropriate resources for Life Sciences	59.3	34.7	94.0	6.0
5. Develop lesson plans	44.0	48.0	92.0	8.0

Preferences of teachers for training in this category varied considerably. Support was indicated largely for 'designing and planning investigations', with 72% of the teachers indicating this as a great need. Looking at the total need, it was clear that nearly all the responding teachers (99%) of Life Sciences lacked confidence in this aspect. As indicated above, discussion on practical work and investigations follows in the next section.

Other skills such as 'designing and organising learning experiences according to local circumstances; selecting teaching strategies appropriate to learners and context; selecting appropriate resources for Life Sciences', also received equal prominence. About two thirds of the responding teachers greatly needed to update these skills. While the Life Sciences curriculum encourages teachers to be sensitive to global imperatives, it also promotes knowledge of local contexts. Teachers are encouraged to design and organise learning experiences, selecting teaching strategies and resources appropriatefor local environments. Examples of such learning activities are provided in the curriculum documents; however, teachers are expected to produce their own relevant learning materials. The results of this investigation demonstrate clearly that teachers are still lacking in this skill.

Shulman (1986, 1987) delineates this dimension as 'knowledge of educational contexts'. Knowledge of educational contexts spreads further than the school, to the knowledge of socio-cultural contexts Ernest (1989). The required knowledge of the educational context is clearly articulated in the South African Life Sciences curriculum. Specific Aim 3 of the curriculum predominantly deals with applications of Life Sciences in everyday life, contextual issues such as the history of Life Sciences and their relevance for society; indigenous knowledge systems. Any contextual/ indigenous knowledge illustrations are required to reflect different cultural contexts in South Africa and to be directly linked to specific areas in Life Sciences subject content (DBE, 2011c). Knowledge of the educational context is therefore one of the factors that influence the classroom approach employed by a Life Sciences teacher in the South African education system. Development of this knowledge for the curriculum implementers is thus paramount.

Teachers of Life Sciences appeared relatively capable of developing lesson plans, evidenced by only 44% of teachers who indicated a great need for development in this area.

e. Delivering instruction

Presented in table 5.8.13 are teachers' needs for delivering instruction.

Table 5.9.13: Life Sciences teachers' needs for delivering instruction (%)

Pedagogic skill	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Doing practical demonstrations to develop learners' practical and investigation skills	75.8	23.5	99.3	0.7
2. Demonstrate and develop science process skills amongst learners.	69.1	29.5	98.7	1.3
3. Use a wide variety of specific teaching techniques	66.4	30.9	97.3	2.7
4. Develop active learning and critical/higher order thinking skills	65.8	32.2	98.0	2.0
5. Use inclusive strategies when teaching	61.7	36.9	98.7	1.3
6. Establish links between Natural Sciences (GET) and Life Sciences (FET) during teaching	63.8	30.9	94.6	5.4
7. Apply knowledge of Life sciences in new and unfamiliar contexts	61.1	34.9	96.0	4.0
8. Apply concepts in Life Sciences to daily life of learners when teaching	59.1	37.6	96.6	3.4

f. Managing instruction

Teachers expressed a rather moderate need for development in this category with only about 40% of the participants indicating a great need for development in all three skills listed in the table below. In comparison with the other categories, the skills in this category were the least sought. This suggested that majority of the teachers were content with their skills of maintaining discipline and managing group-work in their classrooms. Teachers appeared to fairly confident with the way they were assessing their own teaching.

Table 5.9.14: Life Sciences teachers' needs for managing instruction (%)

Pedagogic skill	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Assess the effectiveness of one's own teaching	39.6	53.0	92.6	7.4
2. Appropriate use of group work	40.9	45.6	86.5	13.5
3. Maintain learner discipline in class	38.9	36.9	75.8	24.2

g. Administering instructional facilities and equipment

Presented in the following table are Life Sciences teachers' needs for development in administering instructional facilities and equipment.

Table 5.9.15: Life Sciences teachers' needs for administering instructional facilities and equipment (%)

Pedagogic skill	*Greatly needed*	*Moderately needed*	*Total needed*	*Not needed*
1. Knowledge of CAPS and related assessment guidelines	68.5	26.8	95.3	4.7
2. Identify local sources available for teaching for Life Sciences	61.7	32.2	93.9	6.0
3. Select supportive materials for teaching in Life Sciences	65.1	26.2	91.3	8.7
4. Use media and everyday resources appropriately in teaching	62.4	29.5	91.9	8.1

Because CAPS was in its first year of implementation at the time of data collection, a large percentage of teachers were particularly keen on being familiarised with the changes in content as well as assessment. A substantial percentage of teachers (69%) said they needed help in this regard.

The perceived lack of this curricular knowledge was attributed by many of the teachers, to the absence of subject advisors. Empirical research indicates persistent challenges relating to district support (Bantwini, 2009; 2011). Whilst the apartheid education system in South Africa was criticized for lack of guidance on the part of subject advisors, research evidence suggests that similar inefficiencies still prevail in the new dispensation (Bantwini, 2010; 2011; DBE & DHET, 2011). As articulated by Bantwini, (2011), the perceived lack of capacity by districts led to inappropriate teacher orientation to the reforms. As further pointed out in the Technical Report on Teacher Education and Training (DBE & DHET, 2011), there is an urgent need to improve not only the capability of district officials, more directly the subject advisors to support the teachers, but also to fill subject advisor vacancies. Indeed, there was a fair degree of discontentment on the part of teachers about the departments' failure to appoint subject advisors, and the consequences thereof:

> *"Some of the educators are new in Life Sciences, and not having an advisor is not helping anyone because at the end we produce bad results because there is no one to guide us"*. **(Teacher)**
>
> *"We've been without an advisor for way too long. And since we no longer have a subject advisor, information on changes in the subject is delayed and sometimes we end up teaching wrong topics"*. **(Teacher)**

Whilst this aspect did not transpire in this research, the DBE recently also indicated lack of skills to 'monitor and evaluate curriculum programmes' by some advisors, (DBE & DHET, 2011: 157). The Department of Basic Education has conceded to these inadequacies in curriculum knowledge, making a commitment to improving the current situation, supporting direct training of subject advisors by subject-area experts in curriculum topics and material as well as disciplinary content and pedagogy, and instructional techniques. The timeframe between commitment dates and the actual implementation of the programmes to improve subject advisors' curriculum knowledge remains a fundamental element in improving teacher quality.

As presented in table 5.9.15 above, about a third of the teachers also required guidance in selecting and using supportive materials for teaching in Life Sciences; identifying sources of free and locally available teaching for Life Sciences, and using media and everyday resources appropriately in teaching. Quotes such as *'we need advice on choice of materials for teaching'* and *'I don't know how and where to access equipment and material for teaching*

Life Sciences' implied that a number of teachers did not necessarily trust their judgement when selecting teaching material.

Presented above was Life Sciences teachers' need for development in the seven categories of pedagogy. Knowledge of teaching strategies, classroom management strategies, assessment strategies, etc., all pertain to general pedagogic knowledge (Shulman, 1987). Within these categories Life Sciences teachers clearly indicated the need to advance their knowledge of 'instructional strategies and representations for teaching science' as described by Magnusson et al., 1999. Magnusson et al., 1999 identified these as either subject-specific strategies or topic-specific strategies, where subject-specific strategies include general teaching approaches which are consistent with the goals of science teaching such as inquiry-oriented instruction. For example, the need to improve skills of doing practical work/investigations articulated by teachers in this study is specific to Life Sciences as a science subject. Also essential for Life Sciences teachers, was the need to expand their knowledge of content-specific teaching strategies, i.e. ways to present science concepts to facilitate active learning and critical thinking skills associating this with particularly difficult concepts such as Evolution and Genetics. In view of Life Sciences teachers' pedagogical needs being so strong, they were then collated and ranked as shown in the table 5.9.16.

Table. 5.9.16 : Ranked Pedagogical needs showing mean, standard deviation and category *(n=147)*

Rank		Category	Mean	Std. dev
1.	Doing practical demonstrations to develop leaners' practical and investigation skills	5	2.75	0.449
2.	Update knowledge of effective teaching approaches/strategies	1	2.71	0.468
3.	Design and plan investigations/experiments in Life Sciences	4	2.71	0.485
4.	Develop active learning and higher order thinking skills	5	2.70	0.502
5.	Develop learners' language skills by including it as part of the assessment	3	2.70	0.475
6.	Develop skills in recognizing and correcting learners' common misconceptions	3	2.69	0.517
7.	Use various forms of assessment to identify leaning difficulties in Life Sciences	3	2.68	0.495
8.	Demonstrate and develop learners' science process skills	5	2.68	0.497
9.	Update subject matter knowledge in Life Sciences	1	2.67	0.552
10.	Assess knowledge and understanding of investigations and practical work	3	2.66	0.488
11.	Integrate content and practical skills when teaching and during assessment	2	2.65	0.544
12.	Integrate indigenous knowledge in Life Sciences teaching	2	2.65	0.533
13.	Design and organize learning experiences according to local circumstances	4	2.64	0.509
14.	Appropriate use of Assessment Guidelines in the CAPS documents	7	2.64	0.572
15.	Identify and use a wide variety of specific teaching techniques for Life sciences	5	2.64	0.535
16.	Efficiently integrate different cognitive levels	2	2.62	0.527
17.	Select teaching strategies appropriate to learners and contexts	5	2.61	0.541
18.	Use inclusive strategies for teaching and assessment	5	2.60	0.518
19.	Design assessment items which assess achievement of learning objectives	3	2.60	0.543
20.	Establish links between Natural Sciences (GET) and Life Sciences (FET)	5	2.58	0.594
21.	Knowledge of Curriculum and Assessment Policy Statements (CAPS).	7	2.57	0.618
22.	Apply knowledge of Life sciences in new and unfamiliar contexts	5	2.57	0.573
23.	Select supportive materials for teaching in Life Sciences	4	2.56	0.651
24.	Apply concepts taught in Life Sciences to daily life situations	5	2.56	0.562
25.	Identify free and locally available sources of teaching Life Sciences	7	2.56	0.608
26.	Select teaching strategies appropriate to learners and contexts	4	2.55	0.538
27.	Use media and everyday resources appropriately in teaching	7	2.54	0.642
28.	Identify learning objectives which specify knowledge needed by learners in Life Sciences	2	2.54	0.563
29.	Select appropriate resources for teaching Life Sciences	4	2.53	0.609
30.	Integrate Life Sciences knowledge with knowledge from other subjects	2	2.49	0.610
31.	Use various teaching strategies	6	2.44	0.608
32.	Develop lesson plans	5	2.36	0.627
33.	Assess the effectiveness of one's own teaching of Life Sciences	6	2.32	0.607
34.	Appropriate use of group-work	6	2.28	0.686
35.	Maintain learner discipline in class	6	2.15	0.430

As discussed above and shown in the table 5.9.16, teachers' pedagogical needs were relatively high for all the items. Mean scores for all the items ranged between 2.15 and 2.75

on a 3-point Likert scale. The top ten most desired pedagogical knowledge included the need to improve practical work skills such as doing practical demonstrations and investigations (mean = 2.75); designing and planning investigations and experiments (mean = 2.71); assessing knowledge and understanding of investigations and practical work (mean= 2.67); and integrating content and practical skills during teaching and assessment (mean = 2.65). Other skills which received prominence included the need to update knowledge of various teaching strategies (mean = 2.71); developing active learning and higher order thinking skills (mean = 2.70); developing learners' language skills by including it as part of the assessment (mean = 2.70); developing skills in recognizing and correcting learners' common misconceptions in Life Sciences (mean = 2.69); using various forms of assessment to identify learning difficulties in Life Sciences (2.68); demonstrating and developing learners' science process skills (mean = 2.68); and updating subject matter knowledge in Life Sciences (mean = 2.66).

In view of the needs of the teachers being so strong, with the majority of the teachers either greatly or moderately needing support, there was not much variation between the teachers that needed support from those that didn't. Using the approach by Baird et al. (1993) and Rakumako and Laugksch (2010), all the needs were ordered into dichotomous groups of 'need' and 'no need'. The categories of 'great need' and 'moderate need' were collapsed into a single category of 'need'. Based on these categories, and assuming expected frequencies for each response category to be 50%, chi-square goodness-of-fit analyses were conducted to determine the statistical significance of each item. The need was considered at $\alpha = 0.05$. Life Sciences teachers indicated a need for all the items at $p < 0.\ 001$.

A Kruskal-Wallis Test was also performed to compare total scores on teachers' pedagogic needs per district. A 'total pedagogic needs' continuous variable was first computed. As with the content needs, the test revealed a non-significant difference ($p = .122$) in teachers' pedagogic needs across the three districts.

Furthermore, a logistic regression analysis applied to isolate explanatory variables that could predict teachers' pedagogical needs yielded statistically non-significant values. Regardless of teachers' demographic factors such as their qualification levels, academic level in Biological Sciences, experience in teaching Life Sciences, etc.; all the participating teachers appeared to have little confidence in their pedagogic needs. It can thus be inferred from the results that none of the teachers' demographic variables influenced their needs for development in areas of pedagogy. This clearly suggests a need to pay more attention to issues of pedagogy as it appears to be a challenge for many Life Sciences teachers, irrespective of their academic background. Paying attention to pedagogy requires an accurate analysis of teachers' needs based on knowledge domains.

A logistic regression analysis applied to isolate explanatory variables that could predict teachers' pedagogical needs yielded statistically non-significant values. This implied that none of the demographic variables could predict teachers' needs for development in areas of pedagogy. Notwithstanding the differences in teacher demographics (such as formal qualifications, academic level in Biological Sciences, experience in teaching Biological/Life Sciences etc.), none of these variables influenced their needs for development in areas of pedagogy. It can thus be inferred based on these findings that teachers of Life Sciences lack confidence in their pedagogic skills.

The findings of this study illustrate that Life Science teachers' had much stronger pedagogical needs than content needs. Between 73% and 98% of teachers expressed pedagogical needs. On the other hand, between 75 and 90% of teachers expressed a need for subject matter knowledge. If teachers' expressed pedagogical needs are an indication of their pedagogical knowledge, then this would indicate lack of well-developed PCK required for teaching. As discussed in chapter 3 (theoretical framework), the transformative model which considers PCK as a distinct knowledge requires transformation of other domains of knowledge such as the general pedagogical knowledge and subject matter knowledge into a new form of knowledge (Appleton, 2008). With subject matter and pedagogical knowledge being the key prerequisites for the transformation process (Magnusson et al., 1999), then this may imply that teachers of Life Sciences have very limited knowledge to draw on, and are unlikely to present developed PCK during their teaching. However, as with content knowledge, the study did not assess teachers' actual pedagogical knowledge and therefore the results are presumed to be indicating teachers' low self-esteem and low self-efficacy.

A number of reasons could explain teachers' low perceptions of their pedagogical knowledge. Firstly, a large majority of the teachers were trained to fit in a framework that emphasized rote learning (Asmal & James, 2001; Botha, 2002; Väyrynen, 2003). The expected shift in modes of teaching from more traditional ways of teaching to a more constructivist approach which requires the evolution of new strategies in teachers' pedagogical knowledge may have unsettled many of these teachers. As expounded by E.

Dempster (Personal communication, November 11, 2013) “In the process of reforming the curriculum, we have devalued teachers’ prior practice and not replaced it with skills that they feel confident in using”. Dr Dempster further explains how, during the exposure of teachers to constructivist teaching methods, teachers were told to stop making the children chant, and other “rote-learning” strategies they had been using for years. As a result, some of the teachers were totally disempowered such that they didn’t know what to do at all, a consequence of which, was less learning (E. Dempster).

Furthermore, shifting from a rote-learning teaching approach, towards teaching for understanding requires teachers to grasp deep and highly structured content knowledge and conceptual understanding so that they can transform it to good PCK. As indicated in the previous chapters, the topics in Life Sciences curriculum have been shuffled between the grades, creating some instability. This reshuffling may have resulted in uncertainty and decreased confidence in teachers’ PCK.

Whilst continuing professional development programmes have the responsibility to ensure that PCK is modeled during teacher training sessions as expounded by Loughran et al. (2012), teachers themselves need to play their role, taking ownership to improve their knowledge for teaching. Teachers in this study voiced their desire to develop each other through cluster-based CPD programmes, where they can discuss content and share teaching approaches. There was reported evidence to suggest that when teachers use clusters for their own development, they benefit significantly. Such initiatives and any other available opportunities to enhance teachers’ knowledge should be seized and supported.

5.9 Conclusion

The profile of teachers examined in this chapter revealed that whilst a large proportion of Life Sciences teachers are professionally qualified, only a small fraction possess qualifications at the level of a degree in Biological Sciences. Furthermore, the results of the study show that 37% of the Life Sciences teachers sampled are teaching out of their specialisations. As discussed in the preceding chapters, reliable data on the number of teachers country-wide teaching out of their fields of specialisation is not available, it appears that a fair number of teachers have been displaced. The results discussed in this chapter also suggest that some of the qualifications used by teachers to further their studies have not appropriately addressed the needs of the teacher education system. There was an obvious sense of powerlessness on the part of teachers displayed by their need for development in almost every aspect of subject matter and pedagogic knowledge and skills.

CHAPTER 6

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

Phase Two

6.1 Introduction

This chapter reports on the findings of the second phase of data collection. The results of the first phase of this research study showed that the top ranking pedagogic need for teachers of Life Sciences related to Specific Aim 2 'teaching scientific investigations/practical work'. This chapter thus reports on teacher training workshops conducted to build the capacity of Life Sciences teachers for implementing certain practical work skills.

6.2 Training of teachers of Life Sciences on practical work skills

6.2.1 Context

As discussed in chapter 5 above, there is a need to strengthen Life Sciences teachers' knowledge and skills of conducting investigations/practical work so that teachers can effectively teach these process skills. When the NCS was launched in 2003, emphasis was placed on teaching scientific investigations/practical work in subjects such as Life Sciences. The fundamental role of scientific investigations in the teaching and learning of science has always been reaffirmed in all the revised versions of the curriculum. The findings of this study however suggested that teachers still lacked the confidence to teach the science process skills. Similar findings have recently been published (Motlhabane & Dichaba, 2013). According to Motlhabane and Dichaba (2013), whilst the curriculum envisages that teachers possess the necessary knowledge to facilitate science process skills, it appears that many teachers lack confidence in doing and teaching practical work.

For the first time, a practical examination has been included as a separate paper during year-end assessments of the Life Sciences curriculum in Grades 10 and 11 where it constitutes 20% of the examination mark. Practical work has always been formally assessed since the introduction of the NCS, but without a practical examination as part of summative assessment. The CAPS document specifies that practical examinations should be set by individual teachers in their schools considering resources available. It is perhaps against this background that many of the Life Sciences teachers expressed a great need for development in teaching science investigation skills.

According to the Subject Advisor from district 2, teachers of Life Sciences had not received actual 'hands-on' training in practical work. This according to the Advisor was due to lack of physical resources and infrastructure such as the laboratories. The problem of lack of resources and infrastructure has been persistent in South African schools, (Pillay, 2004; Mji & Makgatho, 2006), in particular, the formerly black, rural schools (OEDC, 2007). Findings from several studies conducted in South Africa (Hattingh et al., 2007; Dlamini, 2004; Pillay, 2004) indicated that whilst teachers conceived practical work as a 'hands-on' activity, they relied mostly on demonstrations as the main method of doing practical work. During practical work, teachers focus largely on basic science process skills (Hattingh et al., 2007; Pillay, 2004). Remarkably however, these studies revealed that it was not the lack of resources that impacted greatly on the teaching of practical work skills. The biggest challenge was that of limited teacher preparedness to teach and therefore engage learners in 'hands-on' practical work activities (Pillay, 2004; Rogan & Aldous, 2005; Hattingh et al., 2007). This finding was confirmed by one of the Subject Advisors:

> *Sometimes even if a laboratory exists in a school you find the materials that were delivered still in sealed cartons. This is what the SCFs (Circuit Managers) complain about. Some of the materials in the schools remain unopened. There is a problem of knowledge on how to utilize those materials. Teachers do not engage their learners in practical work activities because they themselves were not taught how to do practicals.* **(Subject Advisor)**

Rogan and Grayson (2003) developed a Framework of Curriculum Implementation to better analyse and understand the scope of implementation of the ideals of a curriculum such as the type and quality of practical work being implemented in schools. The framework includes three core constructs namely: A Profile of Implementation, Capacity to Innovate and Outside Support. Physical resources, teacher factors, learner factors and school ethos and management are the four sub-constructs making up the 'Capacity to Innovate' construct. The construct 'Outside Influences' comprises of five sub-constructs; professional development, provision of resources required for the innovation, types of pressures and change forces, direct support to learners and monitoring strategies. The Profile of Implementation construct has four sub-constructs, namely: the nature of classroom interaction; use and nature of science; practical work; incorporation of science in society; and assessment practices (Rogan & Grayson, 2003).

Findings by Rogan and Aldous (2005) and Hattingh et al., (2007), which used this framework, revealed challenges on all three constructs of the framework pertaining to implementation of practical work in South African schools. Pillay (2004) had earlier reached similar conclusions. It became clear that there was a need for intervention in all aspects, starting with building teachers' capacity so that they can engage learners in higher levels of practical work activities. As stated by Hattingh et al. (2007), improving resources alone will only make a small difference unless multiple interventions are put in place.

An intervention programme aimed at providing teachers of Life Sciences with selected practical work skills was therefore organised for teachers of Life Sciences in district 2. As indicated previously, district 2 had been the least performing for at least two consecutive years, which is why an intervention was directed towards this district. There was also not enough capacity to provide training for all three districts participating in the study.

6.2.2 Planning for the workshop

The workshop was held at one of the universities in the province of KwaZulu-Natal. The teachers had to travel a distance of about 300 km to get to the university. Due to this constraint, a once-off training was conducted for each group of teachers. Three groups of teachers were trained in three separate days. Each training session lasted five hours. A total of fifty nine teachers received training.

6.2.3 Objectives of the workshop

The main objective of the workshop was to support teachers in laboratory skills such as basic microscopy. These skills had been highlighted by the teachers when completing the survey. The choice of these skills was influenced predominantly by the CAPS requirements for Grade

10 which was to be implemented for the first time in 2012 when data was collected. The workshop was made open to all Life Sciences teachers in the FET phase from district 2. Because of this a few Grade 11 practical work skill requirements were incorporated.

The following microscopy skills were covered during the training workshops:

- Use of light microscope
- Preparation of wet mounts
- Making accurate biological drawings
- Preparation of material for microscopic observation (making longitudinal and transverse sections of plant material)
- Calculation of actual sizes of cells using microscope and using micrographs
- Calculation of magnification of drawings
- Calculation of surface area to volume ratios
- Use of micrographs (in the absence of microscopes) to teach cellular and histological details of plants and animal

The following non-microscopy skills were included in the training.

- Use of real life specimens to teach diversity and evolution in plants and in animals
- Use of diagrams/pictures of plants and animals (in the absence of live specimens) to teach diversity and evolution.

In addition, assessment activities for these practical work skills were incorporated during the training.

6.2.4 Training resources

The venue was an undergraduate Biology laboratory which is fully equipped with microscopes and other pertinent resources. Each bench is equipped with its own set of microscopes, i.e. compound and dissecting microscope. Only the compound microscope was used for the training. A fairly wide range of plant and animal material was made available for the training. Selected materials were used for making cut sections for viewing under the microscope. Other material was put on display to reinforce the importance of bringing real life materials during teaching.

This particular lab was selected mainly because of its sitting arrangement which allows students to work both individually or as a group. The lab is a 48-seater arranged in 6 benches, each accommodating 8 students. This arrangement allowed for formation of small groups of up to eight teacher participants, which enabled interaction between members of the group.

Two facilitators and two assistants provided support during the training. One Subject Advisor also attended, and assisted during training.

The training manual was designed using university first year biology practical manuals as well as the FET Life Sciences textbooks and CAPS curriculum documents. Permission for use of university material was sought through the relevant authority. Use of textbooks was sought directly with the authors and publishers. These stakeholders further contributed by providing training resources including textbooks.

6.2.5 Training Methodology

The main purpose of the workshops was to support teachers of Life Sciences in improving procedural knowledge relating to microscope and other related skills. The development of procedural knowledge is consistent with theories of constructivism. In aligning with the principles of constructivist learning, a hands-on approach was thus used during the training.

Constructivism stresses the importance of understanding existing prior knowledge before engaging in any teaching and learning activity (Bruner, 1986). Before the start of the training, teachers were asked to indicate whether they had used a microscope before and to what extent. There was clear heterogeneity amongst the teachers in terms of microscope skills. A small minority of teachers indicated that they were confident using microscopes, whist the majority were either unsure or had never used a microscope. Groups were then re-arranged so that each bench had a mixture of teachers with experience using a microscope and those that were inexperienced. The main lesson arising from this interaction is that even if the teachers may generally be inadequately trained for a particular skill, other more skilled trainees can provide invaluable support for the less skilled teachers during professional development activities. The building of the small groups thus facilitated interaction between teachers and promoted a supportive atmosphere.

Contextualising learning was also important during the training of teachers. Nearly all the teachers attending the training workshop were practising in rural schools. The selection of materials used for training was therefore influenced largely by the teachers' working background. Activities were contextualised, for example, the preparation of thin sections for viewing plant tissues was done using pumpkin rather than celery. Furthermore, taking cognisance of the fact that many schools had no resources, alternative ways of conducting practical work were suggested for most of the practical skills carried out.

6.2.6 Workshop proceedings

Teachers in the workshop were familiar with microscopes, whether through teaching them in theory or through real life practice. The introduction was therefore directed towards re-familiarising teachers with basic microscope skills such as identifying the parts of the microscope and their functions.

Using the curriculum as the point of reference, teachers were then guided through preparation of wet mounts using onion epidermis and cheek cells. The Grade 10 Life Sciences curriculum underscores the skill of preparing wet mounts to observe structures of cells and tissues. Individual teachers were allowed to prepare their own slides. For some of the teachers, this was the first opportunity to see living cellular detail, so excitement was discernible.

As part of the workshop activity, each individual teacher prepared a drawing of cells, viewing them from the microscope, a skill also emphasized in the Life Sciences curriculum. After implicitly observing a few drawings prepared by the teachers, it became clear that the skill of making accurate drawings needed to be reinforced because some basic rules for making Biological drawings had been disregarded. For example, a few of teachers' drawings were out of proportion; others had a title above the drawing, etc. The rules for making scientific drawings were therefore discussed, allowing for individual teachers to reflect on their drawings.

The appreciation of real sizes of cells is an important skill in microscopy, hence its prominence in the Life Sciences curriculum. Using the same wet mounts and drawings that the teachers had prepared, calculations of the actual sizes of cells and magnification of drawings were computed. Formulae for such calculations had earlier been developed. As with the other skills, whilst this appeared to be a good revision exercise for some of the teachers, the majority of the teachers were not familiar with the skill.

A decision was taken to include as part of the training workshop, specimens of plants and animals to show their diversity. This decision was influenced by the findings from the first phase questionnaire which showed a great demand by teachers of Life Sciences to improve knowledge of 'Biodiversity in plants and animals'. Specimens representing various plant and animal groups were put on display. A practical work activity was then designed to enable teachers to construct evolution timelines from these specimens. Focus was given to key features that evolved with each group of plants or animals from the most primitive to the most advanced group.

6.2.7 Alternative strategies for practical work activities

As indicated by the Subject Advisor, the teaching of practical work had not been truly practical due to lack of resources and skills in conducting 'hands-on' practical work activities. The reality within South African schools (mainly, rural schools), is that there is neither the infrastructure nor the resources to enable teachers and learners to carry out hands-on practical work activities. According to the South African Institute of Race Relations, only 15% of South African public schools have laboratories (March 7, 2012). It was thus an imperative of the workshop facilitators to incorporate practical work alternative strategies to regular laboratory practical work that would not require use of resources such as microscopes, slides, etc. The impact is likely to be drastically reduced when teaching practical skills using alternative resources, such as using micrographs instead of microscopes. With no resources however, use of alternative strategies is the only way to get learners to engage in some form of practical work, as is recommended in the Life Sciences curriculum. Teachers at the workshop were thus taken through various alternative strategies for each skill covered. For example, teachers were taken through use of micrographs to reinforce the teaching of cytology and histology. The same micrographs were used for calculating real sizes of cells. These alternative strategies are also recommended in the Life Sciences curriculum.

6.2.8 Assessment of practical work

As indicated above, teachers have to consider resources available in their individual schools when setting practical examinations. Lack of physical resources means greater use of indirect assessment of practical skills (where learners' skills are inferred in a written examination) rather than direct assessment methods e.g. where a learner is observed manipulating an object such as a microscope. With the majority of the schools in South Africa lacking physical resources, teachers thus need to possess adequate knowledge on how to use indirect assessment strategies to effectively assess practical work.

6.2.9 Workshop evaluation

The participants' views indicated that the workshop fulfilled its objectives and thus met their expectations. For some of the teachers, this was their first exposure to microscope skills.

> *The use of microscope was very useful since it was for the first time for me to operate it.* **(Teacher)**

> *I now know how to use a microscope and prepare slides, observing them under the microscope and calculating the sizes of cells.* **(Teacher)**

Other teachers were presented with an opportunity to reinforce their microscopic skills.

> *Good revision of microscope skills that I attained from my BSc study at university.* **(Teacher)**

> *I improved my microscope skills, including calculating the size of specimen when not given the scale line, which I did not know.* **(Teacher)**

Teachers appreciated the participative, hands-on approach used during the training. The feedback given indicated that the training method was effective in imparting the skills.

> *I prefer these kinds of workshops, where educators are engaged actively rather than listening.* **(Teacher)**

Life Sciences is a practical subject, so training also needs to be practical just like we did in this workshop.

I like the way we did practicals ourselves so that when we do with our learners it is something we have seen and done it.

It is argued that teachers are less likely to change practice as a result of learning activities that follow a presentation format and the memorizing of new knowledge (Desimone et al., 2002; Loucks-Horsley et al., 1998; Opfer & Pedder, 2011). Because teachers in the workshop were actively involved and not playing a dormant role, i.e. observing demonstrations and listening to facilitators, they remained enthused and focused throughout the duration of the workshops. Teachers learn better when the pedagogy of professional development is active and involves teachers learning in ways that reflect how they should teach learners (Borko & Putnam, 1997; Darling-Hammond & McLaughlin, 1999, Opfer & Pedder, 2011). Getting teachers interactively and highly involved in the process of learning rather than passive involvement, improve teachers' engagement (Villegas-Reimers, 2003). The constructivist theories emphasize that learning should be authentic, and that learners should meet real life experiences (Huang, 2002). Similarly, adult learning theories promote practical learning which is designed through real-classroom experiences which will be appealing and meaningful to adult learners.

The inclusion of evolutionary plant and animal trends as a practical activity was greatly appreciated by the teachers. Primarily, the teachers recognized the value of bringing real life materials to classroom teaching. Moreover, specimens of plants and animals exhibiting different diagnostic features provided clarity and simplified evolutionary trends which are generally thought of as complex to teach.

…learning the importance of bringing specimens in class to teach practical work. I used to overlook the idea of bringing reality into lessons now I realize that I have been disadvantaging my leaners. **(Teacher)**

I liked the attention that was given to the evolution of plants and animals using practical means to show their differences. **(Teacher)**

I gained more insight on content such as Evolution and strategies on how to use practical work to teach this content to make it easy for the learners. **(Teacher)**

With many participants practicing in schools without physical resources, acquiring skills of conducting and assessing practical work using alternative means was greatly valued.

Learning creative and innovative strategies when resources are not available was really useful. **(Teacher)**

I gained knowledge and skills on how to set practical exam even if I don't have all the required resources in my school. **(Teacher)**

The importance of social learning also emerged from the evaluation reports as seen in the following excerpt from one teacher:

I was very afraid when we started but there were a lot of other teachers who motivated me and told me I can do it. They helped me a lot. I feel so happy that I came to this workshop. I wish closer to home we can do this on a regular basis. We can learn more. **(Teacher)**

There was good opportunity to share skills between members involved. **(Teacher)**

These comments clearly highlight the importance of shared learning. As argued by Vygotsky (1978) and later by Lave and Wenger (1991), learning does not occur in isolation, but it is a complex process that occurs as a result of association with significant others. Clearly, the workshop enabled meaningful interaction amongst the teachers, thus improving learning on the part of teachers.

Concerns regarding the duration of the workshop were raised by the participants. As previously indicated, teachers had to travel long distances to get to the venue, therefore training could not commence as early as many teachers would have desired. Furthermore, the teachers expressed the need for follow-up workshops, i.e. ensuring the sustainability of the training workshops.

6.2.10 Sustained support

It is widely recognized that in order for professional development to be effective, it has to be sustained over a long period of time (Garet et al., 2001; Villegas-Reimers, 2003). Following the training of teachers for practical work, extended support was sustained through Subject Advisors from the participating district. Assistance in the development of practical activities for assessment purposes and for specific contexts, such as those without resources still continues. This has enabled other districts to benefit. The process is also underway to provide material resources such as donating used microscopes and associated materials to the neediest schools.

6.3 Conclusion

This chapter presented the procedure and the evaluation of an intervention programme designed to assist teachers develop and improve practical work skills in this study. The outcomes of the intervention imply that use of constructivist methods during professional development, where teachers are allowed to assume an active role, can have a positive impact on their motivation and therefore likely improve their learning. This is particularly the case when dealing with practical work skills which are generally taught better through hands-on participation rather than demonstration.

CHAPTER 7

SUMMARY OF FINDINGS AND RECOMMENDATIONS

7.1 Introduction

This chapter gives a brief account of the purpose of the investigation and the guiding research questions. The first part of the chapter therefore is a summary of the findings presented in Chapter 5 and 6. These findings are presented in terms of the key research questions. The latter part of the chapter makes recommendations and draws conclusion for the study.

7.2 Summary of findings

The purpose of this study was to explore Life Sciences teachers' ongoing learning through continuous professional development programmes. It provided an in-depth analysis of Life Sciences teachers from 2 rural and 1 urban/rural district in the province of KwaZulu-Natal. The study developed an inventory of Life Sciences teachers' content and pedagogic needs for development. The study also investigated the extent to which Life Sciences teachers were generally motivated or not motivated to engage in professional development programmes. In view of those engaged in continuous professional development through qualification and non-qualification programmes, the study also documented teachers' perceived gains from such programmes. An intervention method designed based on teachers' needs was then evaluated.

The following summary of findings blends the results derived from survey questionnaires completed by teachers and interviews conducted with Subject Advisors. Findings are discussed based on the following critical research questions which guided the study:

1. How do Life Sciences teachers engage with learning in continuous professional development programmes? i.e. what methods of professional development programmes do they use?
2. Why do Life Sciences teachers engage in ongoing learning through continuous professional development programmes? i.e. what are teachers' attitudes and motivation towards learning through professional development programmes?
3. What are Life Sciences teachers' perceived professional development needs in terms of subject matter and pedagogical knowledge and skills?
4. What gains in knowledge in skills are achieved through engaging in continuous professional development programmes?

Research question 1: How do Life Sciences teachers engage with learning in continuous professional development programmes? i.e. What models of professional development do they engage in?

Key Finding: A fairly large number of teachers of Life Sciences have seized the learning opportunities made available to them. However, a considerable proportion of these teachers appeared to have opted for programmes that improved their qualification status rather than those that addressed subject matter knowledge. On the other hand, teachers who chose qualifications intended to address discipline knowledge appeared to have taken inappropriate specialisations.

This research question looked at the methods of continuous professional development that teachers of Life Sciences used to improve their knowledge and skills. The study examined both the qualification and non-qualification-based methods of CPD programmes utilised by the teachers of Life Sciences. In order to provide a context on why teachers of Life Sciences pursued particular CPD qualification programmes, their qualification profile was first analysed. The profile showed that only 5% of teachers were unqualified. The majority of Life Sciences teachers had a diploma in education, followed by those with a degree, and finally those with an Honours degree. Whilst the majority of the Life Sciences teachers indicated that they had 'specialised' in Biological Sciences during their initial training, these specialisations were at relatively lower levels than the level of Biology studied through a BSc degree. The results also revealed that only 18% of teachers in the study had an appropriate Biological Sciences qualification. These results were consistent with the national indicators showing that while majority of the teaching force had a professional teaching qualification, only 18% were graduates i.e. have a four-year Bachelor of education (B Ed) or a degree plus Post Graduate Certificate in Education (PGCE) or its equivalent, (DBE & DHET, 2011: 30). The results also showed that a fairly large proportion of teachers (14%) that upgraded through B Ed Honours. Whilst achieving an honours degree improves the teachers' qualification status, it is a generic degree and therefore does not necessarily address teachers' subject-specific needs.

The analysis of trends in registration for CPD qualification programmes showed significantly increased enrolments from around 2006. Teachers of Life Sciences appeared to be using an assortment of CPD qualification programmes, depending on their initial qualification status. With the majority of the teachers holding diplomas as their initial qualification, a large proportion (54%) of the participating teachers were furthering their studies through the ACE programme. Further analysis of the results suggested that the teachers of Life Sciences completed ACE programmes not related to the Biological Sciences specialisation. This is due to the fact that when the ACE programme was introduced in 2000 to replace the old FDE, only role specialisations existed in many higher learning institutions. It is possible therefore that a fair proportion of Life Sciences teachers in this study may have furthered their studies through general ACE programmes or programmes that were suitable for teachers changing roles such as Leadership and Management or Social Justice education. On reflection, I think that if I had asked the participants more specifically what specialisation of ACE they had registered for or completed, a much better profile would have emerged. It may be as a result of this problem that the DHET has proposed two new qualifications to replace the ACE programme. The Advanced Certificate in Teaching will focus only on subject specialisations whilst the Advanced Diploma in Education will be taken by teachers who want to pursue a new role such as Leadership and Management (DHET, 2011).

The second most utilised qualification CPD programme by the teachers of Life Sciences was the B Ed Honours. About 23% of the teachers were upgrading or had upgraded through the B Ed Honours programme which is a generic degree and intended to prepare students for research-based postgraduate studies in a particular field of education. A large percentage of these teachers used the STD and ACE qualification route to achieve their B Ed Honours. If these teachers completed an ACE programme in Biological Sciences, and later enrolled for B

Ed Honours, then they have not only improved their qualification status but have also addressed their content needs which would not be addressed by the B Ed Honours programme. However, if they completed an ACE that does not specialise in Biological Sciences, and later enrol for B Ed Honours, then the implication is that they have simply improved their qualification status without really engaging in subject-specific knowledge. This explains why teachers with a B Ed Honours degree compared to those with just a degree such B Ed or B Sc expressed strong needs for development in subject-specific needs. The minority of Life Sciences teachers who completed the B Ed Honours programme after their B Ed or B Sc + PGCE studies would have received a fair amount of training in subject-specific knowledge during their initial qualification. It is clearly as a result of these disparities that the B Ed Honours is now going to streamlined to admit only teachers with a four-year professional teaching degree or an appropriate Bachelor's degree and a recognised professional teaching qualification (DHET, 2011).

All Life Sciences teachers with a BSc/BSc Honours degree were either currently upgrading or had completed the PGCE programme. These results clearly indicate commitment on the part of teachers to get professional qualifications. Similarly, nearly all the teachers with no previous formal training were upgrading through the NPDE programme. As also reported in the results, there was one unqualified teacher registered for a B Ed degree. There has been a sustained appointment of unqualified teachers due to shortages of Maths and Science teachers particularly in rural schools (SACE, 2010). As reported in chapter 4, amongst the bursaries offered by the KZN DoE was one for practising teachers qualifying for a B Ed degree. Whilst learning on the job is not an ideal initial teaching qualification route, it is hoped that process will eradicate the problem of unqualified teachers, particularly with the KZN DoE having ceased the appointment of unqualified teachers.

Training workshops and cluster group meetings were the most utilized non-qualification-based approaches to CPD. Participation in school-based professional development programmes was also at satisfactory levels. Only about half of the teachers indicated that they had mentors or coaches for their development in schools.

<u>Research question 2:</u> Why do Life Sciences teachers engage in ongoing learning through continuous professional development programmes? i.e. What are teachers' attitudes and motivation towards learning through professional development programmes?

Key Finding: Teachers who were unqualified were motivated by the need to be accredited. However, the majority were intrinsically motivated by the need to become better Life Science teachers. One major factor influencing learning outside of structured qualification programmes was the absence or presence, as well as the quality of subject advisors.

This research question sought to investigate the extent to which Life Sciences teachers were generally motivated or not motivated to engage in professional development programmes. The question was intended to determine the factors that influence teachers' participation in professional development activities, both qualification and non-qualification driven. The results showed that about 83% of the teacher respondents had in one way or another been furthering their studies. The remaining 17% of teachers were eligible but not engaged in any further studies. Nearly all of these teachers had a diploma only which they obtained during initial training as teachers. These were Life Sciences teachers with a diploma qualification, usually an STD. The difference in participation rates by type of qualification was found to be statistically significant, confirming that students with a diploma were significantly less likely to register for further study than graduates or unqualified teachers. These findings imply that efforts to motivate teachers to take up higher education studies needed to be directed towards this cohort of teachers, i.e. teachers with a diploma. The results also showed that these teachers were between 30-49 years of age, indicating that they still had a long career in teaching and therefore needed to consider furthering their studies in order to adapt better to the curriculum demands.

The results showed that whilst there were external factors influencing participation in CPD programmes, whether qualification or non-qualification based. It was the intrinsic determination to become better teachers that encouraged most teachers of Life Sciences to engage in lifelong learning. This pointed toward attainment of the 'self-actualisation' level of Maslow hierarchy, suggesting a sense of autonomy and self-directedness on the part of teachers. A number of scholars agree that a teacher's personal desire to attend professional development and learn is an important factor that may influence change in teachers' classroom practices (Smith et al., 2003; Bell & Gilbert, 1996; Smith & Gillespie, 2007; Anderson, 2000; Guskey 2002).

As pointed out in earlier chapters, the majority of South African teachers trained before 2001 have had to urgently upgrade their qualification status in order to be considered qualified. It was therefore not unexpected that a large fraction of the teachers in this study were driven by the need to get accreditation. It is however crucial that in the process of getting certification, teachers enrol for appropriate qualifications and use this as an opportunity to improve subject-specific knowledge if they are not changing roles.

Non-participation in qualification-based CPD programmes on the other hand was largely attributed to lack of financial support. A number of scholars have argued that a vital approach in improving the quality of teachers, especially during reforms is by providing financial incentives for teachers to participate in various forms of CPD (Little, 1993; Villegas-Reimers, 2003; Komba & Nkumbi, 2008). Whilst efforts are being made by the KZN DoE to support teachers through provision of funding, the results of this study suggested that these incentives were only marginally reaching the teachers in need. The large majority of teachers were still unable to access funding to assist them in furthering their studies. It is important to note that despite having received no funding, a number of teachers have remained motivated and funded their own studies.

The absence of Subject Advisors seemed to be influencing the attendance of teachers in training workshops. For example, the workshop turnout for teachers in district 3 where there was no Subject Advisor was lower than the other two districts. Although district 1 was also without a Subject Advisor, the presence of caretaker Advisors from other districts clearly enhanced teachers' participation in workshops. As was reported in chapter 3, district 3 had been without an Advisor at the time of data collection for this study. Training workshops were managed by senior teachers that were also cluster leaders. The caretaker Advisor was not a specialist in Life Sciences and practically could not attend training workshops dealing with content issues. A large group of teachers seemed passively engaged with the workshop. This was due to discontent with the quality of training they were receiving as they explained. The level of support provided by the district was clearly inadequate in this case, yet the system seems to rely heavily on Subject Advisors in ensuring the implementation the curriculum. Opfer and Pedder (2011: 378) argue that professional development and teacher learning should not be narrowed down, looking only at individual teachers or individual activities or programs, i.e. micro level, but should take into consideration influences from the meso (institutional) and macro (school system) contexts. Similarly Smith et al. (2003) reasoned that teacher professional development is an interaction between individual, program and system factors. Each element in the system thus plays an important role in ensuring teacher learning. The persistence of such inefficiencies from districts may thus be seen to be sabotaging the very system it is meant to support.

The challenge of Subject Advisors also extends to cluster-based CPD programmes. As recounted by the Advisors themselves and also noted by the department of education, there are very few Advisors to provide adequate support at cluster meetings. Cluster meetings are restricted to assessment-based forms of development. Because the proportion of clusters to Subject Advisors is so uneven, it is also impossible for Advisors to provide maximum support to any one cluster. The notion of teacher networks that generally carry notable benefits is therefore not fully utilized. The idea of shared learning also emerged during practical work training workshops. There was also an expressed need for 'experts' to occasionally conduct the workshops. What remained unclear though was whether this sentiment was linked to the perceived lack of capacity/absence of the Subject Advisors.

Research question 3: What are Life Sciences teachers' perceived professional development needs in terms of subject matter and pedagogical knowledge?

Key Finding: Content areas that require extra attention during the development of Life Sciences teachers are those relating to 'Evolution and 'Genetics and inheritance'. The pedagogic skill of teaching and assessing practical work also needs urgent consideration.

The purpose of this research question was to explore Life Sciences teachers' needs for development in content and pedagogic areas. The results of the study showed strong needs for development in both content knowledge and pedagogy. Teachers in this study expressed need for development the most in content areas such as 'Genetics and inheritance' as well as 'History of Life on Earth'. Persistent poor learner results during the Grade 12 examinations seem to legitimise teachers' need for development in areas such as 'Genetics' and 'Evolution'. For example, as discussed in chapter 4, 'Genetics and inheritance' is an old topic that has always formed part of the old Biology syllabus. Although the topic is generally considered complex in nature, persistent poor learner performance may be symptomatic of teachers' lack of deep conceptual understanding of these topics. A regression analysis failed to isolate any teacher variables that could be associated with teachers' needs for development in the 'Genetics and inheritance' topic. This implied that teachers in general were challenged by the topic, regardless of qualification level, teaching experience, and so forth.

Teachers' need for development in the 'Diversity, change and continuity' strand, under which 'History of Life' is listed, surpassed all the needs in other knowledge strands. Whilst 'Evolution' topics have been part of the Life Sciences curriculum for at least up to five years at the time of this research study, based on the results, it is likely that some teachers still lack the confidence to teach the topic. A regression analysis identified teachers' initial qualifications as a significant variable associated with their need for development in this knowledge strand. It was found that teachers with a Bachelor's degree had significantly lower needs than teachers with a diploma or no qualifications.

Teachers' need for development in pedagogic knowledge was more pronounced than their content needs. 'Improving personal competence' emerged as the most sought pedagogic skill by Life Sciences teachers. This category included pertinent pedagogic skills such as 'updating knowledge of teaching strategies'. Through open-ended responses, the responding teachers proposed use of platforms such as the cluster meetings to share teaching approaches, especially for 'difficult' topics. Empirical studies have indeed shown that teachers' needs from developing countries are more focused on improving personal competence (Abu Bakar & Tarmizi, 1995; Kamriah et al., 1998; Osman et al., 2006; Rakumako & Laugksch, 2010).

Other pedagogic skills that received prominence were those relating to 'diagnosing and evaluating learning'. Although cluster meetings were used mainly for assessment related activities, it appeared that the development of assessment activities remained a challenge for many of the teachers. As reported, assessment tasks are developed at provincial level, by Subject Advisors. This pool of assessment tasks is then used by teachers in their own schools. The purpose of this centralised development of assessment tasks is to ensure that assessments show evidence that all the skills are assessed at a grade-appropriate level (DBE, 2011c). Assessment tasks are expected to show a clear link between the specific aims and the achievement of outcomes of learning (DBE, 2011c). Putting processes in place to ensure that these objectives are met is indeed pivotal. However, it can be argued that through this practice, individual teachers in their schools are not allowed enough space to develop their expertise in assessment. This is likely to create dependency on the part of teachers in the long run.

The chi-square goodness-of-fit analysis showed significant needs for all the pedagogic items at $p < 0.001$. Furthermore, a logistic regression analysis applied to predict teachers' pedagogical needs produced statistically non-significant values suggesting equivalent needs despite differences in demographic variables.

As presented in chapter 4, the most sought pedagogic skill was that of developing learners' practical work skills, which relates to 'delivering instruction'. This came at the backdrop of the introduction for the first time, of a practical examination in Grade 10 and 11. This requirement brought to the fore issues relating to lack of resources, poor infrastructure and most importantly, inadequate training of teachers to implement practical work. Hence, the second phase of data collection for this study focused on providing teachers with training on a few selected skills. Skills for 'planning instruction' and 'specifying objectives for instruction' were also articulated strongly following the needs for 'delivering of instruction'. The least sought skill was that relating to managing instruction.

The majority of Life Sciences teachers had a fairly low perception of their knowledge of both subject matter and pedagogical knowledge. Some scholars argue that low self-esteem may be good for teacher learning. In the words of Opfer and Pedder (2011), self-doubt may prompt teachers to engage in learning. In the same way, Wheatley (2002) earlier observed and argued that conflict between personal expectations and sense of efficacy may open up the possibility for teacher learning to occur. Similarly, Cobb, Wood and Yackel (1990) believed that cognitive conflict in teachers' thinking challenges teachers' approaches and thinking which could be a motivator for change. Likewise, Ball (1988) argued that dissonance in teacher thinking is often required for teachers to unlearn much of what they believe, know, and know how to do in order to learn and adopt new practices. If these scholars are correct, the perceived lack of confidence exhibited by teachers of Life Sciences should then be interpreted as indicating teachers' aspirations to learn and improve their teaching practices.

<u>Research question 4</u>: What gains in knowledge in skills are achieved through engaging in continuous professional development programmes?

Key Finding: Teachers engaged in some form of CPD appeared to be gaining ‘confidence’ in their teaching. Importantly however, CPD providers need to ensure that quality programmes are in place. Support from districts is likely to improve teacher learning in their clusters.

There was a general perception that Life Sciences teachers were gaining ‘confidence to teach’ by participating in qualification-based programmes. This may have been associated with their low self-esteem which was demonstrated by such strong development needs. Although teachers claimed to be developing both their content and pedagogic knowledge, it remained unclear exactly which programmes were benefiting the teachers the most in this regard, except for one ACE Biological Sciences which was independently evaluated. The results of the evaluation of this programme suggested that teachers were benefiting significantly in both subject matter knowledge and in PCK. With teachers’ development needs having been expressed strongly for the ‘Diversity, change and continuity’ strand, the ACE teachers indicated great development for topics such as ‘Evolution by natural selection’, ‘Human Evolution’ and ‘History of Life’. Similarly, development in ‘Genetics and inheritance’ appeared to be satisfactory. No other ACE programme was evaluated during this research study and therefore the results presented here only represent one institution.

There were inconsistencies in the reported gains from training workshops. Quantitative results from the survey suggested that training workshops were significantly improving teachers’ knowledge and skills. On the contrary, open-ended responses implied that teachers were not content with the level of support received through training workshops. The exaggerated quantitative views on the benefits of training workshops may have been given out of ignorance. Or, as seen in one of the comments by teachers, it was what they longed for rather than what was presented to them in reality, hence the disparity between answers to closed questions and open-ended questions that required them to qualify their views.

The teachers in this study were optimistic about cluster-based programmes. Nonetheless, there was a shared opinion that their role was too restricted. Hence, suggestions were made to expand the scope of cluster meetings beyond development in assessment related activities. Teachers clearly recognised the potential benefits of social learning networks. Although Subject Advisors admitted to not being able to visit all clusters, there was an indication that teachers from different districts were benefiting differently from cluster meetings depending on the presence or the absence of the Life Sciences advisor. This may be linked to the fact that Subject Advisors provide feedback for activities that take place in clusters.

Perceptions on the impact of school-based professional development programmes were also positive. Similarly, teachers of Life Sciences benefited from having mentors and coaches in their schools. As shown in the results participation in mentoring and coaching was lower than school-based professional development programmes. But, the results also revealed that although fewer teachers had mentors or coaches, the gains derived are just as valuable.

Training teachers for practical work through ‘hands-on’ approaches where teachers play an active role seems to carry a lot more benefit than using demonstration methods.

7.3 Recommendations

There is a need for teachers in general to improve their confidence to teach science subjects and implement the ideals of inquiry-based learning introduced in South Africa. The findings of this study on teachers’ perceptions of their development needs revealed teachers’ lack of confidence to teach the inquiry oriented Life Sciences curriculum. The findings also showed that teachers of Life Sciences are motivated to study and have improved their qualification status, yet they remain largely insecure about their knowledge base. This could result in teachers not teaching some of the important knowledge and skills, which may in turn, reflect as poor learner performance. Amongst the factors that lead to poor enactment of the inquiry-based curriculum is teachers’ lack of subject matter knowledge, lack of understanding of the science processes, their beliefs about science, their lack of confidence in teaching science, resistance towards a new teaching approach, lack of science equipment and lack of ongoing professional support (Ambross, 2011). Whilst the results of this study do not explicitly illustrate any of the factors listed by Ambross (2011), it is however alarming to have teachers expressing development needs for almost every aspect of the Life Sciences curriculum. Based on these findings, it is recommended that teachers are encouraged to enrol for qualification programmes that will adequately improve both their subject matter knowledge and PCK. Conceptually demanding topics highlighted in the results require immediate consideration, including proper training on the teaching of science process skills. It is imperative that teachers who intend to continue teaching Life Sciences, who have not had an opportunity to further their studies, are encouraged to take up appropriate courses that will address their needs. Ideally, these teachers should be signing up for the Advanced Certificates in Teaching in Biological/Life Sciences. Similarly, service providers would need to ensure that Biological Sciences subject matter is taught alongside PCK at an appropriate level. In line with this, there is a strong need to incentivise teachers who show motivation to further their studies, ensuring that the bursaries materialise, especially in KwaZulu-Natal where there is still a large number of unqualified teachers.

There is evidence to suggest that teachers of Life Sciences needed to extend their collaboration with other teachers using the cluster-based CPD system. Clusters create space for teachers to embark on co-operative learning, sharing knowledge and information whilst reflecting on their practices (Lieberman & Grolnick, 1996; Jita & Ndlalane, 2009). It is in the interest of districts to provide adequate support for these networks so as to promote teachers' own professional development through communities of learning. Time for development through these learning communities needs to be formally scheduled. Again here, support from the districts in terms of materials for facilitation of learning is vital. A thorough selection and training of cluster leaders will ensure that all activities within these clusters are well coordinated and make a profound impact on teachers. The presence of an expert to lead the cluster may be necessary during initial stages (Maistry, 2008, Bertram, 2011).

The South African education system relies heavily on Subject Advisors to support teachers in schools. As shown by the findings of this study, the absence of Subject Advisors did not impact only on teacher attendance in training workshops, but also affected the flow of crucial curriculum information as well as teachers' overall interest in professional development. The Departments of Education have acknowledged these inadequacies (DBE & DHET, 2011) and it is thus hoped that the appointment of Subject Advisors will not be delayed any further. Furthermore, there is a need to increase the number of Subject Advisors in order to ensure that all teachers receive the necessary support.

Previous studies have shown that it is the lack of procedural knowledge that impacts largely on the teaching of practical work skills in South African schools. Because practical work training requires facilities, it is important that institutions with resources provide practical work training to teachers. Central to this, is the need for the Education department to make available resources to teach process skills which constitute a large component of the science curricular.

7.4 Conclusion

This study concludes that in order to address the quality of teaching and learning in South Africa, the quality of teachers needs to take central stage. There is a need to precisely identify the needs of teachers and respond appropriately to such needs. Without information on the exact needs of teachers, CPD programmes are likely to continue offering irrelevant training programmes that fail to make an impact on teachers and classroom practices. Whilst the sampled Life Sciences teachers' needs appear to be extreme, they clearly revealed teachers' lack of confidence to teach science which may be linked to the persistent poor learner performance. The findings of the study also supported the literature reviewed which showed that whilst the professional status of teachers in South Africa has improved, their confidence to teach has not been enhanced, likely impacting on the quality of teaching and learning. At the core of this, are the large numbers of teachers who have furthered their studies through programmes that were not appropriate for addressing their current content and pedagogic needs. It is however encouraging that new qualifications and some recent specialisations are now set to address such knowledge gaps.

References

Abell, S. K. (2008). Twenty years later: Does pedagogical content knowledge remain a useful idea? *International Journal of Science Education*, *30*(10), 1405-1416.

Abell, S. K., Rogers, M. A. P., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the next generation of science teacher educators: A model for developing PCK for teaching science teachers. *Journal of Science Teacher Education*, *20*(1), 77-93.

Abu Bakar, K. & Tarmizi, R., A. (1995). Teacher preparation concerns: Professional Needs of Malaysian Secondary School Science Teachers, *Paper presented at National Association of Research in Science Teaching Conference, San Franciso*. Retrieved from http://www.hbcse.tifr.res.in/episteme/episteme-1/themes/lilia_finalpaper.pdf

Adler, J., & Reed, Y. (Eds.). (2002) *Challenges of teacher development: An investigation of take-up in South Africa*. Pretoria: Van Schaik.

Alexander, P. A. (2008). Charting the course for the teaching profession: The energizing and sustaining role of motivational forces. *Learning & Instruction*, *18*(5), 483-491.

Aluko, R. F. (2009). The impact of an Advanced Certificate in Education (ACE) Program on the professional practice of graduates. *The International Review of Research in Open and Distance Learning*, *10*(4).

Ambross, J. N. (2011). *A case study of the implementation of science process skills for Grades 4 to 7 learners in Natural Sciences in a South African Primary School* . Unpublished Doctoral dissertation, Nelson Mandela Metropolitan University, South Africa.

Anderson, S. E. (Ed.). (2002). *Improving schools through teacher development: Case studies of the Aga Khan Foundation Projects in East Africa*. Netherlands: Swets & Zeitlinger.

Appleton, K. (2008). Developing science pedagogical content knowledge through mentoring elementary teachers. *Journal of Science Teacher Education*, *19*(6), 523-545.

Asmal, K., & James, W. (2001). Education and democracy in South Africa today. *Daedalus*, *130*(1), 185-204.

Avenstrup, R. (2007). The challenge of curriculum reform and implementation: Some implications of a constructivist approach. *Ministry of National Education.* Retrieved from http://tedp.meb.gov.tr

Babbie, E. R. (1990). *Survey research methods*. Belmont, CA: Wadsworth Publishing Company.

Ball, D. L. & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In G. Sykes and L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp.3-32). San Francisco: Jossey Bass.

Ballantyne, R., Hansford, B., & Packer, J. (1995). Mentoring beginning teachers: A qualitative analysis of process and outcomes. *Educational Review, 47*(3), 297-307.

Bandura, A. (1986). *Social foundations of thought and action: a social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1994). *Self-efficacy: The exercise of control.* San Francisco, California: Freeman.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. San Francisco, California: Freeman.

Bantwini, B. D. (2011). District officials' assumptions about teacher learning and change: hindering factors to curriculum reform implementation in South Africa. *International Journal of Education, 3*(1), 1-25.

Bantwini, B. D. (2009). District professional development models as a way to introduce primary-school teachers to natural science curriculum reforms in one district in South Africa. *Journal of Education for Teaching*, *35*(2), 169-182.

Baird, W. E., & Rowsey, R. E. (1989). A survey of secondary science teachers' needs. *School Science and Mathematics*, *89*(4), 272-284.

Barnes, R. (2005). Moving towards technology education: Factors that facilitated teachers' implementation of a technology curriculum. *Journal of Technology Education*, *17*(1), 6-18.

Barlow, J. (2002). Technology Teacher Education: Is it Time to do a Maslow? *Learning in Technology Education: Challenges for the 21st Century*, *21*, 9-16.

Behar, L. S., & George, P. S. (1994). Teachers' use of curriculum knowledge. *Peabody Journal of Education*, *69*(3), 48-69.

Bell, B., & Gilbert, J. (1994). Teacher development as personal, professional, and social development. *Teaching and Teacher Education, 10*, 483-497.

Bennett, C. K. (1994). Reconceptualizing Staff Development for Technology Diffusion. *Journal of Information Technology for Teacher Education*, *3*(2), 147-161.

Bennett, J. (2005). *Teaching and learning science: A guide to recent research and its applications*. London: Continuum International Publishing Group.

Bertram, C. (2011). What does research say about teacher learning and knowledge?: Implications for professional development in South Africa. *Journal of Education*, *52,* 3-26.

Bertram, C., Mthiyane, N., & Mukeredzi, T. (2012). 'It will make me a real teacher': Learning experiences of part time PGCE students in South Africa. *International Journal of Educational Development*, *33*(5), 448-456.

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership*, *57*(8), 28-33.

Blanche, M. M. J. T., Blanche, M. T., Durrheim, K., & Painter, D. (Eds.). (2006). *Research in practice: Applied methods for the social sciences*. Cape Town: UCT Press.

Botha, M. L., & Reddy, C. P. S. (2011). In-service teachers' perspectives of pre-service teachers' knowledge domains in science. *South African Journal of Education*, *31*(2), 257-274.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3-15.

Boyle, B., Lamprianou, I., & Boyle, T. (2005). A longitudinal study of teacher change: What makes professional development effective? Report of the second year of the study. *School Effectiveness and School Improvement*, *16*(1), 1-27.

Bredeson, P. V. (2002). The architecture of professional development: Materials, messages and meaning. *International Journal of Educational Research*, *37*(8), 661-675.

Bush, T., Kiggundu, E., & Moorosi, P. (2011). Preparing new principals in South Africa: the ACE: School Leadership Programme1. *South African Journal of Education*, *31*(1), 31-43.

Bybee, R. W., & Loucks-Horsley, S. (2000). Advancing technology education: The role of professional development. *The Technology Teacher*, *60*(2), 31-34.

Cape Higher Education Consortium (CHEC). (2009). *Educator supply and demand in the Western Cape*. Western Cape Education Department. Cape Town: CHEC. Retrieved from www.chec.ac.za

Carlsen, W. S. (1999). Domains of teacher knowledge. In N. G. Lederman, & J. Gess-Newsome (Eds.), Examining pedagogical content knowledge: *The construct and its implications for science education* (pp. 133-144). Dordrecht, Netherlands: Kluwer.

Carlson, R. (1989). Malcolm Knowles: Apostle of andragogy. *Vitae Scholasticae*, *8*(1), 217-233.

Chikoko, V. (2007). The school cluster system as an innovation: Perceptions of Zimbabwean teachers and school heads. *Africa Education Review*, *4*(1), 42-57.

Chisholm, L. (2005). The making of South Africa's national curriculum statement. *Journal of Curriculum Studies*, *37*(2), 193-208.

Chisholm, L. (2009). *An overview of research, policy and practice in teacher supply and demand 1994-2008.* Cape Town: HSRC Press. Retrieved from www.hsrc.org.za

Chisholm, L., Volmink J., Ndhlovu, T., Potenza, E., Mohamed, H., Muller. J., Lubisi. C., Vinjevold. P., Ngozi, L., Malan, B., & Mphahlele, M. (2000). A South African curriculum for the twenty-first century: *Report of the review committee on Curriculum 2005.* Presented to the Minister of Education, Professor Kader Asmal: Pretoria.

Chval, K., Abell, S., Pareja, E., Musikul, K., & Ritzka, G. (2008). Science and mathematics teachers' experiences, needs, and expectations regarding professional development. *Eurasia Journal of Mathematics, Science and Technology Education*, *4*(1), 31-43.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*(8), 947-967.

Clermont, C. P., Borko, H., & Krajcik, J. S. (1994). Comparative study of the pedagogical content knowledge of experienced and novice chemical demonstrators. *Journal of Research in Science Teaching*, *31*(4), 419-441.

Cobb, P., Wood, T., & Yackel. E. (1990). Classrooms as Learning Environments for Teachers and Researchers. *Journal for Research in Mathematics Education, 4,* 125-210.

Coble, R. C., & Williams, T. (1998). The partnership concept: A framework for building and sustaining university-school partnerships. *Unpublished paper presented to the forum for Preparing for 21st Century Schools, University of North Carolina*. Retrieved from http://www.ga.unc.edu/21stcenturyschools/reports/partnerconcept.html.

Cohen, L., Manion, L. & Morrison, K. R. B. (2000). *Research Methods in Education*, 5th ed. London: Routledge Falmer.

Council on Higher Education. (2010). *Report on the National Review of Academic and Professional Programmes in Education*. Pretoria. Retrieved from www.dhet.gov.za

Craft, A. (2000). *Continuing Professional Development: A practical guide for teachers and schools*. London: Routledge Falmer.

Creswell, J. W., & Plano Clark, V. L. P. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: SAGE.

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). Advanced mixed methods research designs. *Handbook of mixed methods in social and behavioral research* (pp 209-240). Thousand Oaks, CA: SAGE.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: SAGE.

Crookes, G. (1997). What influences what and how second and foreign language teachers teach? *The Modern Language Journal*, *81*(1), 67-79.

Daloz, L. A. (1986). *Mentor: guiding the journey of adult learners.* San Francisco, California: Jossey-Bass.

Damnjanovic, A. (1999). Attitudes Toward Inquiry-Based Teaching: Differences between Pre-service and In-service Teachers. *School Science and Mathematics*, *99*(2), 71-76.

Darling-Hammond, L. (1993). Reframing the School Reform Agenda: Developing Capacity for School Transformation. *Phi Delta Kappan*, *74*(10), 752-61.

Darling-Hammond, L., & McLaughlin, M. W. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappan*, *76*(8), 597-604.

Darling-Hammond, L.. & Sykes, G. (2003). Wanted: A national teacher supply policy for education: The right way to meet the "Highly Qualified Teacher" challenge. *Education Policy Analysis Archives*, *11*(33). Retrieved from http://epaa.asu.edu/epaa/v11n33/.

Dass, P. M., & Yager, R. E. (2009). Professional development of science teachers: History of reform and contributions of the STS-based Iowa Chautauqua program. *The Science Education Review*, *8*, 99-111.

Day, C. (Ed.). (1999). *Developing Teachers: the challenges of lifelong learning*. London: Falmer Press.

Day, C., & Sachs, J. (Eds.). (2004). *International handbook on the continuing professional development of teachers*. Berkshire: McGraw-Hill Education.

Day, C. (2011). *The Routledge international handbook of teacher and school development*. London: Routledge.

De Vos, A. S., Strydom, H., Fouché, C. B., & Delport, C. S. L. (2005). *Research at grass roots for the Social sciences and human service professions.* Pretoria: Van Schaik.

Delport, A., & Makaye, J. (2009). Clustering schools to improve teacher professional development: Lessons learnt from a Zimbabwean case study. *Africa Education Review*, *6*(1), 96-105.

Dempster, E. R., & Hugo, W. (2006). Introducing the concept of evolution into South African schools. *South African Journal of Science*, *102*, 106-112.

DoE (2000). *National Education policy ACT, 1996: Norms and Standards for Educators, 2000*. Pretoria. Retrieved from www.education.gov.za

DoE (2003). *National Curriculum Statement Grade 10-12 (Life Sciences)*. Pretoria. Retrieved from www.education.gov.za

DHET (2012). *Green paper for post-school education and training*. Pretoria. Retrieved from www.saqa.org.za

DoE (2009a). *Education statistics in South Africa 2007*. Pretoria. Retrieved from www.education.org.za

DoE (2009b). *Report on research into teacher upgrading*. Pretoria. Retrieved from www.education.gov.za

DoE (2009c). *Report of the task team for the review of the Implementation of the National Curriculum Statement.* Pretoria. Retrieved from www.education.gov.za

DBE, & DHET. (2011). *Integrated Strategic Planning Framework for Teacher Education & Development in South Africa 2011-2025: Technical report*. Pretoria. Retrieved from www.education.gov.za

DoE (2007). *A new content framework for the subject Life Sciences as listed in the National Curriculum Statements Grades 10 – 12 (General).* Circular 67/2007; 25 September 2007. Retrieved from www.education.gov.za

DBE (2011a). *Report on the National Senior Certificate examination 2011: National diagnostic report on learner performance.* Pretoria. Retrieved from www.education.gov.za

DBE (2011b). *Guidelines on the organization, roles and responsibilities of education districts*. Pretoria. Retrieved from www.education.gov.za

DBE (2011c). *National Curriculum Statement: Curriculum and Assessment Policy Statement Grades 10-12 – Life Sciences*. Pretoria: DBE. www.education.gov.za

DBE (2012). *National Senior Certificate Examination: Technical Report 2012*. Pretoria. Retrieved from www.education.gov.za

DBE (2013a). National Education Evaluation and Development Unit (NEEDU): *National Report 2012*. Pretoria. Retrieved from www.education.gov.za

DBE (2013b). *Education Statistics in South Africa 2011*. Pretoria. Retrieved from www.education.gov.za

DBE (2013c). *National diagnostic report on learner performance 2012*. Pretoria. Retrieved from www.education.gov.za

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis*, *24*(2), 81-112.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181-199.

Dilley, L., & Roman, A. (1998). *Support services in distance education*. Pretoria: University of South Africa.

Dempster, E.R. & Hugo, W. (2006). Introducing the concept of evolution into the South African school curriculum. *South African Journal of Science 102*, 106-112.

Dlamini, A. P. (2008). *Teaching of scientific investigations by life sciences and natural sciences educators in Bushbuckrigde.* Unpublished Masters dissertation, University of South Africa, Pretoria.

Doidge, M., Dempster, E., Crowe, A., & Naidoo, K. (2008). The Life Sciences content framework: A story of curriculum change. In *Proceedings of the 4th Biennial Conference of the South African Association of Science and Technology Educators* (pp. 14-19).

Driver, R., & Erickson, G. (1983). Theories-Action: Some Theoretical and Empirical Issues in the Study of Students' conceptual Frameworks in Science. *Studies in Science Education*, *10*, 37-60.

Driver, R., Rushworth, P., Squires, A., & Wood-Robinson,V. (Eds). (1994). *Making sense of secondary science: Research into children's ideas*. London: Routledge.

ELRC (2009). *Teacher Development Summit Declaration: 2009*. Pretoria. Retrieved from www.sace.org.za

Engelbrecht, W., Ankiewicz, P., & De Swardt, E. (2007). An industry-sponsored, school-focused model for continuing professional development of technology teachers. *South African Journal of Education*, *27*(4), 579-596.

Ernest, P. (1989). The Knowledge, Beliefs and Attitudes of the Mathematics Teacher: A Model. *Journal of Education for Teaching: International Research and Pedagogy*, *15*(1), 13-33.

Evans, L. (2002). What is teacher development? *Oxford Review of Education*, *28*(1), 123-137.

Ferraro, J. M. (2000). *Reflective practice and professional development.* Washington, DC: Department of Education. Retrieved from ERIC Database. ERIC Document Reproduction Service No. ED449120).

Field, A. (2003) *Discovering Statistics.* London: SAGE Publications.

Fiske, E. B., & Ladd, H. F. (2004). Balancing public and private resources for basic education: school fees in post-apartheid South Africa. In L. Chisholm. (Eds). *Changing class: Education and social change in post-apartheid South Africa* (pp. 267-291). Cape Town: HSRC Press.

Fraser, C., Kennedy, A., Reid, L., & Mckinney, S. (2007). Teachers' continuing professional development: contested concepts, understandings and models. *Journal of In-service Education*, *33*(2), 153-169.

Friedman, A., & Phillips, M. (2004). Continuing professional development: developing a vision. *Journal of Education and Work*, *17*(3), 361-376.

Fullan, M. (1991). *The new meaning of educational change*. London: Casell.

Fullan, M. (2001). *The new meaning of educational change*. New York: Teachers College Press.

Fullan, M. (2007). *The new meaning of educational change*. New York: Teachers College Press.

Fullan, M. (2005). *Leadership and Sustainability. System thinkers in action*. Thousand Oaks, CA: Corwin Press.

Fullan, M. G., & Miles, M.B. (1992). Getting reform right: what works and what doesn't. *PhiDelta Kappan, 73(10), 745-752.*

Fullan, M., 2002. Educational reform as continuous improvement. In W. Hawley, (Ed.), *The key to effective schools: Educational reform as continuous improvement* (pp. 1‑12). Thousand Oaks, CA: Corwin Press.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Giordano, E. A. (2008). *School clusters and teacher resource centres*. UNESCO, International Institute for Educational Planning. Retrieved from http://unesdoc.unesco.org

Geddis, A. N. (1993). Transforming subject-matter knowledge: the role of pedagogical content knowledge in learning to reflect on teaching. *International Journal of Science Education*, *15*(6), 673-683.

Gess-Newsome, J. (1999). Pedagogical content knowledge: An introduction and orientation. In Gess-Newsome, J. & Lederman, N. G. (Eds). P*edagogical content knowledge and Science Education* (pp. 3-17). Netherlands: Kluwer Academic Publishers.

Gierdien, F. (2008). Teacher learning about probabilistic reasoning in relation to teaching it in an Advanced Certificate in Education (ACE) programme. *South African Journal of Education*, *28*(1), 19-38.

Glasersfield, E. (1995). *Radical Constructivism: A way of knowing and learning*. London: Falmer Press.

Goldschmidt, P., & Phelps, G. (2010). Does teacher professional development affect content and pedagogical knowledge: How much and for how long? *Economics of Education Review*, *29*(3), 432-439.

Gomez-Zwiep, S. (2008). Elementary teachers' understanding of students' science misconceptions: Implications for practice and teacher education. *Journal of Science Teacher Education*, *19*(5), 437-454.

González, A., Montoya, C., & Sierra, N. (2002). What do EFL teachers seek in professional development programs? Voices from teachers. *Íkala, Revista de Lenguajey Cultura, 8*(14), 153-172.

Grant, C. (2008). 'We did not put our pieces together': exploring a professional development initiative through a distributed leadership lens. *Journal of Education*, *44*, 85-107.

Graven, M. (2003). Teacher learning as changing meaning, practice, community, identity and confidence: The story of Ivan. *For the Learning of Mathematics*, *23*(2), 28-36.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.

Grundy, S., & Robison, J. (2004) Teacher professional development: themes and trends in the recent Australian experience. In C. Day, & J. Sachs (Eds.), *International Handbook on the Continuing Professional Development of Teachers* (pp. l46–66). Maidenhead: Open University Press.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: Sage.

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational Researcher*, *15*(5), 5-12.

Guskey, T. R. (1995). *Professional development in education: New paradigms and practices*. New York: Teachers College Press.

Guskey, T. (2000). *Professional development*. Thousand Oaks, CA: Corwin Press.

Guskey, T. R. (2002). Professional development and teacher change. *Teachers and teaching: Theory and practice*, *8*(3), 381-391.

Goderya-Shaikh, F. (2010). Professional Development with Follow-up for an Effective Paradigm Shift. *International Journal for Cross-Disciplinary Subjects in Education (IJCDSE)*, *1*(3), 182-189.

Grant, J. (2002). Learning needs assessment: assessing the need. *BMJ: British Medical Journal*, *324*(7330), 156.

Hammerness, K., Darling-Hammond, L., Bransford, J., Berliner, D., Cochran-Smith, M., McDonald, M., & Zeichner, K. (2005). How teachers learn and develop. In L. Darling-Hammnond, & J. Bransford, (Eds.). *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp 358-389). San Francisco, CA: Jossey-Bass.

Hargreaves, A. (1998). The emotional politics of teaching and teacher development: With implicatinos for educational leadership. *International Journal of Leadership in Education Theory and Practice*, *1*(4), 315-336.

Hargreaves, A. Earl, L., Shawn, M., & Manning, S. (2001). *Learning to change: Teaching beyond subjects and standards*. San Francisco, CA: Jossey-Bass.

Hargreaves, A., & Fullan, M. G. (1992). *Understanding teacher development*. New York: Teachers College Press.

Hargreaves, A., & Fullan, M. (2000). Mentoring in the new millennium. *Theory into Practice*, *39*(1), 50-56.

Harvey, P. (2005). Motivating factors influencing teachers' engagement in postgraduate study: The results of a study of five schools. *A paper presented at the Australian Association for Research in Education Conference 2005*. Retrieved from http://publications.aare.edu.au/05pap/har05249.pdf

Hattingh, A., Aldous, C., & Rogan, J. (2007). Some factors influencing the quality of practical work in science classrooms. *African Journal of Research in Mathematics, Science and Technology Education,* 11, 75–90.

Hausfather, S. (2001). Where's the content? The role of content in constructivist teacher education. *Educational Horizons, 80*, 15-19.

Hawley, W. D., & Valli, L. (2000). Learner-centered professional development. *Phi Delta Kappa, 27*, 7-10.

Henze, I., Van Driel, J. H., & Verloop, N. (2008). Development of experienced science teachers'pedagogical content knowledge of models of the solar system and the universe. *International Journal of Science Education*, *30*(10), 1321-1342.

Hewson, P. W. (2007). Teacher professional development in science. In, S. K., Abell, & N. G.,Lederman (Eds.). *Handbook of Research on Science Education* (pp. 1177- 1203). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Holloway, J. (2001). The benefits of mentoring. *Educational Leadership, 58*, 85-86.

Howard, B. C., McGee, S., Schwartz, N., & Purcell, S. (2000). The experience of constructivism: Transforming teacher epistemology. *Journal of Research on Computing in Education*, *32*(4), 455-65.

HSRC (2004). *Trends in International Mathematics and Science Study (TIMSS) 2003*. Pretoria. Retrieved from www.hsrc.ac.za

HSRC (2012). *Towards equity and excellence. Highlights from TIMSS 2011: A South African perspective.* Pretoria. Retrieved from www.hsrc.ac.za

Huberman, M. (2001) Networks that alter teaching: conceptualisation, exchanges and experiments. In J. Sole, A. Craft & H. Bugerss (Eds). *Development: exploring our own practice* (pp141-159). London: Paul Chapman.

Ingvarson, L., Meiers, M., & Beavis, A. (2005). Teaching and Learning and Leadership Professional Development for Teachers and School Leaders : Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes & efficacy. *Education Policy Analysis Archives*, *13*(10), 1-28.

Jansen, J. D. (1998). Curriculum Reform in South Africa: A critical analysis of outcomes-based education. *Cambridge Journal of Education*, *28*(3), 321-331.

Jita, L. C., & Ndlalane, T. C. (2009). Teacher clusters in South Africa: opportunities and constraints for teacher development and change. *Perspectives in Education, 27*(1), 58-68.

Johnson, B., & Christensen, L. (2008). *Educational research: Quantitative, qualitative, and mixed approaches*. Thousand Oaks, California: SAGE.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*(2), 112-133.

Johnson, K. E. (1996). The Role of Theory in L2 Teacher Education. *Tesol Quarterly*, *30*(4), 765-771.

Johnson, S., Hodges, M., & Monk, M. (2000). Teacher development and change in South Africa: critique of the appropriateness of transfer of northern/western practice. *Compare, 30*(2), 179-192.

Joyce, B. R., & Showers, B. (2002). *Student achievement through staff development.* London: Longman.

Kamariah A. B, Rubba, P. , Tomera, A., N., & Zurub, A. R. (1988). Jordanian and Malaysian science teachers' prominent perceived professional needs: A comparison. *Journal of Research in Science Teaching, 25*(3), 170-182.

Karaman, A. (2012). The Place of Pedagogical Content Knowledge in Teacher Education. *Atlas Journal of Science Education, 2*(1), 56-60.

Kazemi, E., & Hubbard, A. (2008). New Directions for the Design and Study of Professional Development Attending to the Coevolution of Teachers' Participation Across Contexts. *Journal of Teacher Education*, *59*(5), 428-441.

Kazempour, M. (2009). Impact of Inquiry-Based Professional Development on Core Conceptions and Teaching Practices: A Case Study. *Science Educator, 18*(2), 56-68.

Kennedy, M. M. (1998). Education reform and subject matter knowledge. *Journal of Research in Science Teaching, 35*(3), 249-263.

Kennedy, A. (2005). Models of continuing professional development: A framework for analysis. *Journal of In-service Education*, *31*(2), 235-250.

Kent, A.M. (2004). Improving teacher quality through Professional Development. *Education, 124* (3), 427-435.

Kiggundu, E., & Nayimuli, S. (2009). Teaching practice: a make or break phase for student teachers. *South African Journal of Education*, *29*(3), 345-358.

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education*, *45*(2), 169-204.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instructiondoes not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75-86.

Knowles, M. S. (1970). *The modern practice of adult education: Andragogy versus pedagogy*. New York: Association Press.

Knowles, M. S. (1998). *The adult learner: the definitive classic in adult education and human resource development.* Woburn, Mass: Butterworth-Heinemann.

Knox, A. B. (1980). Proficiency theory of adult learning. *Contemporary educational psychology*, *5*(4), 378-404.

Komba, W. L., & Nkumbi, E. (2008). Teacher professional development in Tanzania: Perceptions and practices. *Journal of International Cooperation in Education*, *11*(3), 67-83.

Kriek, J., & Grayson, D. (2009). A Holistic Professional Development model for South African physical science teachers. *South African Journal of Education*, *29*(2), 185-203.

KZN Department of Education (2003). *SMT handbook.* Pietermaritzburg. Retrieved from www.kzneducation.gov.za

KZN DoE (2007). Media statement, 22 February 2007: *KZNDepartment of Education upgrades teacher skills*. Pietermaritzburg. Retrieved from www.kzneducation.gov.za

KZN DoE (2011). *Education Management Information Systems: 2011 snap survey report for ordinary schools.* Pietermaritzburg. Retrieved from www.kzneducation.gov.za

KZN DoE (2012). *School's report: National Senior Certificate.* Pietermaritzburg. Retrieved from www.kzneducation.gov.za

KZN DoE (2013). *School's report: National Senior Certificate.* Pietermaritzburg. Retrieved from www.kzneducation.gov.za

Lauer, P.A., Christopher, D.E., Firpo-Triplett, R., & Buchting, F. (2014). The impact of short-term professional development on participant outcomes: a review of the literature. *Professional Development in Education*, 40 (2), 207-227.

Laugksch, R., Rakumako, A., Manyelo, T., & Mabye, D. (2005). Development and validation of the Science Teacher Inventory of Needs for Limpopo province (STIN-LP). *South African Journal of Education*, *25*(4), 273-278.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. UK: Cambridge university press.

Lederman, N.G., Gess-Newsome, J., & Latz, M.S. (1994). The nature and development of preservice science teachers' conceptions of subject matter and pedagogy. *Journal of Research in Science Teaching, 31,* 129–146.

Lee, O., Hart, J. E., Cuevas, P., & Enders, C. (2004). Professional development in inquiry-based science for elementary teachers of diverse student groups. *Journal of Research in Science Teaching*, *41*(10), 1021-1043.

Lee, I. (2011). Teachers as presenters at continuing professional development seminars in the English-as-a-foreign-language context: I find it more convincing. *Australian Journal of Teacher Education*, *36*(2), 29-42.

Leinhardt, G. (1992). What research on learning tells us about teaching. *Educational Leadership*, *49*(7), 20-25.

Leu, E. (2004). *The patterns and purposes of school-based and cluster teacher professional development programs,* (EQUIP1 Working Paper No. 2). Washington, DC: USAID. Retreived from www.equip123.net.docs/working_p2.pdf.

Lessing, A., & De Witt, M. (2007). The value of continuous professional development: teachers' perceptions. *South African Journal of Education*, *27*(1), 53-67.

Lieberman, A. (1995). Practices that support teacher development: Transforming conceptions of professional learning. *Innovating and evaluating science education: NSF evaluation forums*, *1992-94*, 67.

Lieberman, A., & Miller, L. C. (2001). *Teachers caught in the action: Professional development that matters*. New York: Teachers College Press.

Lieberman, A., & Mace, D. H. P. (2008). Teacher learning: The key to educational reform. *Journal of Teacher Education*, *59*(3), 226-234.

Lieberman, A., & Mace, D. P. (2010). Making practice public: Teacher learning in the 21st century. *Journal of Teacher Education*, *61*(1-2), 77-88.

Lieberman, A., & McLaughlin, M. W. (1992). Networks for Educational Change: Powerful and Problematic. *Phi Delta Kappan*, *73*(9), 673-77.

Lieberman, A., & Grolnick, M. (1996). Networks and reform in American education. *The Teachers College Record*, *98*(1), 7-46.

Little, J. W. (1996). The school restructuring study—what are we learning? *An interim report to the Stuart Foundations, the Hewlett Foundation, and case study sites*. Retrieved from http://www.ed.gov/pubs/EdReformStudies/SysReforms/little1.html

Little, J. W. (2002). Professional community and the problem of high school reform. *International Journal of Educational Research*, *37*(8), 693-714.

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, *41*(4), 370-391.

Loughran, J., Mulhall, P., & Berry, A. (2008). Exploring pedagogical content knowledge in science teacher education. *International Journal of Science Education*, *30*(10), 1301-1320.

Loughran, J. J., Berry, A. K., & Mulhall, P. (2012). *Understanding and developing science teachers' pedagogical content knowledge.* Rotterdam: Sense Publishers.

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Hewson, P. W., & Love, N. (Eds.). (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School science and mathematics*, *99*(5), 258-271.

MacMillan, J. H., & Schumacher, S. (2010). *Research in education*. New York: Harper Collins.

MacNeil, D. J. (2004). School and cluster-based teacher professional development: bringing teacher learning to the schools. *US Agency for International Development: Washington, DC*. Retrieved from http://www.equip123.net/docs/eq1workingpaper1.pdf

Magubane, G.P. (2012). A survey of Life Sciences teachers' understanding of the theory of Evolution. Masters dissertation, University of KwaZulu-Natal, South Africa.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome, & N. G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95-132). Dordrecht: Kluwer Academic Publishers.

Maistry, M. (2008). Transcending traditional boundaries for teacher professional development: exploring a community of practice approach to CPD. *Journal of Education*, *43*, 127-153.

Malcolm, C. (2001). Implementation of outcomes based approaches to education in Australia and South Africa: A comparative study. In Sayed, Y. & Jansen, J. (Eds). *Implementing educational policies: the South African experience* (pp 200-239). Cape Town: University of Cape Town Press.

Marshall, C., & Rossman, G. B. (2010). *Designing qualitative research*. Thousand Oaks, California: SAGE.

Martinez, K. (2004). Mentoring new teachers: Promise and problems in times of teacher shortage. *Australian Journal of Education*, *48*(1), 95-108.

Marx, R. W., & Harris, C. J. (2006). No Child Left Behind and science education: Opportunities, challenges, and risks. *The Elementary School Journal*, *106*(5), 467-478.

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*(4), 370.

Matthews, M. R. (1993). Constructivism and science education: Some epistemological problems. *Journal of Science Education and Technology*, *2*(1), 359-370.

McRobbie, C., & Tobin, K. (1997). A social constructivist perspective on learning environments. *International Journal of Science Education*, *19*(2), 193-208.

Merriam, S. B. (2001). Andragogy and self-directed learning: Pillars of adult learning theory. In S. B. Merriam (Ed.). *New directions for adult and continuing education* (pp. 3-14). Jossey-Bass: San Francisco.

Mestry, R., Hendricks, I., & Bisschoff, T. (2009). Perceptions of teachers on the benefits of teacher development programmes in one province of South Africa. *South African Journal of Education*, *29*(4), 475-490.

Mji, A., & Makgato. M. (2006). Factors associated with high school learners' performance: A spotlight on mathematics and physical science. *South African Journal of Education, 26*(2), 253-266.

Moeini, H. (2008). Identifying needs: A missing part in teaching training programs. *International Journal of Media, Technology and Lifelong Learning, 4*(1), 1-12.

Mohono-Mahlatsi, L., & Van Tonder, F. (2006). The effectiveness of mentoring in the Distance Teacher Education Programme at the Lesotho College of Education: student teachers' and tutors' perceptions. *South African Journal of Education*, *26*(3), 383-396.

Morgan, D. L. (2007). Paradigms lost and pragmatism regained methodological implications of combining qualitative and quantitative methods. *Journal of Mixed Methods Research*, *1*(1), 48-76.

Morris, V.G. & Chance, L.H. (2006). Customized professional development for in-service teachers in a school-university partnership. *Journal of In-Service Education*, 23(3), 335-348.

Morrow, W. (2007). What is teachers' work? *Journal of Education*, *41*, 3-20.

Motlhabane, A., & Dichaba, M. (2013). Andragogical Approach to Teaching and Learning Practical Work in Science: A Case of In-service Training of Teachers. *International Journal of Educational Sciences*, *5*(3), 201-207.

Mudaly, V., & Moore-Russo, D. (2011). South African teachers' conceptualisations of gradient: A study of historically disadvantaged teachers in an Advanced Certificate in Education programme. *Pythagoras*, *32*(1), 27-33.

Murphy, E. (1997). *Constructivism: From Philosophy to Practice*. Retrieved from http://files.eric.ed.gov/?id=ED444966

Mutemeri, J., & Chetty, R. (2013). Teacher educators' perspectives about the relationship between research and teaching in South African universities. *European Journal of Academic Research*, *1*(2), 62-75.

Ngema, S. N. (2011). *An exploration of grade 11 teachers' conceptions of practical work in physical sciences within the National Curriculum Statement (NCS) curriculum*. Unpublished Masters Thesis, University of KwaZulu-Natal, South Africa.

Ngidi, D. P. (2005). Evaluation of the effectiveness of the competences of the NPDE programme. *South African Journal of Education*, *25*(1), 34-37.

Ngidi, D., Sibaya, P., Sibaya, D., Khuzwayo, H., Maphalala, M., & Ngwenya, N. (2010). Evaluation of the effectiveness of the 360-credit National Professional Diploma in Education (NPDE) programme. *South African Journal of Education*, *30*(1), 27-39.

Ngxola, N. (2012). *Teaching evolution in a new curriculum: Life Sciences teachers' concerns and needs.* Unpublished Masters dissertation, Wits University, South Africa.

Neufeld, B., & Roper, D. (2003). *Expanding the work: Year II of collaborative coaching and learning in the effective practice schools*. Retrieved from http://eric.ed.gov/?id=ED480874

Nichol, J., & Turner-Bisset, R. (2006). Cognitive apprenticeship and teachers' professional development. *Journal of In-service Education*, *32*(2), 149-169.

Nieto, S. (2003). Challenging current notions of "highly qualified teachers" through working a teachers' inquiry group. *Journal of Teacher Education*, *54*(5), 386–398.

Noh, T., Cha, J., Kang, S., & Scharmann, L., C. (2004). Perceived professional needs of Korean science teachers majoring in chemical education and their preferences for online and on-site training. *International Journal of Science Education, 26*(10), *1269–1289.*

Nykiel-Herbert, B. (2004). Mis-constructing knowledge: The case of learner-centred pedagogy in South Africa. *Prospects*, *34*(3), 249-265.

Oliver, R., Vanderford, S., & Grote, E. (2012). Evidence of English language proficiency and academic achievement of non-English-speaking background students. *Higher Education Research & Development*, *31*(4), 541-555.

Ono, Y., & Ferreira, J. (2010). Acase study of continuing teacher professional development through lesson study in South Africa. *South African Journal of Education*, *30*(1), 59–74.

Onwuegbuzie, A.J., & Teddlie, C. (2003). A framework for analyzing data in mixed methods research. In A. Tashakkori, & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 351-383). Thousand Oaks, CA: Sage.

Onwuegbuzie, A. J., & Johnson, R. B. (2006). The validity issue in mixed research. *Research in the Schools*, *13*(1), 48-63.

Opfer, V. D., & Pedder, D. (2011). Conceptualizing teacher professional learning. *Review of Educational Research*, *81*(3), 376-407.

Osborne, J. F. (1996). Beyond constructivism. *Science Education*, *80*(1), 53-82.

Osman, K., Halim, L., & Meerah, S., M. (2006). What Malaysian science teachers need to improve their science instruction. A comparison across gender, school location and area of specialization. *Eurasia Journal of Mathematics, Science and Technology Education 2*(2), 58-81.

O' Sullivan, M. (2002). Action Research and the Transfer of Reflective Approaches to In-Service Education and Training (INSET) for Underqualified Primary Teachers in Namibia. *Teaching and Teacher Education. 18*, 523-539.

Palmer, D. (2005). A motivational view of constructivist-informed teaching. *International Journal of Science Education*, *27*(15), 1853-1881.

Park, S., & Oliver, J. S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, *38*(3), 261-284.

Patton, M. Q. (2002) *Qualitative research and evaluation methods.* Thousand Oaks, California: SAGE.

Peacock, A. (1993). The in-service training of primary teachers in science in Namibia: models and practical constraints. *British Journal of In-Service Education*. *19*(2), 21–26.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, *44*(4), 921-958.

Perraton, H., Creed, C. and Robinson, B. (2002). *Teacher education guidelines: Using open and distance learning.* Paris: UNESCO. Retrieved from www.uis.unesco.org/Library/Documents/teachers06-en.pdf

Pillay, A. (2004). *An exploration of biology teachers' practice with regard to practical work and how it relates to the NCS-FET Life Sciences policy document.* Unpublished Masters Thesis, University of KwaZulu-Natal, South Africa.

Pressley, M., Harris, K. R., & Marks, M. B. (1992). But good strategy instructors are constructivists!. *Educational Psychology Review*, *4*(1), 3-31.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning?. *Educational Researcher*, *29*(1), 4-15.

Putman, S. M., Smith, L. L., & Cassady, J. C. (2009). Moving Beyond Legislation to Create and Sustain Intentionality in Reading Instruction. *The Educational Forum 73*(4), 318-332.

Rage, O. H. (2006). *Do school-based teacher professional development programmes work? Teachers' perceptions on values of school-based professional development programmes.* Unpublished Masters thesis, University of KwaZulu-Natal, South Africa.

Ramcharan, A. P. (2009). *Language Proficiency and Academic Perfomance: The Case Study for a Secondary School in KwaZulu-Natal.* Doctoral dissertation, University of KwaZulu-Natal, South Africa.

Rakumako, A., & Laugksch, R. (2010). Demographic profile and perceived INSET needs of secondary Mathematics teachers in Limpopo province. *South African Journal of Education*, *30*(1), 139-152.

Ratcliffe, M. (2008). Pedagogical content knowledge for teaching concepts of the nature of science. *Paper presented at the* 9th *Nordic Research Symposium on Science Education, Reykjavik, Iceland, 11 - 15 Jun 2008.* Retrieved from http://eprints.soton.ac.uk/59177/1/PCK_NoS_Nordic_symp.pdf

Rehorek, S. J. (2004). Inquiry-based teaching: an example of descriptive science in action. *The American Biology Teacher*, *66*(7), 493-499.

Rhodes, C., & Beneicke, S. (2002). Coaching, mentoring and peer-networking: challenges for the management of teacher professional development in schools. *Journal of In-Service Education*, *28*(2), 297-310.

Robinson, M. (2002). Teacher reforms in South Africa: Challenges, strategies and debates. *Prospects*, *11*(3): 289-299.

Rogan, J. M., & Grayson, D. J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education*, *25*(10), 1171-1204.

Rogan, J. M. (2004). Out of the frying pan...? Case studies of the implementation of Curriculum 2005 in some science classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, *8*(2), 165-179.

Rogan, J., & Aldous, C. (2005). Relationships between the constructs of a theory of curriculum implementation. *Journal of Research in Science Teaching*, *42*(3), 313-336.

Rollnick, M., Bennett, J., Rhemtula, M., Dharsey, N., & Ndlovu, T. (2008). The place of subject matter knowledge in pedagogical content knowledge: A case study of South African teachers teaching the amount of substance and chemical equilibrium. *International Journal of Science Education*, *30*(10), 1365-1387.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68.

Sahlberg, P. (2006). Education reform for raising economic competitiveness. *Journal of Educational Change*, *7*(4), 259-287.

Sandholtz, J. H. (2002). Inservice training or professional development: Contrasting opportunities in a school/university partnership. *Teaching and Teacher Education, 18*(7), 815-830.

Sayed, Y. (2008). Changing forms of teacher education in South Africa: a case study of policy change. *International Journal of Educational Development, 22*, 381–395.

Schmidt, V. H. (2001). Oversocialised epistemology: A critical appraisal of constructivism. *Sociology*, *35*(1), 135-157.

Schudel, I., Roux, C. L., Lotz-Sisitka, H., Loubser, C., O'Donoghue, R., & Shallcross, T. (2008). Contextualising learning in Advanced Certificate in Education (Environmental Education) courses: synthesising contexts and experiences. *South African Journal of Education*, *28*(4), 543-559.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15* (2), 4-14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-22.

Shymansky, J.A. & Kyler Jr., C. W. (1992). Establishing a research agenda: Critical issues of Science Curriculum Reform. *Journal of Research in Science Teaching*, *29*(8), 749-778.

Singer, J. E., Krajcik, J. S., Marx, R. W., & Clay-Chambers, J. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, *35*(3), 165–179.

Smith, C., Hofer, J., Gillespie, M., Solomon, M., & Rowe, K. (2003). *How teachers change: A study of professional development in adult education* (NCSALL Reports). Cambridge, MA: Retrieved from http://www.ncsall.net/fileadmin/resources/research/report25a.pdf

Smith, C., & Gillespie, M. (2007). Research on professional development and teacher change: Implications for adult basic education. In J. Comings, B. Garner, & C. Smith (Eds.), *Review of adult learning and literacy: Connecting research, policy, and practice* (pp. 205-244). Mahwah, NJ: Lawrence Erlbaum Associates.

Smith, D. C., & Neale, D. C. (1989). The construction of subject matter knowledge in primary science teaching. *Teaching and Teacher Education*, *5*(1), 1-20.

SACE & DoE. (2008). *The design of the Continuing Professional Teacher Development (CPTD) system*. Pretoria. Retrieved From www.sace.org.za

SACE & DoE. (2010). *A review of teacher demand and supply*. Pretoria. Retrieved from www.sace.org.za

South African Institute of Race Relations (2012). *Only 15% of public schools have laboratories*. March 7, 2012. Retrieved from www.sairr.org.za

SAQA (2006). *The National Professional Diploma in Education*. Pretoria. Retrieved from www.saqa.org.za

SAQA (2010). *The National Professional Diploma in Education*. Pretoria. Retrieved from www.saqa.org.za

Spencer, S. S., & Logan, K. R. (2003). Bridging the gap: A school based staff development model that bridges the gap from research to practice. *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children*, *26*(1), 51-62.

Spillane, J., P. (1999). External reform initiatives and teachers' efforts to reconstruct their practice: the mediating role of teachers' zones of enactment. *Journal of Curriculum Studies 31*(2), 143-175.

Stears, M. (2006). The FET curriculum and the teaching of evolution – what are the – challenges facing teachers? *Paper presented at the 3rd biannual conference of the South African Association for Science and Technology Educators*, 4–6 July, Durban, South Africa.

Stears, M. (2012). Exploring biology education students' responses to a course in evolution at a South African university: Implications for their roles as future teachers. *Journal of Biological Education*, *46*(1), 12-19.

Stein, S. J., McRobbie, C. J., & Ginns, I. S. (2002). Implications of missed opportunities for learning and assessment in design and technology education. *Teaching and Teacher Education*, *18*(1), 35-49.

Stephen, D. F., Welman, J. C., & Jordaan, W. J. (2004). English language proficiency as an indicator of academic performance at a tertiary institution. *South African Journal of Human Resource Management*, *2*(3), 42-53.

Stiles, K. E., Loucks-Horsley, S., Mundry, S., Hewson, P. W., & Love, N. (2009). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, California:SAGE.

Tashakkori, A., & Teddlie, C. (1998). Mixed methodology: *Combining qualitative and quantitative approaches.* Thousand Oaks, California: SAGE.

Tashakkori, A., & Teddlie, C. (2003). *Handbook of mixed methods in social & behavioral research*. Thousand Oaks, California: SAGE.

Tashakkori, A., & Teddlie, C. (2010). *SAGE handbook of mixed methods in social & behavioral research*. Thousand Oaks, California: SAGE.

Taylor, N. & Vinjevold, P. (1999). Getting learning right: *A Report on the President's education initiative project.* Johannesburg. Retrieved from http://jet.org.za

Thompson, K. (2001). Constructivist curriculum design for professional development: A Review of the literature. *Australian Journal of Adult Learning*, *41*(1), 94-109.

Trotter, Y. D. (2006). Adult learning theories: Impacting professional development programs. *Delta Kappa Gamma Bulletin*, *72*(2), 8-13.

Turner-Bisset, R. (1999). The knowledge bases of the expert teacher. *British Educational Research Journal*, *25*(1), 39-55.

Umalusi (2007). The Review of the Integrated Quality Management System (IQMS). Retrieved from www.umalusi.org.za

Umalusi (2009). Access to pre-service teacher education. Umalusi/CEPD Seminar: *Access to pre-service teacher education*, 3 September 2009. Retrieved from www.cepd.org.za

UNESCO (2006). *Teachers and educational quality: Monitoring global needs for 2015*. UNESCO Institute for Statistics. Retrieved from www.unesco.rog.za

Vacirca, E. (2008). How do teachers develop their technological pedagogical content knowledge in the context of system-wide pedagogical and curriculum reform? *Conference of Australian Association for Research in Education, Brisbane, Nov 30–Dec* (Vol. 4). Retrieved from http://publications.aare.edu.au

Van Dijk, E. M., & Kattmann, U. (2007). A research model for the study of science teachers' PCK and improving teacher education. *Teaching and Teacher Education*, *23*(6), 885-897.

Van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practice and knowledge. *Journal of Research in Science Teaching*, *38*, 137-158.

Van Driel, J. H., Verloop, N., & de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of research in Science Teaching*, *35*(6), 673-695.

Van Dreil, J. H., (2010). Model-based development of science teachers' Pedagogical Content Knowledge. *Paper presented at the International Seminar, Professional Reflections, National Science Learning Centre, York, February, 2010.*

Verloop, N., Van Driel, J., & Meijer, P. (2001). Teacher knowledge and the knowledge base of teaching. *International Journal of Educational Research*, *35*(5), 441-461.

Villegas-Reimers, E. (2003). *Teacher professional development: an international review of the literature*. Paris: UNESCO International Institute for Educational Planning. Retrieved from www.iiep.unesco.org

Vygotsky, L. S. (1978). *Mind in society: the development of higher sociological process.* Cambridge, Mass: Harvard University Press.

Wanzare, Z., & Ward, K. L. (2000). Rethinking staff development in Kenya: agenda for the twenty-first century. *International Journal of Educational Management*, *14*(6), 265-275.

Welch, T., & Gultig, J. (2002). Becoming competent: Initiatives for the improvement of teacher education in South Africa 1995-2002. *Pan-Commonwealth Conference, Durban, July*. Retrieved from www.col.org/pcf2/papers/welch_t.pdf

Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems Thinker*, *9*(5), 2-3.

Wenger, E. (2000). Communities of practice and social learning systems. *Organization*, *7*(2), 225-246.

Wheatley, K. F. (2002). The potential benefits of teacher efficacy doubts for educational reform. *Teaching and Teacher Education*, *18*(1), 5-22.

Wiggins, G., & McTighe, J. (2001). What is backward design? *Understanding by Design.* Upper Saddle River, NJ: Merrill Prentice Hall.

Wildy, H., & Wallace, J. (1995). Understanding teaching or teaching for understanding: Alternative frameworks for science classrooms. *Journal of Research in Science Teaching*, *32*(2), 143-156.

Wilson, S.M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education*, *24*, 173-209.

Wlodkowski, R. J. (1999). *Enhancing adult motivation to learn: A comprehensive guide for teaching all adults*. San Francisco: Jossey-Bass.

Zurub, A. R., & Rubba, P. A. (1983). Development and validation of an inventory to assess science teacher needs in developing countries. *Journal of Research in Science Teaching*, *20*(9), 867-873.

Appendix 1

Life Sciences teachers' professional development questionnaire

Section 1: Biographical data

The teacher *(Please complete the following table and where relevant tick (✓) in the appropriate box)*

1. Age	
2. Gender	Male ☐ Female ☐
3. Please list your formal qualification/s (e.g. STD, SED, JSTC, BSc, B Ed, ACE, B Ed Honours, etc.).	
4. What is your highest academic level in Biological Sciences?	Grade12 ☐ 1st year university/college ☐ 2nd yr univ/coll. ☐ 3rd year univ/coll ☐ Hons and higher ☐
5. Your last year of registration with Higher Education Institutions	
6. Number of years teaching Biology/Life Sciences	
7. Your specialization (i.e. subjects trained to teach during your initial formal training)	
8. Grade/s currently teaching	

The School. *(Please complete the following table and where relevant, tick in the appropriate box).*

1. School location *(tick one)*	Urban ☐ Rural ☐ Township ☐ Farm ☐ Informal settlement ☐ Other ☐
2. District:	

SECTION 2: Methods of Professional Development

2A. Qualification Programmes

Are you currently registered for a qualification programme OR have you completed one of the following programmes? (i.e. ACE, PGCE, NPDE, B Ed, B Ed Honours, MEd)?

Yes ☐ ***No*** ☐

If YES, please indicate the qualification programme that you are currently doing or have recently completed. If NOT, please go to 1.4 on page 3.

ACE ☐ PGCE ☐ NPDE ☐ B Ed ☐ Hons ☐ Masters & higher ☐

Other ☐ (please specify)…………………………………………………………………………

Please indicate why you chose to do the programme by ticking the most appropriate box.

Statements	***Strongly Agree***	***Agree***	***Neutral***	***Disagree***	***Strongly Disagree***
1. To improve my subject matter/content knowledge and skills for teaching.					
2. To upgrade my qualification and get an accreditation, e.g. certificate.					
3. To get promotion.					
4. I received a bursary from the Department of Education.					
5. So that I can keep up with the continuous changes taking place in the curriculum.					
6. I want to take responsibility for my own learning.					
7. I believe that as a teacher I should continuously upgrade my knowledge and skills.					
8. I want to be a better Life Sciences teacher.					

2B. ***Please indicate the extent at which your qualification studies are helping you/have helped you develop as a teacher.***

Statements	***To a very great extent***	***To a great extent***	***To some extent***	***To a very little extent***	***To no extent at all***
1. My subject matter knowledge is improving/has improved.					
2. My knowledge of different teaching strategies is increasing /has increased.					
3. My knowledge of assessment strategies is improving/has improved.					
4. My knowledge of the curriculum is improving/has improved.					
5. I am developing/have developed confidence as a teacher.					

2C. ***If you are NOT REGISTERED for any qualification programme/or DO NOT INTEND TO REGISTER AGAIN, please indicate your reasons by ticking the appropriate box below.***

Statements	***Strongly Agree***	***Agree***	***Neutral***	***Disagree***	***Strongly Disagree***
1. I believe that I am qualified enough and thus do not need to engage in any further studies.					
2. I have acquired enough teaching experience.					
3. I am competent in content knowledge and therefore do not need to study further.					
4. I do not have financial means to study further.					
5. I have too much work at school and so I can’t make time to study.					
6. The universities are too far and difficult to get to.					
7. I am not aware of options available for me to improve my qualifications.					
8. I simply have no motivation to study further.					

2D. Training Workshops

Please tick the most appropriate box to indicate your opinion of teacher training workshops that you have been attending.

Statements	***Strongly Agree***	***Agree***	***Neutral***	***Disagree***	***Strongly Disagree***
1. We enrich our knowledge of the subject matter/content.					
2. We learn new ways of including practical work in our teaching.					
3. We learn subject matter that is directly relevant to what we have to teach.					
4. We learn how to help our learners answer exam questions better.					
5. We learn new ways of teaching subject matter.					

2E. ***Have you been participating in any of the following types of professional development (PD) activities, and to what extent do you feel they help you develop you as a teacher?***

Please indicate whether you have been participating in each of the professional development activities by ticking YES or NO. If you answer is 'Yes' then please indicate your level of development by ticking the appropriate box.

	A. Participation		***B. Level of development***				
Types of PD activities	***Yes***	***No***	***Very high development***	***High development***	***Some development***	***Very little development***	***No development at all***
1. Cluster meetings							
2. School-based Professional development							
3. Mentoring and coaching							

2F. ***What motivates you to attend professional development activities? Please indicate your response by ticking the appropriate box***

Statements	***Strongly Agree***	***Agree***	***Neutral***	***Disagree***	***Strongly Disagree***
1. To keep up with the changes taking place in the curriculum.					
2. I want to take responsibility for my own learning.					
3. I believe that as a teacher I should continuously upgrade my knowledge and skills through professional development.					
4. I want to be a better Life Sciences teacher.					
5. We are forced by district office to attend workshops.					
6. Because we sometimes get free teaching material such as textbooks.					

In your own view what would you like to see happening in the training workshops, teacher clusters, etc., that would develop you further in your teaching of Life Sciences? Please write your opinions below.

SECTION 3: Pedagogical Needs

To what extent do you think you need training in the categories below? Please indicate the level at which you need this training by ticking the appropriate box.

Category	**Level of training need**		
3A. Improving your personal competence	***Greatly needed***	***Moderately needed***	***Not needed***
1. Update subject matter knowledge in Life Sciences.			
2. Update knowledge of effective teaching strategies.			
3. Efficiently integrate different cognitive levels during teaching.			
3B. Specifying objectives/aims for instruction	***Greatly needed***	***Moderately needed***	***Not needed***
1. Identify learning objectives (i.e. outcomes) which specify knowledge needed by learners in Life Sciences.			
2. Integrate Life Sciences knowledge with knowledge from other subjects.			
3. Integrate content and practical skills when teaching and during assessment.			
4. Integrate indigenous knowledge in Life Sciences teaching.			
3C. Diagnosing and evaluating learning	***Greatly needed***	***Moderately needed***	***Not needed***
1. Design assessment items (e.g. questions and tasks) which assess achievement of learning objectives.			
2. Develop skills in recognizing and correcting learners' common misconceptions in Life Sciences.			
3. Use various forms of assessment to identify leaning difficulties in Life Sciences.			
4. Develop learners' language skills by including it as part of the assessment.			
5. Assess knowledge and understanding of investigations and practical work.			
6. Efficiently integrate different cognitive during assessment.			
3D. Planning instruction	***Greatly needed***	***Moderately needed***	***Not needed***
1. Develop lesson plans (learning activities).			
2. Select appropriate resources for Life Sciences.			
3. Design and plan investigations/experiments in Life Sciences.			
4. Design and organize learning experiences according to local circumstances.			
5. Select teaching strategies appropriate to learners and contexts.			

3E. Delivering instruction	***Greatly needed***	***Moderately needed***	***Not needed***
1. Demonstrate and develop learners' science process skills e.g. classifying, prediction, inference, etc.			
2. Apply concepts taught in Life Sciences to daily life of learners (i.e. real-life situations).			
3. Apply knowledge of Life sciences in new and unfamiliar contexts.			
4. Establish links between Natural Sciences (GET) and Life Sciences (FET).			
5. Identify and use a wide variety of specific teaching techniques for the life sciences.			
6. Develop active learning and critical/higher order thinking skills.			
7. Use inclusive strategies for teaching and assessment.			
8. Doing practical demonstrations to develop learners' practical and investigation skills			
3F. Managing instruction	***Greatly needed***	***Moderately needed***	***Not needed***
1. Maintain learner discipline in class.			
2. Assess the effectiveness of one's own teaching of Life Sciences.			
3. Appropriate use of group-work.			
3G. Administering instructional facilities and equipment	***Greatly needed***	***Moderately needed***	***Not needed***
1. Select supportive materials (e.g. workbooks, library and reference books, videos, etc.) for teaching in Life Sciences.			
2. Use media (e.g. newspapers and magazines, overhead projectors) and everyday resources (e.g. text-books, charts) appropriately in teaching.			
3. Identify sources of free and locally available teaching for Life Sciences.			
4. Knowledge of CAPS and all assessment guidelines.			

SECTION 4: Content Needs

Please indicate your greatest professional development need in specific content by ticking the appropriate box (Please note that these topics are taken from the CAPS document)

Topic	***Grade***	**Level of Need**		
		Greatly needed	***Moderately needed***	***Not needed***
4A Life at the molecular, cellular and tissue level				
1. The chemistry of life	10			
2. Cells: the basic units of life	10			
3. Cell division - mitosis	10			
4. DNA: the code of life	12			
5. Meiosis	12			
6. Genetics and inheritance	12			
7. Plant and animal tissues	10			
4B Life processes in plants and animals		***Greatly needed***	***Moderately needed***	***Not needed***
1. Support and transport systems in plants and animals	10			
2. Energy transformations to sustain life	11			
3. Animal nutrition	11			
4. Gaseous exchange	11			
5. Excretion in humans	11			
6. Reproduction in vertebrates	12			
7. Human reproduction	12			
8. Human endocrine system	12			
9. Homeostasis				
10. Responding to the environment: plants	12			
11. Responding to the environment: animals				
4C Environmental studies		***Greatly needed***	***Moderately needed***	***Not needed***
1. Biosphere and ecosystems	10			
2. Population ecology	11			
3. Human impact on the environment	11			
4D Diversity, change and continuity		***Greatly needed***	***Moderately needed***	***Not needed***
1. Biodiversity and classification	10			
2. Biodiversity and classification of microorganisms	11			
3. Biodiversity of plants	11			
4. Reproduction in plants	11			
5. Biodiversity in animals	11			
6. History of life on Earth	10			
7. Darwinism and natural selection	12			
8. Human evolution	12			

Please indicate any other areas in which you need development/training. Or write any other comments relating to your professional development. For example, what other forms of support do you need to teach better?

Thank you very much for your time

Appendix 2

UKZN ACE EVALUATION QUESTIONNAIRE

SECTION 1: Biographical data

1. Age	
2. Gender	Male ☐ Female ☐
3. What is/are your formal qualification/s?	
4. What were your majors during your initial teacher training?	
5. For how many years have you been teaching Life Sciences/Biology?	
6. In which district do you teach?	
7. Did you receive a bursary from the department?	Yes ☐ No ☐

SECTION 2: Development in Content Knowledge

To what extent do you believe that your knowledge of the following topics has improved/not improved as a result of doing the ACE programme? Please tick the appropriate box

Topic	Level of improvement				
	Very good development	*Good development*	*Some development*	*Very little development*	*No development at all*
Life at the molecular, cellular and tissue level					
7. The chemistry of life					
8. Cells: the basic units of life					
9. Cell division – mitosis					
10. DNA: the code of life					
11. Meiosis					
12. Genetics and inheritance					
13. Plant and animal tissues					
Life processes in plants and animals	*Very good development*	*Good development*	*Some development*	*Very little development*	*No development at all*
1. Support and transport systems in plants					
2. Support and transport systems in plants					
3. Energy transformations to sustain life					
4. Animal nutrition					
5. Gas exchange					
6. Excretion in humans					
7. Reproduction in vertebrates					
8. Human reproduction					
9. Endocrine system					
10. Homeostasis					
Diversity, change and continuity	*Very good development*	*Good development*	*Some development*	*Very little development*	*No development at all*
1. Biodiversity and classification					
2. Biodiversity and classification of microorganisms					
3. Biodiversity of plants					
4. Reproduction in plants					
5. Biodiversity in animals					
6. History of life on Earth					
7. Darwinism and natural selection					
8. Human evolution					

SECTION 3: Development in pedagogic knowledge and skills

To what extent do you believe that your knowledge and skills have improved/not improved as result of doing the ACE Programme? Please tick the appropriate box.

Statements	***To a very great extent***	***To a great extent***	***To some extent***	***To a very little extent***	***To no extent at all***
1. I have gained confidence in teaching the topics I learnt in the programme.					
2. My knowledge of different teaching strategies has improved.					
3. My knowledge of assessment strategies has improved.					
4. My knowledge of the CAPS curriculum has improved.					
5. My knowledge and skills of doing practical work have improved.					
6. I have made some changes in my teaching as a result of what I learnt in the programme.					
7. I can now engage my learners in challenging tasks that promote higher order thinking.					
8. I have gained knowledge and skills which I apply directly to my own classroom teaching.					
9. I have developed interest in teaching Life Sciences because of doing this programme.					
10. My confidence as a Life Sciences teacher has improved.					
11. I have gained knowledge on how to select materials and resources for teaching Life Sciences.					
12. I have gained insight on how to design and organize learning according to local contexts.					
13. I have improved my knowledge of integrating different cognitive levels in assessment.					
14. I have gained skills in integrating indigenous knowledge in Life Sciences.					

In your own words please tell us how you have benefited as a result of doing the ACE programme. If you have not benefited from the programme, please tell us why that is so.

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Thank you

Appendix 3

INTERVIEW PROTOCOL FOR SUBJECT ADVISORS

Section A: Life Sciences teacher development needs

1. Following the survey that was conducted with the teachers of Life Sciences, many of teachers expressed a strong need for development in most of the content, but greatly for content areas such as the Evolution and Genetics. From your own assessment, in which content areas do teachers of Life Sciences still require training on to effectively teach the curriculum?
2. What professional development programmes are in place to address teachers' content needs in these areas, especially following the amendments from the NCS to the New Content Framework and to the recently developed CAPS?
3. Findings from the survey also suggest that a large number of teachers require training in a whole range of pedagogical skills. Is this in line with your own assessment of their needs? Please elaborate.
4. There was a strongly articulated need for training in practical work skills by the majority of the Life Sciences teachers? Have teachers had any opportunities for training in practical work skills since the introducing of NSC and following the inclusion of a practical examination in CAPS? Please explain.
5. Are there any constraints in organizing 'hands-on' practical work training for teachers? Please elaborate.

Section B: Teachers' participation in CPD programmes

1. To what extent do districts have influence in getting teachers to participate in professional development activities, i.e. both qualification-driven and non-qualification programmes?
2. To what extent do you think teachers' enrolment in qualification programmes such as the ACE programme has an impact on improving both their content and pedagogical knowledge in Life Sciences? Please elaborate.
3. To what extent do you think teachers' engagement with non-qualification professional development programmes such as workshops has an impact on improving their knowledge of content and pedagogy? Please elaborate.

4. To what extent are the teachers motivated to engage in Professional development activities (both qualification-driven and non-qualification driven programmes)?
5. Are you aware of any teachers that do not participate in CPD activities, whether qualification-driven and non-qualification driven? What reasons do these teachers provide for not engaging in CPD programmes?
6. How often do you seek teachers' input prior to a PD programme such a training workshop, i.e. how often do you conduct a needs analysis before doing the training? Please explain.
7. It emerged from the survey that teachers were not particularly pleased with the nature and level of development that takes place in teacher clusters. Can you tell me what exactly happens in these teacher clusters? Who conducts them? And how are they conducted?

Section C: The role of Subject Advisors in supporting the teachers

1. In 2009, a report of the task team for the review of the implementation of the National Curriculum Statement (and subsequently the Integrated Strategic Framework for Teacher Development, 2011) highlighted challenges faced by subject advisors, for example, in clarifying the roles of subject advisors, and the training of subject advisors; etc. To what extent have these challenges been addressed?
2. What plans are in place to improve the level of support you provide to the teachers? For example, can you please tell me how frequently you are able visit teachers in schools to support them?

Thank you

Appendix 4: Permission to conduct research

kzn education
Department:
Education
KWAZULU-NATAL

Enquiries: Sibusiso Alwar　　Tel: 033 341 8610　　Ref.:2/4/8/167

Ms. Bulelwa Keke
University of KwaZulu-Natal, School of Life Science (New Biology Building)
Westville Campus
Private Bag x 54001
Duban

Dear Ms. Keke

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **Understanding Life Sciences Teachers' Engagement with Ongoing Learning through Professional Development Programmes,** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the intended research and interviews are to be conducted.
6. The Period of investigation is limited to the period from 01 March 2012 to 31 March 2013.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Mr. Alwar at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Director-Resources Planning, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to the following Schools and Institutions:
    10.1
    10.2
    10.3

Nkosinathi S.P. Sishi, PhD
Head of Department: Education

25/04/2012
Date

...dedicated to service and performance
beyond the call of duty.

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