

**Responses of Science Teacher Educators
to the
Curriculum Change Process in South Africa**

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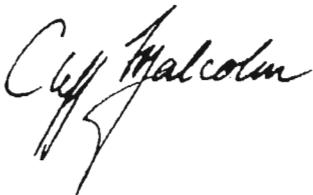
January, 2006

DISCLAIMER

I hereby declare that this thesis is my original work and has not been submitted before to any other institution for assessment purposes.

Further, I have acknowledged all sources used and cited these in the bibliography


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DEDICATION

**For my late Mum (Angela Pillay) and Dad (Danasoo Pillay)
and
my late Father-in-law (Mr B A Naidoo)
and Mother-in-law (Mrs A Naidoo)**

With sincere and deep respect for your roles
as professional teachers
and the
contribution this has made
to my career as a science teacher
and
as a university lecturer in science education.
My doctoral qualification is in recognition of all of you
and
Our Ancestors

ABSTRACT

This study strove to establish how science teacher educators (lecturers) at three universities in a province in South Africa responded to curriculum changes related to C2005 and higher education. The following critical question is posed:

How have science teacher educators in PRESET education responded to curriculum changes proposed for the Natural Sciences Learning Area of Curriculum 2005, the Norms and Standards of Educators, and modularization in the Higher Education curriculum?

The framing of the study from 1996 to 2002 relates to the introduction of C2005 in schools in 1997 which coincided with curriculum changes in higher education prescribed by the NQF. The curriculum change process has to be seen in the context of developments during and after the demise of apartheid in South Africa. Responses of science teacher educators to post-apartheid educational policy developments driven by the NQF form the basis of this research.

The production of data for the study occurred during 2001 and 2002. It involved an interpretive cross-case study of 11 science teacher educators' responses to the curriculum change process. The science teacher educators were selected from three universities in a province in South Africa. They had to be involved with preparation of student science teachers during PRESET for the Natural Sciences Learning Area of C2005. Data was obtained through a semi-structured interview schedule and an observation schedule. A document analysis was also conducted in the study. Qualitative data were first analysed qualitatively and represented at three levels of analysis. Stories of curriculum change experienced by three individuals were also presented as a second level of analysis.

The theoretical frame that informed the methodology and analysis was developed in the context of a pre- and post-apartheid educational offering in South Africa. It operates in an interpretive and critical paradigm of research that includes change theories and other theories that can be used to account for ways in which science teacher educators have changed in response to C2005 and the NQF. These theories work together. Among them are those classified as Traditional Change, Adaptive Change and Advanced Change. Other theories such as theories in action and a theory of academic change were also used as a means to understand change in academic and other settings. Constructivism as a learning theory was included in the theoretical frame since science teacher educators are expected to use the theory as a rationale for the new curriculum. It is therefore an essential component of the theoretical frame in interpreting such change. Also significant is the role of situated cognition in enabling professional learning communities to make meaning of curriculum change and to act accordingly. Argyris' theory of organizational learning, the Concerns-Based Adoption

Model, Complexity Theory and Systemic Reform also contribute to the development of the theoretical frame used to contextualize and interpret the data.

The data analysis showed that the science teacher educators had made a more concerted effort to incorporate changes related to C2005 into their curriculum materials and their actual teaching than the NQF's bureaucratic exercise related to modularization and the NSE. They were better able to account for their actions in terms of C2005 than for modularization. This had occurred despite them not being bureaucratically accountable to the schools.

The role of the new school curriculum as a major influence on change among the science teacher educators goes beyond the complexity associated with the change process. The influence of personal factors related to a moral response to school change (C2005) resulted in the science teacher educators making changes that were major and vastly different from their responses to the NQF's bureaucratically driven higher education changes. The responses of the science teacher educators to curriculum change shows that professional accountability does not flourish under bureaucratic control as displayed by demands of the NQF for modularization.

The changes made by the science teacher educators was also vastly different from the responses of practising teachers to C2005. They made a concerted effort to change and there was no evidence of implementation failure compared to the practising teachers in terms of C2005. My research outcomes, therefore, have contradicted the standard findings of School Improvement research which alludes to the difficulties associated with teacher change, and the needs for long term systemic approaches related to large scale reform – where institutional management, external support, internal support, rewards and punishments work together.

In the three universities in my study, such arrangements were loose couplings at best. But feelings of professional and moral responsibility in the direction of school-related change (C2005) were high for individuals and groups. Personal, social and professional interests were more obvious drivers of change than institutional interests and career interests.

On the basis of the above, my research has suggested the following which serve as a positive contribution to theory pertaining to curriculum change:

- Much change theory developed in the context of schools does not apply to Teacher Education, because professionalism and education are primary concerns for science teacher educators: they chose to do their job well.
- Accountability is not only – or even mainly – about the institution and institutional monitoring systems. It is about professionalism and relationships within institutions and outside them. In this case, the responsibility the science teacher educators felt to schools, science teachers and their communities were much more powerful influences than responsibilities they felt to the reforms indicated in modularization and NSE.
- The professional imperative is not bureaucratically controlled. It flourishes in the absence of pressures related to forced compliance.

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GLOSSARY OF ACCRONYMS AND ABBREVIATIONS

ACE: Advanced Certificate of Education

ANC: African National Congress

CBAM: Concerns-Based Adoption Model

CHE: Council on Higher Education C2005: Curriculum 2005

DEC: Department of Education and Culture

DET: Department of Education and Training

DOE: Department of Education

INSET: Inservice Education and Training

NEPI: National Education Policy Initiatives

NGO: Non-Governmental Organizations

NPDE: National Professional Diploma in Education

NQF: National Qualifications Framework

NSE: Norms and Standards for Educators

OBE: Outcomes-based Education

PRESET: Pre-service Education and Training

RDDA: Research-Development-Dissemination-Adoption

SAARMSTE: Southern African Association for Research into Mathematics, Science
and Technology Education

SAQA: South African Qualifications Authority

SO: Specific Outcome

CO: Critical Outcome

CHAPTER ONE

EDUCATION DURING THE APARTHEID ERA AND THE TRANSITION TO A DEMOCRACY

Fullan (2000:3) quotes a first year student in an English language proficiency test as writing: “*everything must change at one time or another or else a static society will evolve.*” The logic is pertinent to South Africa in its transition to democracy. Under apartheid, the white-dominated Government relegated the non-white majority (Black Africans, Coloureds and people of Indian origin) to an inferior status through its oppressive Bantu Education policy. In 1994 that government was replaced by an elected democratic government. The latter has made serious attempts at establishing political and social redress as part of national development. One component has been the introduction of a new curriculum policy for schools that is outcomes-based and learner-centered (Curriculum 2005, or C2005) and linked to policies of devolution of management (of schools and curriculum). The expectation of these policies is that they will empower learners with the necessary competencies to transform South Africa socially and economically, and create a highly participative and egalitarian society.

The new policies presented many challenges to teacher education, especially coming, as they did, alongside new policies in higher education, restructures, closures, new approaches to management, changed demographic profiles and changes in curriculum. Science teacher education faces particular challenges because of its relevance to economic development, environment and health, and because provision of science education was so inequitable under apartheid (Jansen, 1998).

My purposes in this chapter are to:

- (a) provide a background for my study in terms of developments in the science teacher education curriculum by:
 - i) discussing international perspectives on science teacher education;
 - ii) describing science teacher education during the apartheid era;
 - iii) showing how South African science teacher education featured during the apartheid era in relation to international developments. This will

- also relate to policy developments that influenced teacher education generally and provision by the State for science teacher education;
- iv) presenting attempts by anti-Apartheid movements in South Africa such as the Non-Government Organizations (NGO's) to change the traditional science curriculum for a more progress science education.
- (b) against this background, to present the aims of the research and its research questions.
- (c) develop a rationale for studying the responses of science teacher educators to the curriculum changes in South Africa.
- (d) outline the plan of the dissertation in terms of the purpose of the remaining chapters.

A glossary of acronyms and abbreviations is presented on page xii.

1.1 Background to the Research

My concern is the response of science teacher educators to curriculum policy changes in schools and higher education, during the dizzying period of policy development, restructure and social change that followed the 1994 elections. I can find no reference in the literature of formal analyses of science teacher education and change in South Africa per se at a pre-service level. This appears to be an international problem, even in more stable settings. Anderson and Michener (1994:28) state that:

Indeed there is a dearth of literature describing pre-service science teacher education programmes. Although there are many references to these programmes, these brief mentions are usually in the context of reporting related research. Actual portrayals of comprehensive programmes – including conceptual and structural components are rare.

In what follows, I draw on international literature on science education, literature on teacher education (generally), and policy developments in teacher education in South Africa. Having served as a science teacher during the apartheid era and a science teacher educator during the transition to democracy, I will also use personal

experiences to support my understanding of science teacher education in South Africa.

I am aware that there is no clear definition of teacher educators or science teacher educators in the South African literature or policies – especially given that science teacher education can occur partly in Faculties of Science, partly in Faculties of Education, and partly through mentor teachers in schools. Policy discussions by Lewin et al (2003), Steel (2003), Parker (2003) and others as recorded in the MUSTER project, Avalos (2000) and Eraut (2000) deal with policy issues related to teacher education in South Africa and other developing countries, but none of them explain who a teacher educator is. Neither does Laugksch (2003) in his accounts of lecturers in science education. Fedock et al. (1996) distinguished between scientists and science educators in the US. He viewed scientists as professors who teach content science courses to university students while science educators teach prospective science teachers about issues in education related to the teaching of science.

Fensham (1992:798) recognizes science educators as a professional group, distinct from science teachers or educational researchers. He states that:

...these professionals have had the responsibility, time, and access to resources to develop a number of new, well-formulated bases for use in science curriculum. They carry out research studies on many aspects of science education. They have identified with a number of social movements and have worked to understand them and to translate them into terms that enable them to influence science curricula. These professionals and the many results of their research and other professional work were simply not available in the 1950/1960's. They now occupy many key positions in the curriculum discussions, decisions, and developments that are at present in progress. They are a very significant new source of influence, standing between the academic scientists and the science teachers.

On the basis of this view I am inclined to accept the US concept of teacher educators as proposed by Ducharme and Ducharme (1996) viz., that they represent the higher education faculty responsible for teacher preparation. I am also inclined to accept

Fedock et al's definition of a science educator. However, Fedock et al (1996), unlike Fensham (ibid) paint school-based practicing science teachers and university science education professors involved with the initial teacher education with the same brush. I therefore accept Fensham's view and for the purpose of this research use de Feiter's (2002) reference to university-based science educators as science teacher educators and base my study on such a community of educators whose role is to educate science teachers at the pre-service and in-service level at universities.

1.2 International developments in the Science Teacher Education Curriculum

In a review of research in science teacher education internationally, Anderson and Michener (1994) report that the purposes of science teacher education are many and that these vary considerably from one programme to another. In some programmes the emphasis is on transmitting to science teachers knowledge of learning and instructional practices; in others the emphasis is on the acquisition of instructional skills and the ability to utilize various instructional strategies. In another case, the programme focus may be on helping build a conception of as well as facilitating productive collegial relationships. A survey conducted by Feiman-Nemser (1990) identified a critical/social conceptual orientation that combines a radical theory of teaching and learning with a vision of a new social order. Such an orientation appears to be significant to the current South African situation because the teacher sought in this orientation is one who serves as educator and activist, i.e., one who works to remove social inequities, promote democratic values in the classroom and foster problem solving among students (Pendlebury, 1998).

In the critical/social orientation referred to above, teacher preparation programmes are aimed at preparing teachers to change society. In the South African context, the Norms and Standards for Educators or NSE (DOE, 2000) as a post-Apartheid strategy for change endorses such an expectation because one of its propositions is that a teacher should develop a reflective competence through the "community, citizenship and pastoral" role. These orientations for science teacher preparation move away from the traditional model for science teacher preparation that appears to be an

international model as presented in the Handbook of Research on Science Teaching and Learning edited by Dorothy Gabel (1994), and critics such as Anderson and Michener (1994:3) claim that they:

.....portrayed the science teacher as a generic technician which de-professionalized them. It encouraged intellectual dependency and discouraged professional development and adaptation to change.

The roles of science teacher education as a vehicle for political and social redress have implications for science teacher educators and their practice. Such trends add to the complexity of the curriculum change process and place new demands and expectations upon science teacher educators. I have to emphasize however, that many science teacher educators in South Africa were active in the liberation movement and have made attempts to address some of the issues formalized in the new Norms and Standards for Educators through engaging with the (preceding) COTEP Norms and Standards for Educators (D.W Brookes, personal communication, 18 February, 1997).

In the following section I explain how the traditional model for science teacher education was implemented in the South African context and served to stifle the progress of non-White science teacher educators based at colleges of education. During apartheid, teacher education was the only readily accessible form of tertiary education available to Blacks, and there was a surfeit of it. Two reasons could be advanced for this. Firstly, it was the intention of the apartheid government to reduce employment possibilities for Blacks in more empowering and higher-powered positions in the work sector, which it reserved for other race groups. Secondly, the Government developed a firm bureaucratic control of education to suit its agenda based on race (Pendlebury, 1998).

1.3 The traditional science teacher education curriculum

The curriculum for science teacher education was laden with science content. In diploma programmes, courses were offered in Botany, Zoology, Chemistry and

Physics, with additional courses in teaching methodology included as separate subjects. Students who completed a Bachelor of Science (BSc) degree were required to complete a professional diploma in teaching which included instruction in teaching methods for science.

Curriculum manuals from several universities indicate that science methods courses typically included the following:

1. how to use a laboratory for teaching science;
2. laboratory safety rules;
3. preparing charts for teaching science;
4. prescribed methods for teaching science traditionally;
5. using text books for teaching science;
6. developing science process skills;
7. how to plan excursions.

The approach was highly technicist. The science teacher was trained to keep the laboratory clean, become involved in stock-taking, preservation of plants and animals, preparation of chemicals, etc. Flexibility for teaching science according to the context of the school and community were usually not encouraged. Some subject advisers for science instructed their teachers not to use improvised equipment in contexts in South Africa that were under-resourced for science teaching. This especially pertained to some Black teacher education colleges and many Black schools. The subject advisers argued that it was the duty of the apartheid government to provide equal resources for all race groups in the country and not to exclude Blacks from the formula (G. Ntombela, personal communication, 16 April, 1988).

According to Jansen (2003) the central requirement of teachers in the apartheid era was bureaucratic and political compliance with state education. Compliance was ensured through a complex system of instruments including school-wide and individual teacher inspections, a rigid syllabus outlining official content, objectives and methods of teaching, and a hierarchy of internal and external controls. The teacher was an obedient civil servant that executed the well-defined instructional tasks through an official syllabus and a “moderated” examination.

Science teacher educators had to prescribe a fixed plan of teaching and assessment. There was very little room for innovation. Issues such as teaching science to large classes, language issues and science, and curriculum development for science teacher education were not included in programmes and not encouraged. Teacher-centred strategies such as science demonstrations and use of voice were encouraged. Student science teachers were told by their lecturers how to teach science according to the “telling” (transmissive) method (Brookes et al., 1993). They typically used an applied science model based on Stuart’s (1997) model of “academic” teacher education, through which theory is presented first, followed by its application to practice. Samuel (2003) claims the content of many South African teacher education colleges may be said to follow this model that elevates the value of “theoretical knowledge” as foundational to developing practice. Such prescriptive methods were poorly suited to the culturally diverse and generally under-resourced schools in South Africa.

I acknowledge that such approaches were common across the world in the 60’s and 70’s and may currently still be evident. However, the apartheid government was always viewed with suspicion in terms of its treatment of Blacks since it afforded enhanced resources to Indians, Coloureds and Whites.

The tendency of the apartheid science teacher education curriculum to exclude the preparation of student science teachers for a reflective practice (linking theory to practice) resulted in perspectives among teachers which conformed with the observations of Russell (1993) in studies conducted in North America. He suggested that the following six interrelated barriers are characteristic of the ways in which pre-service teachers perceive new knowledge about teaching and learning internationally.

1. Teaching can be told and teachers are expected to be told how to teach. Those who know and/ or have responsibility convey ideas to those that know less and have less experience.
2. Learning to teach is passive. What needs to be known can be presented clearly and the receiver has little responsibility beyond listening.
3. Discussion and opinion are irrelevant. Personal opinions have rarely mattered in previous learning, so why should they be significant in learning to teach?

4. Personal reactions to teaching are irrelevant. The powerful effects of personal teaching experience are less important than what others have to tell about teaching.
5. Goals for students do not apply to personal professional learning. Although the goal of independent learning is appropriate for students, it seems less appropriate for the way in which a teacher learns to teach.
6. Theory is largely irrelevant; survival and success in the classroom do not seem to be associated with what is told and expected to be applied in formal teacher approaches. Theory rarely works and is not useful, especially for beginning teachers.

In the light of changes for schools, including C2005, proposed by the post-apartheid Government, there was a need for formal changes to the science teacher education curriculum, aimed in part at overcoming these six observations made by Russell (ibid). Arguments in favour of such a change are discussed in the next chapter as a follow-up to discussions on C2005.

In the section that follows I will explain how the traditional model for science teacher education was used during the apartheid era to support its Bantu Education policy. In the process I will show the possible turmoil this may have created in the minds of science teacher educators especially in relation to post-apartheid strategies for curriculum change and the need for a paradigm shift.

1.4 The turmoil facing science teacher educators in South Africa during the Apartheid Era (1948-1980)

In response to the curriculum offered at non-White colleges of education during apartheid, Moletsane (2003), for example, called for radical transformation of the content and processes of teacher education in tertiary institutions, to reflect diverse contexts and identities so that teachers can respond effectively to the educational and social needs of the communities that they serve. According to Hodgkinson (1991:208)

understanding educational change requires a political analysis. Welch (2002:18) notes that:

..... segregation, fragmentation, authoritarian and bureaucratic control of the curriculum, institutions and governance, inefficiency and inequity have been characteristic of South African education for a very long time.

She refers, for example, to the duplication of services that characterized the apartheid era, when educational services were offered separately to race groups through a complex of governments, administrations and providers. The consequences included turmoil and confusion in science teacher preparation, especially when the post-apartheid government sought to produce a unified system consistent with the new Constitution.

During the apartheid era, the State provided teacher education for non-white student teachers that was inferior in many ways to that provided for whites. It also limited its responsibilities for post-initial teacher education, so that progress of non-white teachers was further stifled (Levy, 1992). The Bantu Education Act (N0. 47) of 1953 was viewed by critics as highly oppressive, prescriptive and centralized in its control of teacher education (ANC Policy Framework for Education and Training Discussion Document, 1994). The majority of teacher educators at Black colleges of education, like non-white school teachers, were compelled to function in this model. There was a set curriculum with a prescription as to the number of periods needed to cover each section, and examinations that were externally administered (Salmon and Woods, 1991).

The Research-Development-Dissemination-Adoption (RDDA) model, common across the world in the 1950s and 1960s, formed the dominant process of curriculum development (see Fig.1). However, the model was “watered-down” to a DA (Dissemination-Adoption) model (D.W.Brookes, personal communication, May, 1997), using materials and ideas especially from UK and USA. Samuel and Naidoo (1992) state that there was very little evidence to show that research and development did occur. The science teacher education curriculum was disseminated to colleges of education for adoption and adaptation. Marsh and Huberman (1984) refer to such

curriculum dissemination as a high control condition with administrators relying on their formal authority to get things done the way they want by exerting influence over people, processes and the use of resources.

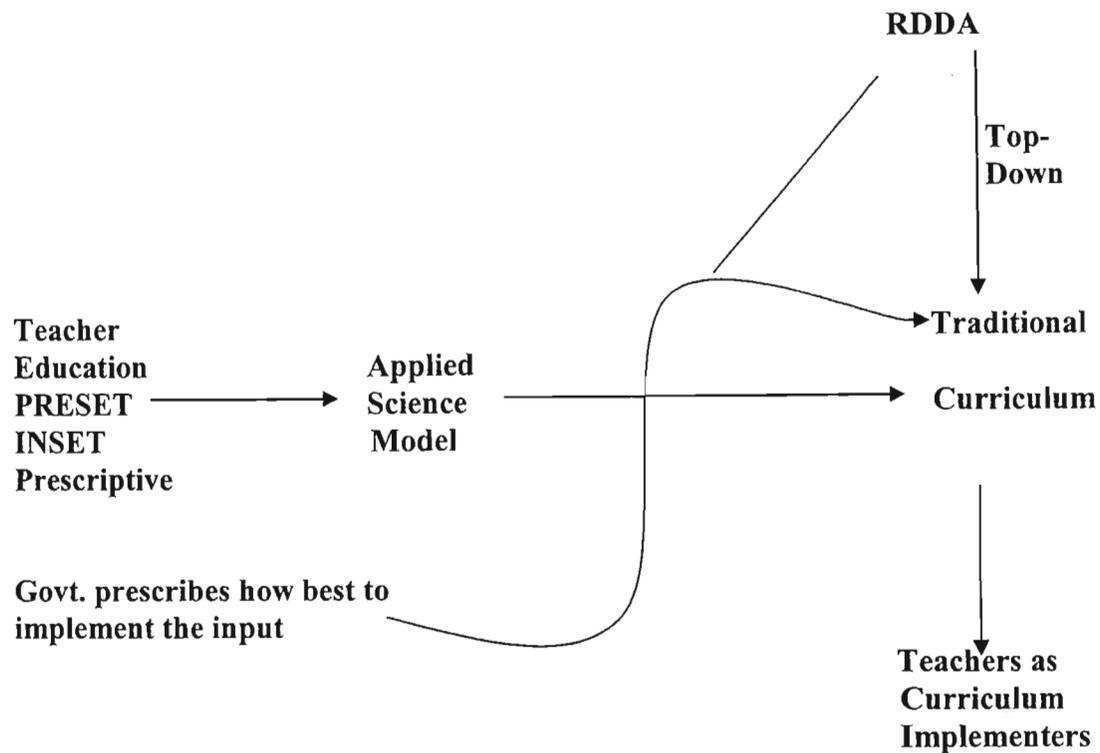


FIG. 1: STATE CONTROLLED EDUCATION IN SOUTH AFRICA

By 1980, the science teacher education curriculum offered at non-white colleges of education was far behind international developments, in part because of academic embargoes by the international community. For example, it did not feature aspects related school-based curriculum development, constructivism, multiculturalism, critical theory, outcomes as competences, etc. But for the non-white colleges, there were further restrictions: *historically, (Black) colleges of education had been carefully designed to ensure isolation from the education mainstream* (Salmon and Woods, 1991).

Two policies during the apartheid era warrant elaboration. The Bantu Education Act (No. 47) of 1953, as noted earlier, was part of the relegation of Africans (85% of the

population) to a subservient role in South African society. It widened the gaps for educational opportunities and resources, on the basis that, as Hendrik Verwoerd (the Minister for Education at the time) explained, '*the African teacher shall not rise above his community*' (Walker, 1990). Coloureds and Indians were offered more privileges than Black Africans, but much less than those afforded to Whites. The second policy was the National Education Policy Act of 1967, which promoted a racially and culturally segregated and differentiated education system. This policy relegated science teacher education for Africans, and to a lesser extent, for Coloureds and Indians to a highly traditional, behaviourist, content-laden approach which conformed with the principles of Fundamental Pedagogics.

The "science" of Fundamental Pedagogics came to underpin Christian National Education and Bantu Education (Caldwell, 2003). Christian National Education focused on an 'ideal' child in terms of Christian principles, and placed "hope for the child" in "his or her being schooled to adulthood" within the context of a specific community with its distinctive cultural character and tradition. The policy sought to entrench racial segregation. Also, its lack of sensitivity to religious and cultural diversity had negative implications for science teacher education. For example, it restricted science teacher educators and science teachers to a creationist view of the origin of life on earth, as opposed to a scientific evolutionary view. It selected science textbooks with a strongly euro-centric focus, to the exclusion of local contexts and the contributions made to science by other race groups in the world through indigenous knowledge systems.

Teaching methods at pre-service teacher education institutions controlled by the apartheid state were based in Fundamental Pedagogics, which insisted on compliance and fear of authority which in turn encouraged unquestioning attitudes. Teaching methods revolving around "telling" were typical, with learners expected to be passive. According to Gozo (1997:2) the majority of lecturers in the universities and colleges were "brought up on a diet" of this approach. Science teacher educators and student science teachers were subject to a single source of information that informed their practice. The school curriculum, textbooks and teacher education were manipulated and used as instruments of propaganda and indoctrination.

Fundamental Pedagogics aside, teaching approaches were teacher-centered and followed an applied science principle. The situation is captured by the Salmon and Woods (1991: 105):

The development of Black teacher education from 1953 to 1982 is largely a freeze-frame story of carefully preserved stagnation. Strict syllabus prescription, external evaluation and centralized control ensured that little was allowed to permeate the teacher training programme. The ethos of teacher training schools (later teacher training colleges) was barely one step removed from that of secondary schools. Uniforms, bells, strict disciplinary measures and even corporal punishment were common, and indeed many teacher training colleges which had originally been high schools remained unchanged in terms of internal management and operation.

For Black Africans, one consequence was poor quality science education. Another was that students did not choose to study science, perhaps because of resources, or because they had become convinced that science was “not for them”. Sometimes science subjects were not offered beyond grades 9 or 10. There were a few teachers who were co-opted to teach those subjects though they had limited knowledge or qualifications in that field. The teachers who were fully qualified to teach the science subjects were even fewer and were sparsely scattered resulting in a great shortage of science teachers in Black communities. The National Teacher Education Audit (Hofmeyer and Hall, 1995) indicated that there was a great need for African science teachers especially in township and rural schools. Mda (1997) has claimed that student teachers taking the natural science curriculum in South Africa were almost always assured of being admitted to teacher education institutions.

Naidoo (1997) investigated the shortage of Physical Science teachers in the KwaZulu-Natal province. He stated that in 1994 there were 564 secondary schools in the DET and DEC systems which offered Physical Science as a subject. These schools had a total of 927 teachers teaching Physical Science. Of these 927 teachers, 595 were qualified Physical Science teachers, while 332 were not. He also discovered that 572 (62%) of those who were qualified chose to teach other subjects and not Physical Science. Naidoo (ibid) indicated that was due to lack of resources at such schools.

Superintendents of science education argued (G. Ntombela, personal communication, May, 1993) that science teachers also feared their careers might be in jeopardy in the event of breakage of available equipment. Black, Coloured and Indian science teachers did not have access to laboratory technicians, and had to perform technical functions themselves.

According to Parker (1998) by 1994 there were approximately 150 public institutions providing teacher education to approximately 200 000 students nationally. Of these, 80 000 were in colleges of education, the large majority being Black African. In terms of resources for science teacher education, the white colleges were most privileged, followed by the two Indian colleges and a few Coloured colleges. Until recently, Black colleges of education were generally under-resourced and with science resources comparable to an Indian or Coloured secondary school.

During the early political transition period in South Africa, Brookes et al. (1993) claimed that in the context of post-apartheid political change, teachers who were not trained as curriculum developers could serve as obstacles to change. The reality of such a claim was proved to be partly true when C2005 was introduced in South Africa in 1996. There was much resistance to the new curriculum that required a paradigm shift of teachers as implementers to teachers as reflective curriculum developers. Such a dualism added to the turmoil facing science teacher educators in developing a contextualized curriculum.

1.5 Attempts at building a more enabling progressive science teacher education during the apartheid era

In spite of the system described above, there were some science teachers and science teacher educators who developed alternative approaches and operated to that extent 'outside the system'. Various Non Government Organizations (NGO's), usually with overseas support, and some liberal universities in South Africa, developed support systems and "new" approaches to teacher education. Levy (1992) visited educational institutions across South Africa to assess the extent to which these innovations in

science teacher education prevailed. In her publication “Projects Speak for Themselves” she presented many cases by science teacher educators such as Brian Gray (University of Western Cape), David Brookes (University of Natal), and Peter Moodie (University of Witwatersrand), among others. For example, Brookes and his colleagues at the Science Education Division of the University of Durban-Westville (a historically Black university) developed and implemented a model of collaboration interfacing pre-service and in-service education through a learning partnership involving student science teachers, practising science teachers and science teacher educators. The science teacher educators and the student science teachers served as agents of change for disempowered practising science teachers through an action research strategy (Levy, 1992; Pillay, 1998). The aim was also to develop reflective practitioners (see Fig. 2 in this section). At about the same time (during the 1980s) the international community’s concerns about South Africa led to greatly increased support of NGOs, and a number of innovative and adventurous programmes resulted, more often in in-service support than pre-service support of science teachers.

NGOs sought to move away from highly prescriptive curricula and teaching. For example, the NGO’s were generally ‘allowed’ to change approaches to science teaching (pedagogy) on the condition that they stayed within the traditional curriculum. There were also attempts by science teacher educators from some universities to develop science teachers’ abilities to reflect on their practices for improvement. These ideas are shown in Fig 2 in this section)

The NGOs were incapable of reaching the majority of school teachers due to the large numbers of teachers, many of them working in rural areas (Welch, 2002). By the mid 1990s, the Joint Education Trust (1996:17–32, in Welch, 2002:22) estimated there were 99 NGO’s spread across the nine provinces – offering short courses, school-based courses, classroom support, materials and information, and reaching 111 862 teachers (a third of those employed). Worthy of note in the field of science teacher education are the Primary Science Programme (PSP), Science Education Project (SEP), and the Centre for the Advancement of Science and Mathematics Education (CASME) (Levy, 1994).

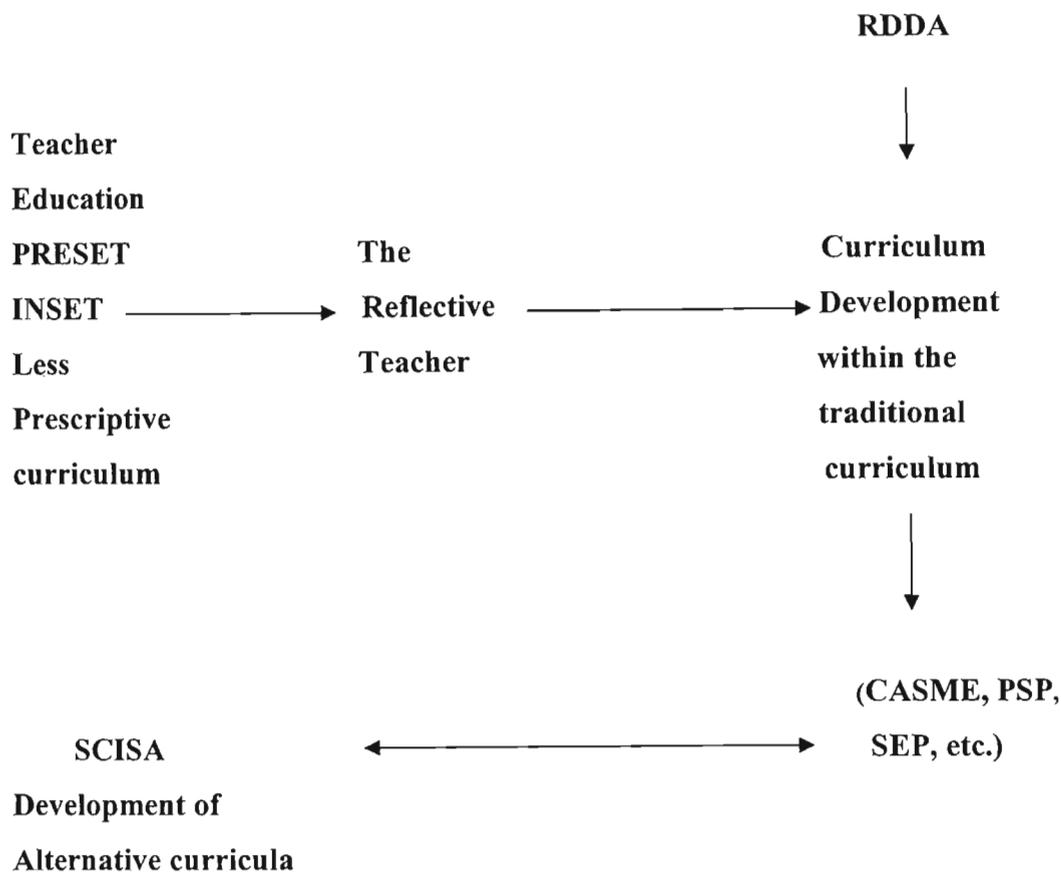


FIG. 2: NGO INFLUENCE ON STATE CONTROLLED EDUCATION

The Science Curriculum Initiative of South Africa (SCISA) and FULCRUM went further than most NGOs in their attempts to subvert the existing traditional curricula by extending beyond teaching methods and resources. According to Levy (1994) SCISA engaged teachers with experiences in challenging the prescriptive and decontextualized science curricula typical of the apartheid era. It replaced this with alternative curricula. FULCRUM strove critically to “break the mould” of Fundamental Pedagogics. Some NGOs sought the participation of science teacher educators from universities and colleges of education in workshops. Some NGOs also collaborated directly with science teacher educators based at universities in extending the concept of a reflective science teacher. However, such collaboration seldom reached the large number of Black colleges of education.

During the early political transition period in South Africa, Brookes et al. (1993) claimed that in a context of post-apartheid political change, teachers who were not prepared as curriculum developers could serve as obstacles to change. References have been made earlier to science teacher educators “telling” student teachers how to teach according to the applied science concept (Stuart, *ibid.*, Berliner, 1984; Feiman-Nemser, 1990). Aspects of teacher education programmes that subscribe to such an approach may include arrangements for student teachers to try out desired behaviours and teaching strategies in experimental conditions set out in micro-teaching laboratories. Such a conception defines the role of the teacher narrowly as an implementer of a curriculum designed externally by experts and approximates to the expectations of the RDDA model for curriculum development.

In contrast Schon (1987) claims that teaching is a reflective practice, entailing a different set of assumptions about the knowledge base that informs practice teaching. He suggests that this knowledge base develops from the practice of teachers who *reflect-in-action* or *reflect-on-action*. Reflection-in-action refers to thinking that goes on in the midst of action as teachers reframe problematic situations in the light of information obtained from acting. This reflection reshapes the teachers’ actions while they are acting (i.e., teaching). Grundy (1987:145) defines reflection as:

.....looking back to previous action through methods of observation that reconstruct practice so that it can be recollected, analysed and judged at a later time. Reflection also looks forward to future actions when planning.

She also claims that reflection is concerned with developing an understanding of practice and bringing about continual improvements to that practice.

I am doubtful about the ability of student science teachers to engage in a reflective practice by using only their intuition to act in a teaching situation. The role of theory plays a significant role in informing their practice (Gultig, 1992). The reflexive competence advocated by the Norms and Standards for Educators as a post-Apartheid strategy for change also expects teachers to reflect on their knowledge base as presented in theory at the university campus to inform their practice at school. Brookes et al. (*ibid.*) may be partly correct in their assumption that reflective teachers

are needed in a context of political and social change of the kind currently facing South Africa. But this is dependent upon how science teacher educators and others effectively develop such a conception and monitor its progress during school-based teaching practice.

Brookes et al. (ibid.) also caution that the paradigm shift from the applied science conception to the reflective practice conception requires a change in attitude amongst science teacher educators and science teachers for effective curriculum change. Whether science teacher educators have undergone such a change in the South African context is one of the outcomes of this research. A further challenge is the extent to which schools are prepared to change in accordance with such an expectation! This adds to the dilemmas and confusions associated with teacher preparation in the complex educational scenario in South Africa.

1.6 The Aim of the Study

Fullan (2000:xi) states that:

*We have to know what change feels like from the point of view of the teacher, student, parent, and administrator if we are to understand the **actions** and **reactions** of individuals; and if we are to comprehend the big picture, we must combine the aggregate knowledge of these individual situations with an understanding of organizational and institutional factors that influence the process of change as governments, teacher unions, school systems, and communities interact.*

Fullan's view is pertinent to my study because it emphasizes the complexity of the curriculum change process in the South African context, as experienced by individual science teacher educators and science teachers alike. It captures the essence of my thesis since it shows movement between the big pictures and the daily lives of science teacher educators. My study has therefore aspired to conduct research amongst science teacher educators from three teacher education institutions by investigating how they have interpreted, developed and implemented aspects of C2005 and its

methodologies pertinent to the preparation of pre-service student science teachers for school contexts in South Africa. It is also aimed at establishing how the science teacher educators changed in the process. I am especially interested in discovering how such shifts were being made in a community of science teacher educators, most of whom have been accustomed to functioning in a traditional paradigm in their curriculum offerings for teacher preparation especially at former Black colleges of education (Salmon and Woods, 1991).

It is ironical that whilst science teacher educators may not have experienced an outcomes-based, learner-centred education themselves, they are required to prepare student teachers in such approaches, student teachers who were also not schooled in such a system. The process is further compounded by other rapid policy changes and restructuring at a higher education level, including the National Qualifications Framework (NQF), the South African Qualifications Authority (SAQA), the Council on Higher Education (CHE) and its quality assurance mechanism, a new Department of Education (DOE) and a level of decentralization of control of education from central Government to schools through such policies as the South African Schools' Act, Whole School Development, Whole School Evaluation and Teacher Appraisal. Such policies as these provide the current context for education, and as such cannot be ignored in teacher education programmes. They add greatly to the complexity of the change process and its implications for the daily lives of science teacher educators.

I regard my research as representing a key study because while the new curriculum was being implemented in schools, the expectation was that it was imperative for science teacher educators to prepare their student teachers for the new reality. This study therefore strove to establish how science teacher educators at three universities in a province in South Africa engaged with C2005 and its methodologies during the period 1996 to 2002. The study involved an interpretive analysis of science teacher educators' responses and the data for the study was collected in 2001. I have chosen to focus on two policies: the Natural Sciences Learning Area of Curriculum 2005 (C2005), the major curriculum policy at school level (Grades 1-9), and the Norms and Standards for Educators (NSE). A third policy is relevant: the restructuring of curricula in higher education according to the NQF, which involved modularisation of courses, and their redevelopment according to principles, templates and requirements

laid down by SAQA as part of course accreditation. Thus pressures to respond to C2005 and the NSE coincided with institutional requirements of modularisation and curriculum revision. The framing of the study from 1996 to 2002 relates to the introduction of C2005 in 1997. The production of data for the study occurred during 2001 and 2002.

1.6.1 Research Question

My research purpose is to find out how science teacher educators in three institutions in one province responded to the post-apartheid changes in curriculum policy, with particular attention to C2005, the NSE, and curriculum modularization in higher education. This purpose is expressed in my critical question:

CRITICAL QUESTION:

How have science teacher educators in PRESET education responded to curriculum changes proposed for the Natural Sciences Learning Area of Curriculum 2005, the Norms and Standards of Educators, and modularization in the Higher Education curriculum?

1.7 The rationale for the study

The rationale for the study flows from the introductory sections of this chapter. It is based on the following observations and issues:

- my personal observations about science teacher education during and after the apartheid era in South Africa;
- a unique and profound period of change in South Africa during the transition from apartheid;
- a changing science teacher education curriculum and the nature of its implementation in the South African context of change;
- literature which suggests that science teacher educators' practices and change have been a neglected area of study;

- interest in whether and how science teacher educators are capable of abandoning traditional approaches to science teacher education in favour of more progressive, more critical approaches.

1.7.1 My observations as a science educator

I have been employed as a science teacher educator (lecturer) for the past 15 years at a historically Black university. Earlier, I trained as a school science teacher at the same institution and then taught science at three schools for 16 years. My school-based and university teaching experiences spanned the second half of the Apartheid era and the transition to a political democracy in South Africa.

The science teacher educators in this study comprise a small community of university academics who, unlike those from the former colleges of education in South Africa, have always been somewhat free to utilize progressive approaches during their preparation of science teachers. I was aware that many of them were concerned about apartheid and Bantu education. To the extent that education and teacher education can contribute to transformation and redress in South Africa, how do science teacher educators respond, now that they are not only freer to respond, but required to respond? Research into science teacher educators' practices and change has not been documented in South Africa.

1.7.2 A neglected area of study

There is little research in South Africa on the practices and change experiences of science teacher educators compared to (school level) science teachers. Evidence of this, for example, is provided by Laugksch (2003) who developed an indexed bibliography of South African science education research. While there is considerable research into how science teachers have responded to C2005 and its methodologies, there is none on science teacher educators. Yet there is no reason to presume that research findings from schools apply in higher education institutions. I presented my research in progress at the 10th Conference of the Southern African Association of Research into Mathematics, Science and Technology Education (SAARMSTE) (Pillay, 2003), and found that my paper was the only one that presented research

about science teacher educators. This was true similarly for conferences over the last decade.

Internationally, science teacher educators have a tendency to study aspects related to school-based science education issues or aspects of their own practice. They have not ventured to investigate their colleagues' beliefs and practices, or to consider the ways in which science teacher educators and their institutions change (Lanier and Little, 1986).

Outside science education, there has been some research. In an analysis of geography teacher educators' perceptions of C2005, Balantyne (1999:75) indicated that they lamented the loss of geography as a discipline due to its integration in the Natural Sciences Learning Area as "The Earth and Beyond". Muofhe (2001) studied the influence of beliefs, experiences and structures on three teacher educators' practices at a university in the Northern Province of South Africa. Her research focused on the influence of the White Paper on Education's recommendations for a learner-centred education in South Africa. One of the three teacher educators in her study was a science teacher educator.

According to Conrad (1978) colleges and universities are frequently susceptible to external and internal environmental pressures such as satisfying conditions of accreditation and internal policies respectively. Although much has been written about the sources of change, little is known about the conditions under which, or the degree to which, sources of change are influential upon those who make the decision about the changes. Models of change have not provided a satisfactory explanation as to how change occurs or who and what are finally changed in the process. Cornbleth (1990) argued that an understanding of the internal processes of teacher education involves understanding the belief systems that underlie the practice of teacher educators.

In my focus on science teacher educators, I have chosen to work only with those in Faculties of Education, teaching at least in part in undergraduate pre-service education, where 'science education' includes both science and education, and where courses/modules might be expected to relate to the school curriculum and policies such as C2005. It is unlikely that professors who teach in BSc programmes in the pure

sciences would focus directly on issues related to teaching school science, not withstanding attempts made by science education professors in the US such as Fedock et al (1996) and Gallagher (J. Gallagher, personal communication, October, 2001) at providing science professors with the pedagogical basis for teaching science.

1.7.3 A changing science teacher education curriculum

As noted earlier, the current context in South Africa is one of immense turmoil and change in policies, structures and activities in all dimensions of South African life. The responses of schools, principals and teachers to the changes have been documented in several studies and show that there are deep confusions, with implementation of the new policies falling far short of government hopes (eg., Jansen, 2002, 2003; De Clerq, 1997, Christie, 1997, Mattson and Harley, 2003, Chisholm, 2000, Rogan and Grayson, 2003). One response in schools has been what Mattson and Harley refer to as 'strategic mimicry', where schools and teachers exhibit some of the trappings of the new approaches, but do not change in deeper ways. Explanations have been suggested in terms of the difficulties of paradigm shifts, weaknesses in past teacher education programmes, failures of school management, lack of resources, and so on. There is no research on whether similar responses and explanations apply in teacher education.

Of additional relevance to the South African context is the extent to which university science teacher educators have taken the lead in promoting curriculum change during the apartheid era and after. The report of the Review of C2005 commissioned by government (Chisholm 2000) indicated that the implementation of C2005 ultimately rested on teachers motivated to teach accordingly and provided with adequate support. It would appear that, during the 1990s, non-governmental organizations (NGOs) were more instrumental than universities in contributing to the development of science teachers. Recent changes in higher education have given universities primary responsibilities for teacher education and educational leadership, placing extra demands on science teacher educators. My research focuses on pre-service education programmes, but the same science teacher educators also engage with in-service education and programmes of teacher upgrade. The beliefs and practices of science teacher educators, and their responses to the recent policies have wide implications.

1.7.4 Abandoning traditional practices

A central goal of C2005, the NSE and the NQF is to produce critical thinkers who are prepared to examine various ways of solving real life problems (DOE, 1997, (b)). In a study of teacher education in the Northern Province of South Africa, Gozo (1997:2) expressed serious doubts as to whether teacher educators at colleges and universities would be able to change and abandon the methods they have become accustomed to. He recommended that teacher educators be given assistance in their attempts to meet the new requirements. He saw needs for universities to take the lead by organizing seminars and debates on the new curriculum for their own staff. Gozo (ibid) also concluded that:

It is however important to note that if teacher education institutions could provide data that showed that their programmes did in fact succeed in making progress towards the achievement of important outcomes, the credibility, status and professionalism of teacher education and teachers would be immeasurably enhanced. Who needs this more than the teacher education programmes and teachers of the new South Africa?

During the transition to democracy, many academics were part of shaping education policies for the emerging democratic government (NEPI, 1992), though the primary concerns were general policy more than subject-specific policies such as science education. It perhaps follows that the new curricula might be welcomed by the community of science teacher educators, in so far as the new curricula draw on recent research consistent with the commitments to social development and democracy. The challenges for science teacher educators become the focus of this research as it attempts to establish how science teacher educators have responded to education policy changes in post-apartheid SA.

1.8 The Plan of The dissertation

In **Chapter One** I presented a background for the research in terms of developments in the science teacher education curriculum in the South African context especially during the Apartheid era. This included some policy developments and NGO interventions that influenced science teacher education during that era. This led to statements of my research purposes and critical questions.

Chapter Two reports on policy developments that have occurred as a post-apartheid strategy that influenced science teacher education and contributed to educational change. These policies had implications for how science teacher educators were expected to function and added to the complexity that confronted them. In particular, I describe C2005 and related developments in the Natural Sciences Learning Area, the Norms and Standards for educators and the National Qualifications Framework as it applies in higher education.

Chapter Three relates relevant literature, focusing on international developments, change theory and other issues related to curriculum change with the intention of developing an appropriate theoretical frame that informs the research.

Chapters One to Three together inform the theoretical framework for the study which in turn informs the methodology for data production and analysis described in **Chapter Four**. The methodology chapter relates to an interpretive, inductive and descriptive frame for the methodology and analysis.

In Chapters Five to Eight, I present the analysis of the data on three levels. **Chapter Five** represents a first level analysis of the data in which my qualitative interpretations of interviews, curriculum materials, and observations of teaching during “lectures” are quantified to provide a general impression of the data. **Chapters Six and Seven** present second level analyses with the intention of representing the complexity of change for these individual science teacher educators. Chapter Six shows complexity by representing responses to the change process across all eleven cases (science

teacher educators), and Chapter Seven elaborates the themes through three selected cases.

In **Chapter Eight**, the final chapter in this dissertation, I attempt to synthesize the elements comprising the analysis in Chapters Five, Six and Seven into the final thesis.

CHAPTER TWO

POST-APARTHEID EDUCATION POLICY CHANGES

The purpose of this chapter is to place science teacher education in the context of a transition from apartheid rule to a democracy, pointing especially to the curriculum policies that were developed and that are central to this research. My intention is to locate the thesis in the suite of education policies and associated structures that emerged as part of the political changes from the mid 1990s. It is also my intention to present and critique developments related to these policies and their implications for science teacher education and science teacher educators. This chapter must also be viewed as an attempt at presenting new and positive changes in the face of the turmoil that science teacher educators faced during the apartheid era (see section 1,4 in Chapter One) and which may have influenced their professionalism, responsibility and accountability, either to the school or teacher education institution or both.

As briefly indicated in Chapter One, the main policies, in relation to this research, are the National Qualifications Framework (NQF), Curriculum 2005 (C2005) and its revision as the Revised National Curriculum Statement (RNCS), the Norms and Standards for Educators (NSE), and curriculum revisions required in higher education in response to the NQF. The main structures are NEPI, SAQA and the national Department of Education. These policies and structures should be seen in the broader context of wide-ranging restructures of government, departments of education and educational institutions, aimed to provide an integrated, unified, accessible, single system to replace the race-based fragmented system that existed under apartheid. While the period was characterized by turmoil, it was also a time of optimism as, for most South Africans, the hopelessness of the apartheid era gave way to the hopefulness of 'the new South Africa'.

2.1 The Transition to a post-Apartheid Educational System and its Implications for Science Teacher Education

Significant developments in research and policy are presented and critiqued here in an attempt to provide the context which finally resulted in fundamental curriculum changes that added yet more complexity to the lives of science teacher educators.

2.1.1 NEPI

In anticipation of government change, the broad democratic movement that opposed apartheid established the National Education Coordinating Committee (NECC), which in turn instigated the National Education Policy Investigation (NEPI). The NEPI initiative was not to develop policy, but to provide a research basis for policy. Its objective was to interrogate policy options in all areas of education within a value framework derived from the broad democratic movement. Prominent science teacher educators served on NEPI panels of investigation.

Of significance to science teacher education was the recognition by NEPI (1992) that education in South Africa has a responsibility to equip people as citizens living in a post-industrial era and that science, mathematics and technology education in the school curricula should be priorities. It followed that teacher education programmes should have as one focus the education of competent science and mathematics teachers. Science teacher educators had a special role to play in the new educational dispensation.

NEPI's research group on teacher education, a consultative forum, proposed that there was not enough emphasis on preparing competent science, mathematics and english teachers in current programmes, and there was too much theory and too little practice within the curricula (NEPI, 1992). Several respondents from the Black African colleges expressed deep concern about the stranglehold Fundamental Pedagogics had on curriculum and teaching. Some noted that innovative, reflective and critical approaches were present in some colleges and universities, and these should be preserved (NEPI, *ibid.*).

The White Paper on Education and Training (DOE, 1995) was informed by the NEPI research initiative, but also by negotiations between government, unions and business (Jansen, 2002). It spelled out the government's policy approach on the National Qualification Framework (NQF) and conceived education comprehensively and not merely in terms of formal schooling:

- it provided strategies, policy instruments and mechanisms to transform higher education. It specified that these must be determined not only by goals and principles but also by existing conditions within society and in the higher education arena.
- It argued that the critical value of higher education to society lies in its ability to provide graduates with thinking and practical abilities that can both enrich society and enhance its development.

The White Paper on Education and Training placed demands on teacher preparation that were very different from and more complicated than the apartheid curriculum. Science teacher educators, for example, would have to relate their practices to a broader social framework. This was spelled out clearly in the National Qualifications Framework and the Norms and Standards of Educators.

2.1.2 The National Qualifications Framework (NQF) and Lifelong Learning

The Education and Training White Paper (DOE, 1995) and the South African Qualifications Authority Act (1996) established the framework and processes for the NQF (DOE, 1996). The aim of the NQF was to provide a national system of standards and structures through which courses (and other educational experiences) and learners' achievements could be registered. This would control standards, guide planning, and enable national recognition and portability of learners' credentials. In this, the NQF sought to bring together 'education' and 'training' across schools, adult education, higher education, apprenticeships and work-place programmes. It sought to encourage life-long learning for South Africans through an hierarchy of qualifications that allow exit and entry points as and when they are required. The system was unified by a set of principles, including outcomes-based, learner-centred curriculum design.

For example, a single set of Critical and Developmental Outcomes overarches all education programmes in South Africa, promoting competences such as problem-solving, critical thinking, communication and teamwork (see Appendix 1).

2.1.3 The South African Qualifications Authority (SAQA)

Initial teacher training degrees, like all education qualifications and modules, have to conform to the principles of the NQF and be registered and accredited with the South African Qualifications Authority (SAQA). Science teacher educators, therefore, became legally bound to conform to the principles of the NQF. This is indicative of leverage through a systemic reform process in the new educational dispensation in South Africa.

2.1.4 The NQF and outcomes-based education

Qualifications and modules registered with SAQA must be described in terms of learning outcomes. Such outcomes are competences that go beyond knowledge to encompass knowledge in and through action and transdisciplinary forms of skill. For teacher education (pre-service and in-service), SAQA requires that modules conform to the Norms and Standards for Educators (NSE), an outcomes-based framework. As explained in Chapter One, this represents a paradigm shift in teacher education, compared to traditional approaches.

In the next section I will present the challenges faced by teacher education, and especially science teacher education since the introduction of a democracy through change of government.

2.2 The Challenges of Teacher Education in a Fledgling Democracy

After its election in 1994, the government was faced with a fragmented, inequitable system in which records were often inadequate, so, for example, there was no accurate knowledge in some parts of the system of the number of schools, or students in schools. There was consequently a need to develop national policy through a national

teacher education audit. According to Le Roux (1998), a Commission on Teacher Education Policy (COTEP) was established in 1993 to advise the Minister of Education (during the transition to a democracy) on national policy related to teacher education. Until 1993, there was no national policy on teacher education, nor was there a national data base on teacher education. Also, a national qualification structure for teacher education did not exist. COTEP committed itself to undertake a situation analysis of all teacher education in South Africa (Le Roux, *ibid.*) so as to inform teacher education policy at a national level.

The National Teacher Audit aimed, among other issues, at an evaluation of the capacity of teacher education institutions and programmes to provide pre-service and/or in-service teacher training (Hofmeyr & Hall, 1996:1). The Audit revealed several strong boundaries: a sharp divide between pre-service teacher education and in-service education; the dispersal of teacher education over several kinds of institutions (colleges, universities and technikons) with varying degrees of institutional autonomy; the separation of institutions according to mode of delivery (contact or distance). It showed a large concentration of disadvantaged student teachers at institutions least equipped to prepare them to work as teachers, for example, in rural and 'township' colleges and 'correspondence' universities (Welch, 2002; Christie, 1998).

The Audit also found a specific shortage of teachers in subjects such as Mathematics, Physical Science, Technology, and Commercial subjects. Science teacher educators who were accustomed to working in racially segregated institutions of teacher education were further faced with classes that included diverse cultures and languages. Those who were not accustomed to teaching student science teachers for whom English was a second language, or whose learners would speak English as a second language, had to find new approaches.

The new government was also re-entering the global market. It had to consider how education could serve the economy in the face of the challenges of globalization. Welch (2002:24) observes that:

...the nature of the economy is global, created and sustained by information and communications technology, and demands an education that equips

learners for flexibility and change. The present government also has a powerful mandate from its voters to increase access for the poor, for redress, and for equity.....

At the same time, the majority of South Africa's population is rural and poor, engaged in subsistence and small scale farming, without access to the infrastructure or the skills required of the global economy. Their lives often are framed by traditional cultures and ways of living. South Africa has to find pathways through the different values-positions, hopes and ways of life of different groups within the society.

Science education has important roles to play not only in enabling redress for equity, but in deciding what equity means in South African society. A report by Schreuder (1994) on the Core Syllabus Committee for the Natural Sciences provided a rationale for including the Natural Sciences in the new South African school curriculum. Amongst others, two fundamental purposes for science education were identified:

- to provide the knowledge and skills necessary for an improved quality of life for all individuals since a large majority of South Africans were exposed to poor living conditions and were victims of disease, malnutrition, polluted water supplies, etc.
- to provide for national economic growth and science related employment opportunities.

With respect to this Committee's proposed purposes for science education, what kind of teacher education curriculum could science teacher educators develop?

An added complexity was the decision by the Minister of Education on 15 December 2000 to rationalize teacher education. This involved the incorporation of some colleges of education into higher education and the closure of others. The result was to reduce the number of institutions offering teacher education from approximately 150 to 23 institutions. While the other intention of the rationalization was to overcome the findings of the National Teacher Audit which showed that there was an over-supply of teachers (based on an educator:learner ratio), current developments with respect to teacher attrition rates and the HIV AIDS crisis in the Province in which my

research has been conducted indicates that there is a looming shortage in the supply of teachers (DOE, 1996).

2.3 The new school curriculum

Science teacher educators (and other teacher educators) were faced with additional challenges related to the introduction of a new outcomes-based curriculum at a school level.

2.3.1 The Introduction of C2005

C2005, consistent with the NQF, advocates an outcomes-based, learner-centred system of education in the General Education and Training phase (Grades 1 to 9). It was introduced in 1996 and implemented in schools in 1997. It was followed by a revised version in 2001, the Revised National Curriculum Statements (RNCS).

Along with the changes in philosophy, purpose and methods, C2005 introduced a plethora of new terminology. Its Critical Outcomes (across learning areas) and Specific Outcomes (specific to learning areas) replaced the objectives of the traditional curriculum. The new curriculum referred to pupils or students as learners, subjects as learning areas, teachers as educators. For each of the outcomes, the policy prescribed assessment criteria, range statements and (possible) performance indicators. To support integration across learning areas as part of curriculum design, teachers were to decide on phase organizers such as 'The Environment', and, within particular learning programmes, programme organizers such as 'Weather' (DOE, 2002). Schooling was divided into three phases: the Foundation Phase (grades 1 to 3), Intermediate Phase (grades 4 to 6) and the Senior Phase (grades 7 to 9). C2005 advocated learner-centred approaches to curriculum design and teaching, based in constructivism and context-based learning. Thus teachers were expected to be curriculum designers, and design learning programmes suited to children in their local setting.

In the Natural Sciences Learning Area, four content themes were specified: Life and Living, Energy and Energy Transfers, The Earth and Beyond, and Matter and

Materials. Thus curriculum design had to encompass four themes, nine specific outcomes, the set of critical outcomes, and integration with other learning areas, all in a learner-centred framework. Assessment too had to be learner-centered and competence based, achieved through continuous assessment (with assessment an integral part of learning) and not just tests and quizzes.

The introduction of C2005 in 1996 and its implementation in 1997 was met with resistance from some teachers and applauded by others (Jansen, 2002). For example, teachers complained about the expectations that they would function as curriculum developers and assessors, especially when so many schools lacked facilities, equipment and libraries, and worked with large classes. As Fullan (2001) observes, curriculum change is a complex process, involving many actors and interests, and facing many difficulties. Christie (1998) anticipated that while C2005 allowed greater space for teacher involvement in curriculum construction, changes at the classroom level would be hard to achieve.

The concern of my research is the extent to which such changes and difficulties were felt in science teacher education. In the next section I attempt to relate science teacher education to the expectations of C2005 and the NQF.

2.3.2 Outcomes-based Methodologies

2.3.2.1 What are outcomes?

Van Rensburg (1998:28) points out that outcomes-based education provided a means to a single, unified education system (with one set of outcomes applicable across the nation), but with the outcomes defined as competencies, allowing variations in the details of teaching and learning in particular settings. According to Kudlas (1994:32, in Pretorius, 1998:ix) an outcome is a “demonstration of learning”. It is what the student is “to know or do”. Spady (1994:18) defines outcomes as “high quality, culminating demonstrations of significant learning in context”. On the basis of definitions of Spady and Kudlas, Pretorius (1998) presents an outcome as *a visible, observable demonstration*, something that a learner can do as a result of the range of learning experiences and capabilities that underlie that demonstration.

Critical outcomes are critical in terms of economic and social development, redress and democratic participation. They include such competences as creative problem-solving, critical thinking and working with others (see Appendix 1) The critical outcomes are mandatory in higher education as they are in C2005. Science teacher educators must support student science teachers to develop the critical outcomes as part of their own courses in terms of the process of modularization. However, preparing student science teacher educators for C2005 is not a mandatory expectation for them to fulfil in their own higher education programmes.

Specific outcomes are linked to particular context or to a learning area. Spady (1994:20) states that a clear set of learning outcomes (specific outcomes) should be developed around which all the system's components can be focused. The Natural Sciences learning Area in C2005 has nine specific outcomes (see Appendix 1). The first two of these concern processes of investigation (SO1) and conceptual knowledge (SO2). The other seven extended to applying science in problem solving (SO3), management of resources (SO4), responsible decision-making (SO5), science and culture (SO6), the nature of scientific knowledge (SO7), bias and ethics in science (SO8) and the relationships between science and economic development (SO9).

Thus while the Critical Outcomes strongly reshape teaching (promoting problem-solving, critical thinking, team work, and so on), the Specific Outcomes reshape science. Science teacher educators were not obliged to respond to the latter which were more a responsibility for teachers at public schools.

2.3.1.2 Learner-centred education and Constructivism

The documentation on C2005 (Department of Education, 1997(b)) uses the following phrases related to learner-centredness:

- learner-centredness means that the learners are active participants in the learning process.
- learner-centred activity is activity in which learners take individual ownership of the task.

- the learning environment is one in which learners are partners in the process of their own development.
- learner-centred methodology enables learners to develop their own skills and understanding in contrast to a teacher-centred environment in which the teacher is dominant and uses the “show and tell” or “chalk and talk” approaches to education.

Together with the Critical Outcomes, learner-centredness implies the use of teaching strategies such as group work, class discussions and problem-based learning, and at the same time underlines participatory democracy as a cornerstone of classroom life.

These approaches to learner-centred education are in accord with constructivism as a learning theory and, to a lesser extent, as an epistemology. The focus is not on the theory per se, but on the role of constructivist approaches to develop learner-centredness for meaningful learning and problem solving. C2005 therefore set up constructivist learning as a contrast to behaviourist learning and transmission teaching in its emphasis on the use of cooperative learning strategies. The theory of constructivism and its relevance to my thesis is presented and critiqued in Chapter Three.

2.4 Curriculum 2005: Policy and Principles compared with international perspectives for change

2.4.1 C2005 and Social, Political and Economic Redress

As noted above, the Critical Outcomes and learner-centred methods and the broad definition of science entailed in the Specific Outcomes work together in promoting participation, critical thinking and the value of diversity. The Chisholm Committee’s review of Curriculum 2005 notes that the Critical Outcomes are aimed at uplifting a historically oppressed majority (Chisholm, 2000). This is in keeping with Paulo Freire’s “Pedagogy of the Oppressed” which after 25 years since he wrote his controversial book, is currently relevant to the South African context, when he claimed that:

people develop their power to perceive critically the way they exist in the world with which and in which they find themselves; they come to see the world not as a static reality, but as a reality in the process of transformation.

(Freire 1970:33)

While such a reading of C2005 is possible, so is one in which the goal is to develop knowledge and skills that serve and drive a market-related economy (Christie, 1997; Jansen, 1998). Given the degree to which Blacks were excluded from leadership in the science-based economy, and the levels of poverty and inequity in South Africa, wider participation in the market-related economy is vital (DOE, 1994). However, Chisholm (1992) and others are dubious about the capacity of educational change alone to generate an improved economy and society.

At the classroom level, socially critical curriculum and curriculum that advances technical knowledge and economic development are far from incompatible. However, they add to the complexities of curriculum design for science teachers and science teacher educators.

2.4.2 Criticisms of OBE

While there was general support across South Africa for the underlying principles and purposes of C2005 (Chisholm, 2000), there were, from the beginning, many critics and criticisms. Some teachers were extremely negative (Jansen, 1998), considering themselves inadequately trained and their schools poorly resourced. Vocal parents felt that educational standards would drop, in part because their children would be caught up in an educational experiment and a system in major transition. Many view OBE as a first-world model (Jansen, 1998), developed in contexts where schools and teachers had long histories of school-based curriculum experiences. Pretorius (ibid) argued that OBE could be applied only in countries where favourable teacher-learner ratios were possible, where teachers had received adequate training and where they had sufficient resources and support. On the other hand, critics of OBE, especially using sources from the USA, argued that OBE had not 'worked' in countries such as the USA, Canada, Australia and New Zealand. Jansen (1999) observed South African primary

school classrooms where OBE was practiced and attended workshops conducted with teachers. He concluded that OBE would fail in South Africa.

The HSRC's (1995) comments about problems related to imported policies are significant in the current South African context:

It is usual for policy developers to seek advice and guidance from the work done in other countries, but no policy, no matter how carefully developed, can be imported and developed directly. Local contexts and conditions may be far removed from those existing in the countries in which policies originated. Local research, development, debate and contestation are therefore crucial ingredients of policy work (HSRC, 1995).

Christie (1995) offered a further explanation in which she articulated the importance of local conditions when following global trends and “borrowing” policy. Referring to competency approaches to education she stated (in HSRC, 1995:37):

Most of the policy proposals in the White Paper, including an outcomes-based approach to curriculum and assessment, are merely fields mapped for play in a very uncertain game. And if global policy outlines can be easily transferred from context to context, it is surely the case that the struggles of implementation are a wholly local matter.

The symbolism associated with new policies is important here: in part, C2005 symbolised a new, democratic South Africa; in part it symbolised parity with systems such as the UK and Australia. It is as in implementation that the policy takes its shape, and this was an uncertainty that played itself out among science teacher educators and schools more generally.

2.5 A changed system of assessment

Assessment can drive curriculum change in a number of ways. In particular it enacts what is important to learn, and what it means to learn successfully. For example,

Lemke (2004:4) observed that 'large scale standardized testing imposed an artificial fitness landscape that pulls the system towards behaviours that maximize test results rather than deep conceptual understanding'. Coaching students with pre-prepared responses to higher level questions could defeat the purpose of meaningful learning. It has been my observation as a school science teacher myself that the assessment system in the traditional science curriculum in South Africa focused on tests to measure the scientific knowledge of learners in the cognitive domain, knowledge that was often fragmented and decontextualized. Science teacher education programmes for initial teacher education helped student science teachers to overcome such approaches by employing a varied approach to assessment as a role modeling process. There was room for low levels of class-based assessment, especially of practical work, but this posed no great challenge to science teacher educators.

C2005, with its emphases on broad competences and learner-centred approaches, urged teachers to use continuous, formative assessment which would also provide data for summative assessments. A variety of modes of assessment were encouraged, to be brought together in learners' portfolios, from which progress and achievements could be inferred. Descriptive assessment criteria (C2005) or assessment standards (RNCS) were provided to guide teachers' analyses and judgements. Devising multidimensional assessments for a number of outcomes and keeping track of individual students constituted major challenges to schools and science teacher educators. They also involved marked increases in workloads. As Barnes et al. (2000) found in Australia, mandated assessment of this kind does not necessarily produce curriculum change in school classrooms that matches the rich expectations of policy: teachers find manageable short-cuts. Preparing student science teachers for such a policy of assessment was a new development in the lives of science teacher educators.

2.6 Review of C2005

As a result of confusion and implementation problems at schools related to C2005 (Jansen, 1998;1999), the government commissioned a review, just three years into its implementation. C2005 has a built-in review process (DOE, 1997 (b)) The Chisholm Committee reported in 2000. It confirmed many of the concerns and problems

outlined above (see sub-section 2.4.2). In general, respondents endorsed the underlying principles and purposes of C2005, but found the policy much too complex and the terminology confusing. The Committee recommended a ‘streamlining’ of C2005 – holding on to its bases in outcomes and learner-centredness but simplifying the structure and terminology. It recommended also that ‘horizontal integration’ (across subjects and contexts) give way to vertical development and the promotion of ‘high knowledge and high skills’.

The Revised National Curriculum Statement was formally introduced in May 2002 and set for field integration in schools by 2008 (DOE, 2002). The principles of C2005 for social and political redress, including the Critical Outcomes, continue to prevail. However the number of specific outcomes, in all learning areas, was greatly reduced. In the Natural Sciences Learning Area the first two outcomes were retained, and the others were subsumed into a single outcome. Thus, the resulting outcomes are:

- the development and use of science process skills in a variety of settings;
- the development and application of scientific knowledge and understanding; and
- appreciation of the relationships and responsibilities between science, society and the environment.

The confusion of assessment criteria, performance indicators, expected levels of performance, range statements and phase and programme organizers was replaced with a set of grade-based ‘assessment standards’ in each of the outcomes. The emphases on competence and continuous assessment were retained, as was the expectation that teachers would design curriculum and assessment that would suit local learners and conditions. The pressure to incorporate Indigenous Knowledge remained, along with the idea of presenting science as ‘a way of knowing’.

The Chisholm Committee stressed that the goals of social justice, equity and development through creative, critical and problem-solving action lay at the heart of the curriculum, but at the same time warned that education should not be viewed as the sole agency of social change. As she had cautioned years earlier (Chisholm,1992)

education should not be seen as an eternally malleable vehicle for the realization and expression of all social hopes, even accepting that such hopes are often placed in education in moments of social change. Even when solutions are known to lie in the economic sphere, the educational space is appealing because it is a symbolic one, at its heart concerned with change and development.

The Chisholm Committee also recommended that teacher education be consolidated into higher education, including preparation for the revised curriculum (Chisholm, 2000). It followed that higher education (universities and technikons) had to be involved in the planning of curriculum support for the RNCS. The Committee observed that, at a national level, higher education was usually left out of debates around school curriculum (including C2005 and its revision); institutions providing teacher education and training usually came aboard only after plans have been drawn and implementation under way. Hence, it has to be emphasized that the Chisholm Committee had made such a recommendation in the face of the need to engage teacher education institutions with the curriculum change process aimed at and designed for the public schools. It has to be therefore emphasized that C2005 was not an imperative for teacher education institutions. It was planned for implementation in public schools and science teacher educators were not obliged to fulfil its expectations.

2.7 Pressures on traditional science teacher education

The foment surrounding C2005 and other school level policies fed indirectly into teacher education, and added to direct pressures on higher education from the NQF. Smith (2000: 7) noted that the logic of the traditional model for teacher education was out of step with the times, more concerned with the teacher as a classroom technician than as a catalyst for change. He argued that:

student teachers should be made aware of reform initiatives and alternatives to existing schools so that children will achieve better outcomes.

The traditional teacher education model was out of step with C2005 and incapable of dealing adequately with social change (Smith, *ibid*).

As I noted in Chapter One, some universities and science teacher educators had already deviated from the traditional pattern (Levy, 1992), for example by:

- engaging Student Science teachers with reflective approaches to teaching science,
- encouraging student science teachers to adopt a collaborative approach to teaching science using action research strategies,
- providing student science teachers with opportunities of curriculum development experiences linking science teaching to the context of reality. These included the teaching of science to large classes, taking into account indigenous language issues when teaching a western science, recognizing using indigenous knowledge systems when teaching science, etc.,
- overcoming expository teaching methods with learner-centred strategies informed by appropriate learning theories such as constructivism to generate meaningful learning in science,
- teaching environmental education in “outdoor classrooms” linked to the reality of environmental degradation,
- role modeling learner-centred strategies for science teaching,
- improvising science equipment innovatively in under-resourced contexts without compromising rational science knowledge by generating misconceptions in science.

2.8 Higher Education Policy Changes

2.8.1 The Norms and Standards for Educators (NSE)

The NSE was designed to link with C2005 and the devolution of curriculum design to schools (DOE, 2000(a)). An earlier form was developed by the Committee on Teacher Education Policy (COTEP) in 1995 and declared national policy. Le Roux (1998) claims that COTEP attempted a radical shift in devising a set of national Norms and

Standards for all educators. For example, it specified that teacher education should aim to promote education for critical, responsible and useful citizenship in order to equip the individual for service to the wider community and environment. Pendlebury (1998) regarded the COTEP initiative as a significant step in featuring democracy in the new curriculum frameworks for teacher education. The catalytic role of the teacher in social transformation is built into the policy.

The COTEP document was revised to fit the emerging National Qualifications Framework (NQF), and the resulting NSE, gazetted on 4 February 2000, became the basis of the design and accreditation of courses and modules in teacher education.

The NSE provides a “generic” picture of an educator, in terms of required competencies and roles (see Appendix 2). It conceptualises an educator as a self-directed professional; an individual with practical, foundational and reflexive competencies who is able not only to consider a range of possibilities for action, make decisions about what possibility to follow, and perform the chosen act competently, but also demonstrate an understanding of the knowledge and thinking which underpins the actions taken, and reflect on the actions with a view to adaptation. This represents a shift from the view of an educator as a technician who translates the syllabus into classroom activities and administers tests (Le Roux, 1998).

In its guidelines for course development, the NSE recognized Teaching Practice as an essential feature of teacher education, but did not require specific competences or prescribed time in schools. Teaching practice was seen as an experience through which all the roles of educators would be developed and assessed.

Gultig (1999) claims that the NSE can meet the requirements to improve classroom practice, restore to teacher education a focus on schools, and equip teachers to meet global demands through:

- a deep understanding of higher order concepts and perspectives;
- reflexivity;
- the ability to think metacognitively.

Some views on the NSE

However, De Clercq (1997:128) states that the NSE has a largely symbolic function presenting a holistic picture of an ideal teacher toward which teacher education curricula should aim.

The notion of applied competence and its associated assessment criteria are deemed by the policy as its cornerstone. While the perception of applied competence is regarded as behaviourist (Jansen, 1998), its potential in enabling a paradigm shift for practitioners trained as implementers of curriculum during the apartheid era appears to be the most appropriate means of developing the kind of reflective practitioner needed in South Africa's new democracy (Pendlebury, 1998).

Some or most of the roles prescribed by the NSE are not new in the South African context of science teacher education. For example, all science teacher education programmes had prescribed subject specializations for science teaching methodology courses during the apartheid era (Levy, 1994). PRESET science teachers were exposed to Biology, General Science and Physical Science special methods which prepared them to teach Biology, General Science and Physical Science as high school subjects. Some institutions offered Natural Science as a special method for primary school science teaching. One of the roles in the NSE which prescribes that the educator (teacher) has to be developed to become a learning area specialist (e.g., Natural Sciences Learning Area) appears to approximate the former traditional trend. But the difference is that Learning Areas of Curriculum 2005 are no longer referred to as subjects. This is due to the need to soften the boundaries between subjects so as to enable cross-curricular collaboration between educators for a more holistic or integrated offering at schools intended for meaningful learning and the development of the principles of democracy.

The purpose of my research question seeks to further probe the extent to which the NSE were taken seriously by them. Did the science teacher educators fulfil the procedural and regulatory aspects of this policy change and if so, did they implement the NSE as per policy prescription, or was it symbolically applied as a form a strategic mimicry? Or, did they read the document at all?

2.8.2 Modularization

Part of the curriculum revision in higher education imposed by the NQF was the conversion of university subjects and courses to modules. The process was intended to improve portability and credit for achievement, in comparison with year-long subjects. Modules were to be redesigned in terms of outcomes, according to SAQA guidelines, and were to shift towards continuous assessment practices. Universities had to write their module plans according to given templates and submit them for registration with SAQA.

The process of modularization, including the shift to outcomes-based designs and continuous assessment, was no doubt handled in different ways by different individuals and groups. At one end, it was possible to essentially ‘repackage’ courses according to the SAQA templates; at the other end it was possible to totally re-think programmes and modules. In teacher education, given the accompanying changes in school policies, major redevelopment of courses might have been expected.

The modularization process and the NSE were intended to provoke the same kinds of change that the science teacher educators were expected to make in response to C2005. The changes were related to a shift to learner-centredness, cooperative learning techniques and continuous assessment – rationales typical of C2005. However the policy imperatives driving teacher education were not the same as that for schools. The science teacher educators were not expected, from the NQF’s bureaucratic expectations, to directly serve the interests of schools in terms of C2005. They were expected to change their practices in their lecture rooms to become learner-centred.

2.9 Education, macro-economics and social policy

While I have chosen to focus on C2005, the NSE and the modularisation and revision of curricula in higher education in this research, it is important to see them in the broader context of policy development and change in South Africa. Education during the apartheid era was part of a larger agenda, used, as Samov (1999:17) claims to structure economic, political, and social roles for the purposes of segregation and

subordination. In contrast, education in the post-apartheid period is aimed to maximize participation in economic, social and cultural development consistent with a Constitution strongly based in human rights, democracy and social justice. The ways to achieve this, in broad terms, have been hotly debated, with choices vacillating between, on the one hand, neo-conservative strategies to strengthen the economy and promote investment before tackling social redress, and on the other hand to give priority to social transformation as a longer term strategy to build the economy. The government sought a compromise that in effect favoured priority to economic development (Jansen, 1998).

This conflict between economy-driven and socially critical approaches to curriculum was played out in the development of the NQF, and again in the revision of C2005 to produce the RNCS. For example, Jansen (1998) observes that the first drafts of the NQF and the choice of outcomes-based approaches 'came from nowhere', in that they had not been anticipated in reports such as NEPI and the work done earlier in the name of 'People's Education for People's Empowerment'. Even so, aspects of People's Education and critical pedagogy were absorbed into contemporary policy (Chisholm, 2000), including:

- the critical and developmental outcomes, carried forward also in the specific outcomes in the Learning Areas
- an egalitarian political mission;
- a critical thinking, creative problem-solving thrust;
- learner-centred, participative approaches to curriculum and teaching;
- teachers as curriculum developers;
- group work rather than transmissive teaching;
- community participation.

In the Natural Sciences Learning Area, aspects of People's Education can be seen in the broad definition of science, its concerns for critical thinking, outcomes that link science with society, culture, and the environment, and the inclusion of Indigenous Knowledge. In the NSE, the community, citizenship and a pastoral role is one of its seven roles of educators.

Malcolm and Alant (2004), in a review of science education research in South Africa, claim that, from the evidence of the professional papers and conferences, science education researchers as a group were not deeply engaged in the critique of apartheid education and political movements such as People's Education. They claim also that much of the science education research through the transition period remained essentially technicist, with a tendency to identify specific problems (in learners, learning, teachers and schools) to be overcome, and offer solutions to these problems. This suggests that science teacher educators (who are often also the researchers) do not have a strong record of involvement in political activism or classrooms and curriculum as political sites. The new policies challenge science teacher educators and teachers to think about the purposes of science education much more broadly than the development of science knowledge and skills.

2.10 Conclusion

The introduction of policies such as C2005, the NSE and modularization of higher education courses occurred at a time of immense change in South Africa, amidst a sea of policy development, restructure, unimagined levels of individual freedom and mobility, and fresh links with people, thinking and financial support from other nations. As Chisholm (1992) observes, in such times of change, there is a tendency to place great hopes in education, in part because education by its nature symbolizes change, development and a new future. The new policies, for all their concerns for social transformation and economic development, have at their centre the devolution of curriculum design and assessment according to a central, national framework. Thus the responsibilities for 'interpretation', 'implementation' and effect lie especially with teachers. Given that policies have now placed all teacher education within higher education institutions, the professional responsibilities of teacher educators, including science teacher educators, are great. Such professional responsibilities have implications in terms of how the science teacher educators viewed themselves in terms of the higher education institution and public schools.

CHAPTER THREE

CONCEPTUAL UNDERPINNINGS AND CHANGE

The main purpose of this chapter is to establish the theoretical framework that underpins my research by developing the theoretical tools I will use to inform my methodology and analysis. This is especially in terms of the complexity of the context and the theories of change that support my thesis. The complexity of the South African context for curriculum change that has been presented in Chapters One and Two will be extended further in this chapter.

In organizing this chapter, I will first comment on the role of the theoretical frame as this pertains to my research. Thereafter I will present and critique theories of change to support my interpretive perspective. This will be followed by other issues affecting curriculum change in the South African context. The main pressures affecting curriculum change will then be discussed in relation to my developing thesis. The latter will be presented as an emerging frame for the thesis which will be developed further in the three chapters that follow.

3.1 The Role of the Theoretical Frame in this Research:

I will use the theoretical frame as the lens through which the analysis is interpreted and represented. This will determine, according to Denzin and Lincoln's (1998) view, how I position myself in terms of the research.

In developing my theoretical frame I have been guided also by Newman's (1997:56) claim that:

theory frames how we look at and think about a topic. It gives us concepts, provides basic assumptions, directs us to the important questions, and suggests ways for us to make sense of data. Theory enables us to connect a single study to the immense base of knowledge to which other

researchers contribute.

Given the purpose of my study, to investigate responses of science teacher educators to changes in curriculum policies, my central concerns are organisational and individual change, teacher educators as learners, and reasons why the teacher educators did or did not change. Thus, in the first part of this chapter, I present a review of issues and theories that other researchers have written about, that might be relevant to science teacher educators and my study.

In doing that, I build on ideas introduced in Chapters One and Two. In these Chapters I outlined curriculum change as a part of national ‘transformation’, from apartheid’s Objective Model to post-apartheid’s Outcomes-based Model and the policy changes informing these. Underpinning such transformation are principles of human rights, democracy and participation, as set out in the Constitution. Thus, while my study is essentially interpretivist in its purpose, it arises in the context of social transformation, and commitments to social justice and redress.

In this chapter I include change theories and other theories that account for changes among persons such as science teacher educators. These theories work together. Among the change theories are those classified as Traditional Change, Adaptive Change and Advanced Change. Other theories such as theories in action and a theory of academic change are useful in understanding change in academic and other settings. Constructivism as a learning theory, integral to the new curriculum policies, is an important component of the theoretical frame for interpreting teacher educator change. Systemic reform as leverage for change is a significant pressure influencing the responses of science teacher educators to curriculum change. In a context of political and social change, they may forge different identities depending on how they experienced apartheid education. The political symbolism associated with curriculum change may result in them strategically mimicking change or being morally obliged to conform. The pressures of curriculum change during the political transition therefore adds complexity to the change process and also to the lives of science teacher educators.

3.2 Viewing the research through different lenses

Fullan's (2000:198) emphasis that 'educational change is technically simple and socially complex' serves as a recognition that there is a need for hermeneutics in understanding educational change. I therefore adopted an interpretive stance in my research. Even though some of my research instruments (see Chapter Four), especially my observation schedule and document analysis, were developed in advance of the data collection (implying a positivist approach insofar as they assume predetermined hypotheses and criteria), my semi-structured interview schedule, document analyses and classroom observations provided my respondents with freedom and flexibility of expression within the (broad) parameters of the intentions of my research (see Appendix 4).

3.3 Theories of change

One strategy in an interpretivist framework is for me as the researcher to become knowledgeable about different theories and paradigms that respondents might be using. Arming myself with different interpretive frameworks leaves me in a better position to understand what teacher educators claim during interviews and what they do in practice. I therefore used change theories to assist in designing my research instruments and analysing the data produced.

One of the assumptions in conducting this research was that, because science teacher educators come from different backgrounds (for example, as a result of apartheid structures and processes), they may respond differently to change. How they have changed in the process of relating to the new curriculum change process at a higher education and school level may therefore differ among individuals. I will therefore briefly describe each change theory for its potential in supporting my critical question so as to understand their responses to change.

Traditional Change Theory (Chin and Benne, 1969), Adaptive Change Theory (Heifetz, 1994), and Advanced Change Theory (Hooijberg, Hunt and Dodge, 1997) are among change theories that are pertinent to my study. I make this claim on the basis that these theories have been formulated through studies based on change in workplace situations. They are relevant here because science teacher educators based at tertiary institutions have to respond to demands from their employers in conducting their practice. The bureaucratic demand of the NQF in terms of modularization and the NSE through the teacher education institution was not a demand for the science teacher educators to respond to school related curriculum changes.

As explained in the rationale in Chapter One, there has been limited research conducted on curriculum change and its influence on science teacher educators. The change theories presented in this study relate positively to the lives of science teacher educators. In the next sections, these are also presented and compared with learning from the business sector as per Argyris's writings (see later) on organizational learning (Argyris, 1996) based on one's theory in action.

3.3.1 Traditional Change Theory:

Traditional Change Theory relates to positivist tendencies to ensure change through persuasive or coercive means. Chin and Benne (1969) developed the following categories of change strategies within Traditional Change Theory.

3.3.1.1 Empirical-rational (making logical arguments for change):

- ✓ This strategy assumes that people are guided by reason and will calculate whether it is in their best interest to change. It assumes that if people understand the logic for change and see themselves as benefiting from the change, they will be more likely to change. Chin and Benne (ibid) suggest that individuals must be educated about the logic and benefits of change. Such a view conforms with Fullan's (2000) assertions that finding moral and intellectual meaning related to change may serve to overcome resistance to change.

Chin and Benne (ibid) claim that although this strategy is sometimes effective for technical changes, it has proven less effective for adaptive change (see below)

because it has a narrow cognitive view of human systems. It fails to incorporate the affective and normative domains, and acknowledge the complexities of the change process. Although people may understand why they should change, they may not be willing to make the changes required. Such opportunities for curriculum change did not occur during the apartheid era in South Africa due to negative impact of the RDDA model for curriculum change that resulted in implementation failure (see Chapter One).

3.3.1.2 Power-coercive (using forms of leverage to enforce change):

This strategy focuses on forcing people to change through the use of external sanctions. It emphasizes political and economic power. Political power implies an ability to apply sanctions when others do not align themselves with the change. Economic power brings control over resources as well as the ability to apply economic sanctions to force change on those with less power. Hence this strategy identifies and applies levers of power to force others to comply, i.e., forced compliance and is typical of the RDDA model for curriculum development used during the apartheid era (Samuel and Naidoo, 1992).

The problems associated with power-coercion may be better understood in relation to adaptive change as discussed in the following section.

3.3.2 Adaptive Change Theory:

One consistent research finding is that **change** is not brought about easily (Fullan, 2001). Part of this is the difficulty of altering human perception. Successfully altering this aspect of a person is a critical part of **adaptive change** – in situations, according to Heifetz (1994), where needed expertise and tools do not already exist.

Adaptive change can only be achieved by mobilizing people to revise their attitudes, work habits and lives. Heifetz (ibid) claims that in adaptive change, people must step outside known patterns of behaviour – they must surrender their present selves and, depending on the extent of the change required, put themselves in jeopardy by becoming part of an emergent system. This process usually requires the surrender of personal control, the toleration of uncertainty, and the development of a new culture at

the collective level and a new self at the individual level. Yet, it is also important to note that in terms of control, they can also be part of it. The secret of adaptive change is that change comes from within as well as without. It is similar to constructivist learning compared to behaviourist learning.

When adaptive change is required, traditional change strategies are not likely to be effective. The power-coercive strategy has limited use in **adaptive situations** because in adaptive change people must commit themselves to the collective purpose in a meaningful way. Power-coercive strategies can invoke anger, resistance and damage to the fundamental relationships of those involved in the change. Thus, power-coercion is not likely to result in the kind of voluntary commitment that is necessary in most adaptive situations (Heifetz, *ibid.*). Research related to the management of change in the corporate sector has shown that while coercive change can change behaviour, it may not change underlying beliefs. It might even crystallize counter beliefs, such as resistance to change (Argyris, 1996).

However, pressure as well as support are necessary for organisational change – whether that pressure arises from self-imposed deadlines, or systems of reward and punishment. The line between pressure and coercion can be a very fine line. For example, where does one place a deadline for implementation of a policy or the submission of an exam paper for printing? Both are needed for efficiency in a context of systemic reform. The chances of chaos prevailing without these deadlines are real if a system is to be efficiently led. Modularization as a bureaucratic pressure in higher education in the South African context has implications for deadlines that demand compliance from Science Teacher educators.

Implementation of procedural and regulatory aspects of education policy in a post-apartheid dispensation appears to approximate both power-coercion and adaptive change, especially in higher education institutions. This claim is made on the basis that the process of systemic reform follows a centralized power coercion strategy (Marsh and Huberman, 1984) aimed at forced compliance by higher education institutions, while providing these with the autonomy for adaptation of the policy to their context through adaptive change. It is expected that the establishment of quality assurance bodies – within and beyond the institutions – would ensure policy

implementation. In the context of my thesis, I have attempted to investigate internal and external pressures for change, as part of the change process as it applies to science teacher educators and their curricula. The question that I also pose in terms of my thesis is whether or not adaptive change occurs in the context of external pressures to change – viz., pressures from the NQF, the institution, and public schools. Also, whether there were individuals who ‘sacrificed everything’ to drive the change process as ‘movers and shakers’. This is discussed in the following section.

3.3.3 Advanced Change Theory (ACT)

This theory is regarded as advanced because it involves a strategy which is less observable and more complex than the traditional change strategies of rational persuasion, coercion, or participation. It is based on principles which deal with both the change practitioner or leader (who changes and empowers him/her self to be aligned with a vision for the common good) and the change targets or followers (the change practitioner attracts others to change themselves to achieve the new vision). This is represented through the lives and achievements of Jesus Christ, Mahatma Gandhi and Martin Luther King – people who were prepared to lose their lives to enhance religious or political change in the society.

ACT is more complex than rational or adaptive change because it requires the leader to employ high levels of cognitive, behavioural, and **moral** complexity (Hooijberg, Hunt and Dodge, 1997). It also requires the leader to engage a path of courage. Notions of ACT not well developed, not definitive; the intention here is to evoke ideas and thinking regarding the process of effecting change in human systems. It is highly unlikely in South Africa, for example, that leadership for curriculum change involving science teacher educators through ACT occurred, because change was politically driven, through participation across a range of learning areas, interest groups and ideologies, with the results ‘handed down’ to higher education institutions and schools. Hence the practical application of ACT could be viewed as limited in such a context – a context more amenable to adaptive change. Indeed, Lebaree (1999) has observed that there is no record of sustained, large-scale classroom change anywhere in the world that seems to have been the result of ACT (notwithstanding the

significant roles of individuals and visionaries in some instances). Even so, I will analyse the data to establish whether any of the science teachers in my study had subscribed to an ACT change process.

3.3.4 Theory in Action and Double-Loop Learning

When subjects are interviewed as to whether they have changed in response to the need to change, some have demonstrated a tendency to act differently in a real situation compared to their claimed or espoused intentions. Much can be learned from Business Science studies based on such responses that bear a mismatch between intention and action. This has also been demonstrated in educational research and most certainly has implications for how science teacher educators respond and commit themselves to action for curriculum change

Argyris (1996:152) and his co-workers conducted empirical research which indicated that subjects in the business sector carry beliefs and values concerning how they and others ought to behave. These beliefs and values can be stated in the form of propositions about effectiveness: “if I behave in such and such a manner, then the following consequences should occur.” Since these propositions have the same structure as propositions in any scientific theory, Argyris and his co-workers have called them *theories in action*.

Argyris (ibid) claims that individuals hold two theories of action: ✓

- i) their espoused theory which explains the way they say they behave
- ii) their theory-in-use which explains the behaviour they actually display

Translated into the context of this research, this implies that science teacher educators ✓ may claim that they agree with the curriculum change intentions (e.g., C2005 per se – espoused theory), but may not necessarily implement these according to policy expectations or may engage in a symbolic application (i.e., theory in use).

Argyris (1996) proposed double-loop learning theory which pertains to learning to change underlying values and assumptions – for the individual, and for the institution – as compared to single-loop learning, which is concerned to improve the efficiency

of existing routines and practices. Part of double-loop learning is to bring together espoused theories and "theories-in-use", by questioning both. Typically, interaction with others is necessary to identify the conflict between what one espouses and what one does in reality, especially if there is a mismatch between the two.

There are four basic steps in the action theory learning process: (1) discovery of espoused theory and theory-in-use, (2) invention of new meanings, (3) production of new actions, and (4) generalization of results. In double-loop learning, assumptions underlying current views are questioned and hypotheses about behavior tested publicly. The end result of double loop learning should be new ways of thinking and working, increased effectiveness in decision-making, and better acceptance of failures and mistakes.

According to Argyris (1996:9) single-loop learning occurs when matches between espoused theories and theories-in-use exist, and the concern is for improvements in actions. Double-loop learning occurs when mismatches are corrected by first examining and altering the governing variables and then the actions. Governing variables are the preferred sites that individuals strive to "satisfice" when they are acting. These governing variables are not the underlying beliefs or values people espouse. They are the variables that can be inferred, by observing the actions of the individuals acting as agents for the organization, to drive and guide their actions.

Argyris and his co-workers also stated that it is important for social scientists to study double-loop change because if they focus only on single-loop change, they may unwittingly become servants of the status quo (Argyris, 1996). Such a statement may not hold true in the South African context of social and political redress since policy related to the new status quo is very explicit in its need for social transformation. However, the requirement that science teacher educators may need to engage in adaptive changes for such a transformation means that double-loop learning can serve as a useful source of information to enable them to learn through workshops in professional learning communities. Also, single-loop learning was a primary requirement for teachers and teacher educators in the highly bureaucratic system of education during apartheid.

In the next section I present a grounded theory of academic change that accounts for the behaviour of university-based academics confronted by conflict situations in an academic setting. The theory shows a significant link with the South African context of curriculum change and the role of double-loop learning.

3.3.5 Academic Change: A Grounded Theory of Academic Change

In proposing a Grounded Theory of Academic Change, Conrad (1978:108-109) used a constant comparative method (see Chapter Four) to study how academics at three universities in the US contributed to a change process influenced by an internal change agent working from an administrative position. On the contrary, C2005 proposes curriculum changes emanating externally from policy mandated by the State. Conrad's grounded theory on academic change proposes and focuses on the process of internally driven change. The following issues have been selected from his theory as being pertinent and useful to this research:

1. conflict is a natural process in colleges and universities which may or may not lead to change. Change, on the other hand, will invariably include some conflict between old and new social conditions and their proponents;
2. although underlying conflicts may be embedded in the social structure of colleges and universities, they become visible when one or more external and/or internal pressures threaten the status quo. External pressures in the context of Conrad's research pertain to administrative influences on academic staff, the entry of new students and the appointment of new personnel;
3. the faculty at large serve as advocates for interest groups and for change proposals emanating from policy-recommending bodies.

The first issue could be of significance in the South African context of curriculum change because it is reminiscent of the old educational order of the apartheid regime when compared to the current progressive changes in education. The second issue may be relevant in view of the influence of the rapid systemic reform process and the

changes it imposes on, and expects of, academic staff such as science teacher educators. This becomes compounded by the introduction of a new school curriculum that may serve as another pressure for change among science teacher educators – a key feature of this thesis. With respect to the third issue, curriculum change in South Africa was centrally driven as an external pressure from the State and with a degree of consultation with other stakeholders.

Conrad's theory of academic change appears to be useful in supporting my thesis, especially with respect to the pressures academics had to respond to in the change process from the institution of teacher education. It also indicates the need for science teacher educators to extend their professionalism not only to the higher education institution but also to other interest groups outside the institutions such as public schools. As explained earlier, science teacher educators are not compelled to respond to the latter.

There appears to be an international trend for academics at Universities to engage in workshops and conferences to make sense of issues related to change. The participants in such workshops and conferences are regarded as constituting professional learning communities that co-construct knowledge and share meanings through their deliberations. I have especially chosen to include a discussion about constructivism as a learning theory since it plays an important role in informing some aspects of my analysis related to professional learning by science teacher educators because it involves a complex curriculum change process. In the discussion that follows, I will locate constructivism in the lives of school learners in science, student science teachers as prospective future practising teachers, border crossing and collateral learning in the South African context. I will also refer to its (constructivism) role as a key rationale in the new science curriculum for schools. In addition, I will relate constructivism to situated cognition.

3.3.6 The Theory of Constructivism and change

3.3.6.1 Children's learning of science

According to Driver et al. (1994), children learn science through a constructivist approach by interacting with natural phenomena and with their peers. In this process

they co-construct knowledge about science in their mental schemata. When they come to science classrooms they bring their views about science and hold onto them tenaciously, even if these represent misconceptions. The role of the teacher as a facilitator of knowledge bears implications for teaching and learning. It implies that teachers of science need to use learner-centred strategies to elicit their alternative knowledge base and to restructure such knowledge so that it conforms to the alternative viewpoint in science. The use of cooperative learning strategies, in which learners share ideas in groups in constructing knowledge, is regarded as being an essential feature in the teaching and learning process in the South African post-Apartheid context of OBE. Unlike traditional transmission teaching, it empowers learners by ensuring that the responsibility for the learning is theirs. This is in keeping with the principle of learner-centredness. I therefore use the term 'constructivism' as an approach to teaching and for the development of meaningful learning.

3.3.6.2 The emancipatory nature of a constructivist approach

C2005 contains aspects of People's Education and critical theory philosophy. From a People's education perspective, C2005 embraces the science for all approach which conforms with the South African democratic constitution. It also endorses a critical theory philosophy (see Chapter two) in which its critical outcomes aim at political and social redress related to the legacy of apartheid. This appears to be contradictory to the behaviouristic nature of outcomes which demand that these have to be demonstrated. The emancipatory nature of using a constructivist approach to teaching and learning science (see below) may be compromised in such a paradoxical situation. This would occur unless appropriate quality assurance structures are put in place by the Department of Education to ensure that the inputs which generate the outcomes/outputs are essentially constructivist in approach. Despite the behaviourist connotations of some aspects of C2005 and OBE, this dissertation values the role of a constructivist approach.

3.3.6.3 C2005 and a constructivist approach to teaching and learning

Science teacher educators are expected to make student science teachers aware of constructivism as a learning theory in preparation for an outcomes-based system of education as proposed by C2005. The aim of such an approach is to go beyond

memorization of science facts through expository teaching. If OBE is a new pedagogy for South African teachers and teacher educators, and science teachers come with old or traditional pedagogies, then there is a need for the use of constructivist approaches to deconstruct their thinking by accommodating the new pedagogy into their conceptual frames. This means that science teacher educators will have to find ways of enabling their student science teachers to develop constructivist approaches to teaching and learning science in preparation for teaching in school contexts that are becoming outcomes-based.

Alternatively, Matthews (1998: 8) exposes a fundamental theoretical problem with constructivism in the form of an epistemological contradiction: “If knowledge cannot be imparted and if knowledge must be a matter of personal construction, then how can children come to a set of complex conceptual schemes that have taken the best minds hundreds of years to build up”?. He also poses another question: many science (teacher) educators are interested in finding out how, on constructivist principles, one teaches a body of scientific knowledge that is in large part abstract (e.g. velocity, force, gene), removed from experience (e.g., propositions about atomic structure), has no connection with prior conceptions (e.g., ideas of viruses), and is alien to common sense, and in conflict with everyday experience, expectations and concepts?

He recognizes the role of epistemology in such an instance: teaching a body of knowledge involves not just teaching the concepts, but also the method, and something of the methodology or theory of method. In making such a statement he acknowledges constructivism as having an epistemological foundation. However, he also admits, despite the epistemological contradiction, that few would dispute Peter Fensham’s claim that ‘the most conspicuous psychological influence on curriculum thinking in science since 1980 has been the constructivist view of learning’ (Fensham, 1992:801). So, it appears that constructivism has its epistemological contradictions and yet also has its positive practical applications. The latter appears to be more acceptable from a learning theory perspective since it informs practice.

C2005 appears to fulfill the expectations of constructivism as a learning theory which underpins its learner-centred philosophy, although none of its policy documents that I have read make direct reference to this theory as its driving force. Terwell (1999:197)

claims that 'many educators and researchers see in constructivist approaches the key to reforming contemporary education'. He cites as a motivation for his claim the application of constructivist ideas to design experiments by great constructivist icons, such as Vygotsky, Leont'ev, Bruner, Geertz, Piaget, Dewey and other educational researchers. However, Terwell (ibid) cites the powerful case made by Schwab that no single theory can provide an adequate foundation for educational practice due to constructivism's inability to change classes into 'communities of inquiry' by offering practical guidelines which overcome ineffective interaction patterns during face-to-face cooperative learning.

Matthews (ibid) recognizes the psychological theory about the manner in which beliefs are developed as being the original core of constructivism. He states that 'From this core, constructivism has expanded to incorporate views about epistemology, teaching, curriculum, educational theory, ethics, ontology, and metaphysics. He regards the epistemological claims of educational constructivism as important claims that 'constructivism has done a service to science education by alerting teachers to the function of prior learning and extant concepts in the process of learning new material, by stressing the importance of understanding as a goal of science instruction by fostering pupil engagement in lessons, and other such progressive matters'.

3.3.6.4 Constructivism and science teacher education

Matthews (1998:X1) views constructivism as epistemology that cannot be excluded from a science teacher education programme:

Teachers are concerned with children gaining knowledge, thus they have to be attentive, as Socrates was two-and-a-half thousand years ago, to what knowledge is. This involves teachers in epistemology, an involvement that is increasingly recognized in the science education community, but one for which teachers are inadequately prepared by standard programmes of science teacher education. Whatever the responsibility of classroom teachers to neoconservatives be acquainted with core philosophical questions, the responsibilities of teacher educators is far greater.

From a constructivist perspective, prospective teacher knowledge is not found in textbooks or external science education experts. Rather it is personally created and socially mediated as prospective teachers of science make sense of their experiences. Conceptions of teaching science to children are generally based on prospective teachers' own experiences as learners of science in schools, as learners of science at the university, and as learners in formal courses and clinical experiences in teacher education programs. When a critical and emancipatory system of meaning is applied to constructivism, science teaching and learning takes on new significance. A critical and emancipatory notion of knowledge construction implies that learning does not take place in an economic and social vacuum. Instead it depends on interactions among the subjectivity of learners and the power relations of their educational situations (Laughlin, 1995). Matthews (1998) also indicates that if one is in favour of educational reform, and the emancipation of human beings, then one must be a constructivist in learning theory and pedagogy. Such a view appears to be very pertinent to the South African context of social and political change.

3.3.6.5 Border crossing and constructivist approaches

Of significance in the African continent is the phenomenon of border crossing which occurs, for example, when individuals/learners from indigenous communities respond to the dominant western science culture promoted by science curricula imported by colonial influences. Jegede (1995) and Aikenhead (1996) report the development of competing and parallel mental schemes in the minds of science learners, one which has developed through the influence of cultural belief systems, and the other the result of implementing a western science culture in teaching science. The apparent incongruence between the two mental schemes in the interpretation of western science is referred to as border crossing.

Jegede(ibid.) and Aikenhead (ibid) have proposed collateral learning as a cognitive explanation for border crossing and refer to the associated confusion as cultural violation since the two mental schemes appear to be in conflict with each other. It would appear that the recognition of the views of learners as being a principal component of the sequence of teaching and learning science as proposed by Driver et

al (1994) would play a significant role in restructuring misconceptions emerging from cultural beliefs in the South African context. Of significance to this thesis is the acknowledgment that a constructivist approach to teaching and learning may not occur in a traditional teacher-centred approach that disregards the thinking or ideas of science learners.

Stofflett (1994) claims that if one takes a constructivist view of science learning and teaches conceptual change science methods to student science teachers, then one must consider that these students bring to science methods courses preconceptions about science teaching and learning. She also maintains that simply telling and showing student science teachers conceptual change methodologies will not be sufficient to accommodate their traditional preconceptions. Thorley and Stofflett (1996) have proposed a conceptual change model for science teacher education in which they offered a method for developing conceptual change among student science teachers for science teaching. They proposed that students should be given opportunities of conceptualising conceptual change models themselves instead of science teacher educators providing them with strategies for engaging with conceptual change in science education. Whether science teacher educators have implemented such a proposal in their teaching of student science teachers becomes a necessary aspect of my analysis of interviews and observations of teaching.

The issues and arguments presented above imply that that the cognitive, ontological and epistemological implications of constructivism cannot be excluded from a science teacher education curriculum (see Matthews, 1998:X1 above). It may be necessary for them to be incorporated into their own curriculum and teaching. But, the feasibility of implementing constructivist approaches as teacher educators means that some of them need to undergo in-depth changes especially within the constraints of university structures and assessment systems. An investigation into such responses of science teacher educators to curriculum change in South Africa forms part of this study.

3.3.6.6 Constructivist approaches and situated cognition

C2005's emphasis on contextualizing the learning process implies a constructivist leaning since situationism, according to Terwel (1999), emphasizes the requirement

that authentic learning should take place in meaningful contexts, i.e., it should be situated in the lives of learners for meaning making and positive action. Lave and Wenger (1991) and Brown et al. (1989) claim that situationism also emphasize the requirement that authentic learning should take place in meaningful contexts, in what are called communities of practice. So, as important as existing knowledge and beliefs are, changing them through constructivist principles appears to be insufficient. For example, developing the knowledge base for an effective teaching practice through constructivist principles may not necessarily translate into action in a context of reality due to a lack of situatedness. Such an anomaly adds to the complexity of the change process in terms of the expectations of curriculum policy change that emphasizes constructivism as one of its rationales. Therefore, while constructivism may be a useful learning theory informing teaching practice, more is required of it.

Change in individuals can also be influenced by psycho-social forces or pressures such as psychological stress that results in resistance or strategic mimicry (Matsson and Harley, 2003). This may result in a mismatch between policy and practice and is also linked to the symbolism associated with policy. In the sections that follow, I will demonstrate how these issues relate to my thesis since science teacher educators were expected to relate to curriculum policy changes at a higher education level and a school level. The role of the literature related to understanding their psycho-social responses is therefore worthy of consideration in developing my thesis.

3.4 Other Issues and Change

3.4.1 Psycho-Social responses to change

The brief reference to theories of change already presented emanate from research conducted on the main actors of change, viz., those who finally implement the change. These views and theories may be useful in interpreting the responses of science teacher educators to curriculum change. What follows are research findings based on psycho-social responses to curriculum change:

3.4.1.1 Psychological Issues and Change

The proposition that all behaviour has a causative factor is a basic premise of psychology. It flows well into Argyris's (1996) view that behaviour results in consequences. Responses to curriculum change are inadvertently informed by these propositions. According to Shorris (1976:395) change is often the cause of stress. Change can be frightening and always requires adjustments on one's part. Therefore it is not surprising that change and stress are associated. Science teacher educators cannot be excluded from such an influence in a context of change and this research attempts to identify such influences.

Peters and Waterman (1976:254) state that the need to function in a comfort zone can make people resistant to change, especially if they have not been consulted or asked about the change. This is particularly so for people who experience a sense of security and a feeling of importance with familiar routines and surroundings. New routines or other changes threaten this feeling. As a result, some people become resistant to change without being aware of it. Because change appears inevitable, it becomes necessary for one to cope with it by not feeling threatened by it. Peters and Waterman recommend that managers should try to involve those who will be affected by the change in planning how it could be implemented. People will more readily accept change if they feel they have been involved in bringing it about.

It seems that in South Africa consultation about and the management of change appears to be problematic, especially if such a development is embraced by policy. Jansen (1998) supports this view when he observed that the curriculum change process in South Africa was subject to limited consultations with teacher educators and school teachers at ground level. This is a significant aspect of my research because it determines the success of the implementation of curriculum change. The possibility of resistance to change is therefore quite likely to occur at both an individual and organizational level.

3.4.1.2 Resistance to change at organizational and individual levels:

Despite the significance of resistance to change at these levels, little is known about teacher educators' resistance to change. The literature abounds with information related to practicing teachers' resisting curriculum change in schools (Jansen, 2000, etc.). It could be inferred that science teacher educators' may resist change imposed on institutions in a similar way, especially those which are power coercive or related to the need for adaptive change.

Fullan (2000) claims that change may appear to be primarily a rational process. However, in reality organizations change only when people in them are willing and able to do so. He states that just as the character of a person is deep-seated and resistant to change, so the culture of an organization is difficult to influence towards change. Many proposed changes are viewed as threats to an existing culture and may be resisted for that reason alone. In the South African context, despite the implementation of educational policy changes aimed at improving the political and social aspirations of South Africans, there was resistance to change from teachers to the introduction of C2005 (Jansen, 1998) due to the traditional curriculum representing a comfort zone for teachers, and the influence of the moulding effect of Fundamental Pedagogics. Matsson and Harley (2003) showed that teachers have tended to strategically mimic the new curriculum so that their implementation served to superficially resemble that curriculum. Could such a tendency represent a covert resistance to the new curriculum, and is it not possible for a similar situation to prevail among some science teacher educators?

3.4.2 Symbolism, Strategic Mimicry and Change

Symbolism is described as something one can see and that has taken a meaning beyond itself. It is also described as a visible object or action that suggests some further meaning in addition to itself. The Oxford Dictionary defines a symbol as 'a

thing generally regarded as typifying, representing, or recalling something'. In relation to policy development, symbolism is used as a term that expresses policy as a form of rhetoric in which the reality of its implementation differs from its expressed intentions. Jansen (2002) also notes that in the South African context there is a rift between education policy and practice in which the latter manifests itself as being symbolic of policy expectations. He vociferously indicated that a policy might fail if sufficient resources such as support for change does not accompany such a policy. While school-based teachers resisted the change due to a lack of support, my study was also designed to establish how science teacher educators related to the pressure associated with policy symbolism. Did they also resist the change, or did they find ways to succeed in terms of it? Did they mimic the change?

Mattson and Harley (2003) refer to strategic mimicry in the context of South Africa's C2005 and the implementation of its outcomes-based methodology in public school contexts. They claim that it is a strategy used by teachers to mimic competency led education so that it begins to look as if it is competent and has the trappings of a modern globalized education aimed at attracting international credibility for a global economy. Such a resemblance to the change expectations of policy conforms with Fullan's (2001) reference to the false clarity of change that occurs when people think they have changed but have only assimilated the superficial trappings of the new practice. Matsson and Harley's (ibid) use of the term 'strategic mimicry' fits such a description appropriately. They cite as an example empirical research conducted in school classrooms in which cooperative learning strategies are employed. The group work appears to simulate the rationale of C2005, but the teaching approach ends up being teacher-centred without any evidence of a constructivist engagement for meaningful learning through a co-construction of knowledge leading to skills development. Harley and Mattson also align education policy's symbolism as being a form of strategic mimicry which enables it to look modern in the "eyes" of globalization and global competition for world markets.

The professionalism and identities of science teacher educators cannot be isolated from theories of change and other issues discussed thus far, especially in terms of political and social changes anticipated by the new government in South Africa.

3.4.3 Professionalism and Identities of Science Teacher Educators

There appear to be no reports on professionalism and identities of science teacher educators. Jansen (2003) describes teacher identities as the way teachers feel about themselves professionally, emotionally and politically. I will present the principles of teacher professionalism and teacher identities and attempt to relate this to teacher educators and apply the principles in my analysis of the professionalism and identities of science teacher educators. I make such a claim on the basis that school-based teachers are influenced to an extent by teacher educators in terms of how they develop their professionalism and identities as teachers before they leave teacher education institutions and assume employment at schools.

Soudien (2003) argued that the specific context and social conditions in which teachers find themselves are crucial for the self-understanding they take on. He quotes Zeichner's (1994) view of self-understanding as being the product of complex structural forces that permeate every aspect of what it means to be a teacher and that teachers are implicated in the creating of their own identities. He also analysed teachers' voices in the South African context to understand the nature of the socialization process that they undergo in developing their professional identities. He showed that the role of militancy of Black student teachers and practicing teachers against the status quo of apartheid was a contributory factor in shaping their identities in opposing control and manipulation by an oppressive system. His research also shows that in white colleges of education, the syllabus was essentially a rehearsal of what teachers would be expected to teach in their classrooms. Black teacher educators who did not conform were dismissed from their posts. However, in some colleges, teacher educators would attempt to deal with race and class. Soudien (ibid:281) stated that:

'notions of professionalism which emanated from such a pervasive discourse held teachers in thrall to an ideology of subservience and subordination to the (apartheid) state.Black teachers coming out of the universities were thus confronted with large dilemmas about the nature of teaching. They emerged from these dilemmas with clearly articulated notions of the kinds of politically engaged professionals they wished to be.'

Soudien further claims that on the basis of the above findings, the repertoire of professional identities emerging from black colleges and historically disadvantaged universities was extremely diverse as compared to the repertoire which emerged from white institutions. This claim is supported by Carrim (2003) that race, more than gender, has dominated the construction of teacher identities in the South African context. Consequently, as a post-Apartheid development, Moletsane (2003) calls for a radical transformation of the content and processes of education offered in tertiary institutions. She claims that the challenge for teacher educators and other professional development agencies is for them to revamp existing programmes to reflect such diverse contexts and identities so that teachers can respond effectively to the educational and social needs of the communities which they serve.

In the context of my thesis, I have attempted to establish whether science teacher educators have responded to such a challenge and whether there is evidence of a symbolic response in the implementation of their science teacher education programme, i.e., whether it strategically mimics (Matson and Harley, 2003) policy expectations. Also, did science educators forge other identities due to the extent to which they have experienced change differently in terms of contextual realities and new opportunities?

The next issue of relevance to this study is related to the systemic reform process emanating from the new Government.

3.4.4 Systemic Reform and Leverage

Systemic reform of the education system has been proposed as a means to control the curriculum change process. It has been used by the democratic government in South Africa to ensure that its educational reform through C2005 would be implemented as per policy so that its political and social redress intentions would not be compromised. The associated restructuring of universities so that their curricular offerings would conform to the prescriptions of the NQF through SAQA in the conversion of courses to modules, coincided with, and had implications for the introduction of C2005 at the school level during this rapid systemic reform process. Institutions such as universities were threatened that modules on offer would not be accredited if these did

not conform to the requirements of SAQA. Science teacher educators were therefore obliged to comply through institutional pressures that emerged from such leverage.

The implications of systemic reform in the context of my thesis is that this constitutes a pressure for individuals to change in accordance with new demands. Reform of the system through new policies, rules and structures, shapes and constrains what people do – whether conforming, contesting or both. A change in the system makes its own demands – whether it provides opportunities, or pressures, threats, or both. I have shown in the discussion above that pressure alone can cause severe resistance to change if it is not accompanied by support. In change strategies, changes in practice can precede or follow changes in beliefs (or both). Science teacher educators who submit to the coercive effect of traditional change may change their practice to conform with policy expectations without changing their beliefs about change. The tendency of policy to use the assessment system as a form of leverage for change may be followed slavishly by some, or it may be accepted by others who agree with such policy. Or, they may adapt to the change meaningfully by altering their beliefs about change to suit policy. How they have changed in response to these pressures is the basis of my thesis since the pressures influencing change contributes significantly to the complexity of the entire change process. The source of potential pressures for change will be discussed later in this chapter.

In the next section I will relate Complexity Theory to the pressures for change in the South African context. These have to be conceptualized in relation to my thesis and in conjunction with the complex picture of the South African scenario presented in Chapters One and Two with respect to curriculum change and the role of the systemic reform process.

3.5 Complexity Theory and Change

Complexity theory (including Chaos Theory) had its beginnings in the mathematical sciences. It is a system of thinking that has emerged as a means of understanding human behaviour. The theory was first used by Norman Packard in 1988. Complexity Theory became also known as Chaos Theory. Complexity Theory claims that

understanding the whole is more than understanding the sum of the parts. The latter is related to Cartesian analytic tradition that understood systems in the past that were believed to be linear and hence predictable. Complexity Theory recognized that human beings do not live in a linear world – that, one cannot understand human social systems by analysing the links holding the parts together. It also claims that a small input may result in a large and unexpected output (Hunt, 2005).

Lemke (2004) recognizes contemporary education systems as one of the most complex social systems of all. He bases his claim on his view that the educational system as a whole is driven by external events and pressures, such as advances in scientific understanding, the increasing complexity of problems addressed by communities and societies, changing technologies, and public demands for reform. The factors contributing to educational change in the South African context as expressed in this and previous chapters indicates very clearly the complexity of the change process. Such a view also indicates the added complexity that science teacher educators and other teacher educators had to confront in their lives as academics.

Changes related to public schools, the NQF and Higher Education, higher education institutions, individuals on a collective and personal level, and the pressures of rapid changes add to the complexity facing science teacher educators. The influence of the curriculum changes on their professionalism as science teacher educators serves as a relevant and interesting issue in this research. Also, their moral responsibility to change (considering the complexity of the change process especially with respect to the school context), their personal loyalties to their careers and their personal concerns for social change serve as important considerations in this thesis.

In the next section, I will present the perspectives that were used to frame the study. These are developed from the literature review already presented. I will also present the developing thesis in progress prior to analysing the data in the next three chapters and finalising it in the last chapter.

3.6 The Emerging Theoretical Frame and a Developing Thesis

I regard Adaptive Change Theory as contributing an essential perspective which serves to provide answers to my research question. Science teacher educators' responses to dramatic curriculum changes as proposed for schools cannot be overlooked in terms of the adaptive expectations related to such changes. This change theory therefore could play an important role in informing the analysis. I also see a significant place for the theories-in-action that determine whether espoused theories of science teacher educators are translated into action in reality. This stems from the need to find consistency in the data especially in terms of the intentions and practices of science teacher educators. The possibility of strategic mimicry, therefore, also cannot be ignored.

One cannot disregard the role of constructivist approaches that science teacher educators may use in making meaning of the curriculum change process since such a process has occurred with concurrent political and anticipated social changes. Professional learning communities of science teacher educators that may be formed as a result may be a typical response to understand and support change. The role of situated cognition, therefore, is an important perspective that can be used in this research.

The professionalism of science teacher educators in engaging with professional learning communities and how these associations may have influenced their responses to curriculum change will serve as an important indicator for change. The data will be analysed to establish the degree of collaboration that possibly may have occurred among them and the personal and moral responsibility associated with this.

On the basis of the foregoing discussion and those in Chapters One and Two my thesis will be based on the following argument:

- **that science teacher educators have been able to fulfil the procedural and regulatory aspects of policy despite the pressures associated with curriculum change;**
- **that there were significant institutional and other external pressures driving curriculum change among science teacher educators in the direction of policy expectations;**
- **that individual change among science teacher educators has grown out of the complexity of institutional, school and personal factors, i.e., what they did emerged from a triad of institutional pressures, school pressures and individual pressures;**
- **that the changes that some science teacher educators displayed were beyond the influence of complexity.**

The thesis will be developed on the basis of my analysis of data produced through the use of appropriate research instruments designed to find answers to the main research question.

3.7 Conclusion

Some aspects of the literature review have been presented in the first three chapters. The literature review presented in this chapter together with issues presented in the previous chapters is extended further in the following chapter. Erickson's interpretive approach to research and Conrad's constant comparative method are presented next in an attempt to support the methodology used in studying the responses of science teacher educators to curriculum change. The theoretical frame established in this chapter will be used to develop the research design in Chapter Four. It will also serve to contribute to the data analysis in the analysis chapters that follow.

CHAPTER FOUR

RESEARCH METHODOLOGY

In this chapter I aim to motivate for a research methodology which best provides answers to the research questions proposed in Chapter One. It is also my intention to present an appropriate research strategy to achieve the objectives of this dissertation in relation to its main thesis, viz., that science teacher educators tend to fulfil the procedural and regulatory aspects of policy related curriculum change. They attempt to convert the symbolism of policy to reality in the face of a rapid systemic reform process and the complexity associated with it.

4.1 Choice of Methodology

I have chosen a qualitative case study approach to my research. I chose a descriptive and interpretive approach to the case study in anticipation of it contributing to an in-depth understanding of how science teacher educators related to the curriculum change process for schools, and in higher education for pre-service education and training. My main decision for such a choice is also related to a personal interest in complexity as this relates to the reasons science teacher educators undertake the things they do when they are exposed to several external pressures from many sides simultaneously. I case study approach would therefore enable me to probe deeply and analyse intensively the responses of science teacher educators to such pressures.

I have also attempted to undertake a comparative case study across individual cases represented by a total of eleven science teacher educators from three institutions – two being peri-urban and one situated in a rural area. The main reason for such a choice is that it served as a means of providing me, as an interpretive researcher, an opportunity to compare the reality of curriculum change with different individuals at different times and in different places (Denzin and Lincoln, 1998). Such an approach conforms to Patton's (1990) view that comparative case research enables the synthesis of

different qualitative studies to occur on the same subject for the purpose of cross-case analysis. I therefore have attempted (see later) to include a limited, yet meaningful, low profile quantitative approach to my largely qualitative study when I used a constant comparative technique of inductive analysis (see later).

In the context of my research, the subject refers to science teacher educators' responses to curriculum change. I attempted to gather comprehensive, systematic, and in-depth information about each case. This includes all the interview data, the observational data, and the documentary data as suggested by Patton (1990:387) as being relevant to a cross-case analysis and that involves grouping together answers from different subjects to common questions or analyzing different perspectives on central issues which in the context of this research pertains to curriculum change.

It was my intention to compare the responses of science teacher educators to given instances of curriculum change. I attempted to achieve this by posing the same questions to all subjects in the sample. Simultaneously in order to enhance the interpretive nature of the research, I also provided flexibility to the respondents by permitting open-ended responses wherever necessary. Such an approach also enabled me to establish how the science teacher educators had changed when exposed to the different pressures of curriculum change in the South African context. In the context of this research, the apparent quantitative dimension is based on establishing the frequency of qualitative judgments made across cases. I therefore have attempted (see later) to include a limited, yet meaningful, low profile quantitative approach to my largely qualitative study when I used a constant comparative technique of inductive analysis (see later).

The role of interpretive approaches in studying these responses to change, relate most appropriately to the research question posed in Chapter One and which is action-oriented. It is also highly consonant with my developing thesis which argues that science teacher educators changed their behaviour as an adaptation to institutional pressures and other pressures.

4.1.1 Using Interpretive Research as an approach to the study

In order to support my thesis about external pressures influencing curriculum change in a complex situation, I found Erickson's (1986) views on interpretive research to be relevant to the purpose of this study. He claims that interpretive research is not a methodology, but that it should be viewed as a technique or an approach to research because the research technique does not constitute a research method. Erickson (ibid) also states that, interpretive research can involve both qualitative methods and quantification to support the research. The latter relationship of interpretive research to quantitative aspects appealed to me because it enhanced my analysis of the data when I used a constant comparative technique (see later). Erickson (ibid) also maintains that the specifics of action and the meaning perspectives of actors are overlooked in other standard approaches to research. I therefore considered the interpretive technique to be most appropriate in serving the needs of my research into responses of science teacher educators to curriculum change in terms of the "how", "what" and "why" expectations.

My decision for making the choice of an interpretive research technique as opposed to survey data is that the latter does not tell us all or most of what we need to know. The specifics of action and the meaning perspectives of actors must be interpreted in the context of their theoretical presuppositions about the nature of teaching and about the nature of cause in human social life in general. Cohen et al (2000) maintain that an individual's behaviour can only be understood by the researcher sharing their frame of reference., i.e. understanding of individuals' interpretations of the world around them. Erickson (1976) also shares this view when he states that:

...perhaps the most basic difference between the interpretive and standard approaches to research on teaching lies in their assumptions about the nature of cause in human social relations. People interpret events, contexts and situations and act on the basis of those events. There are multiple interpretations of, and perspectives on, single events and situations. We need to examine situations through the eyes of participants rather than the researcher.

My decision to analyze the data from an interpretive perspective embraces Erickson's view. I attempted to examine situations through the eyes of the respondents in this research. In doing a comparative cross-case analysis of eleven science teacher educators' responses to curriculum change in South Africa, I was able to obtain multiple interpretations across the cases which provided a richer insight to the process from more people. This would not be possible through a full qualitative case study involving fewer subjects, despite there being a thicker or more extensive description in the latter.

In interpretive research, the immediate and often intuitive meanings of the actors involved are of central interest. An interpretive perspective towards research aims at being rigorous and systematic through the medium of subjective meaning in a wider social world, i.e., analyzing and developing meaning in a wider social context. My research is descriptive and interpretive (in addition to being analytical and critical) and intends to provide a description and interpretation of an existing situation as this pertains to responses of science teacher educators to curriculum change.

4.1.1.1 Data collection and the interpretive approach

I had initially planned to design my interview schedule by going into the field as a naïve interviewer, i.e., one who does not know much about the expected outcomes of the research or the theory related to it. I believed that such an approach might be appropriate since it would provoke spontaneous responses from my interviewees if they realized that I did not come from a position of strength or power which could make them feel threatened by my presence. However, Erickson (1986) states that one approach to data collection in the field is to make it as intuitive as possible. In the context of my research, this meant that I could not go into an interview situation as a naïve interviewer. I finally changed my approach when I concurred with Erickson's view that fieldwork begun with no prior conceptual expectations might limit the field worker's openness to the uniqueness of experience in the setting. I therefore desisted from not arming or informing myself with sufficient theory in designing my interview schedule and conducting the interviews in order to ensure that my personal reflections on theoretical perspectives about change, developed through additional reading, (as indicated in the next paragraph), could generate a more meaningful interview

schedule and interview process pertinent to fulfilling the objectives of this research. This view will now be fully developed.

I realized that I had to produce the necessary data through an interpretive paradigm involving a comparative case study with multiple interpretations from eleven science teacher educators. This included the possibility of a degree of commonness across the different cases. In order to achieve this, I had to ensure that I was adequately equipped or armed with a wide variety of interpretive frameworks, especially in respect of educational change related to C2005 and its outcomes-based methodology. This also meant becoming familiar with the Argyris Model 11 (Argyris 1996) view of power-sharing and openness to critical thinking as may be displayed by the interviewees.

I tried therefore, not to give my interviewees the impression that I believed that I was an expert in the situation. I was aware that their role as science teacher educators working in a university context as academics might reveal that they were equal or more knowledgeable than myself in terms of curriculum change. I had to gear myself to meet with that challenge in generating data when responses to my questions were not spontaneous. This left me with the third alternative, consistent with my research framework, viz., to encourage 'real conversations' where I had to probe their beliefs as a fellow-expert. Further, to 'open my mind' to hearing their interpretations and stories, I armed myself with a wide variety of theories as expressed in my literature review (Chapter Three).

In the following section I outline the role of the constant comparison method and its inductive approach to enhance my descriptive and interpretive cross-case comparative study.

4.1.2 An Inductive Approach utilizing the Constant Comparative

Method

To develop my thesis further, I chose the constant comparative method. This method is designed to permit the kind of flexibility that assists the creative generation of theory from the data. I used this approach to support the quantitative analysis as developed in the following chapter.

Cohen et al (2000:151) state that by using a constant comparative approach, the analyst first codes each datum incident (shown as summaries of the data in Chapter Five) into as many categories of analysis as possible. As categories emerge or as data emerge that fit existing categories, the analyst begins thinking in terms of theoretical properties of the category: its dimensions, its relationship to other categories, and the conditions under which it is pronounced or minimized in order to build theory.

The identification of categories that emerged from the data in this research were informed by the theoretical frame and the research questions through an inductive process of analysis. Patton (1990:40) views inductive analysis as a theme of qualitative inquiry and describes it as:

Immersion in the details and specifics of the data to discover important categories, dimensions, and interrelationships; begin by exploring genuinely open questions rather than testing theoretically derived (deductive) hypotheses.

Patton (1990) suggests that categories, patterns and themes of analysis should emerge out of the data rather than being imposed up on them prior to data collection and analysis. In this research, I have generated categories that appear to be common in the literature, yet coincidentally, may appear to resemble those that appear in the literature due to possibly being a natural universal occurrence. However, I contend that their content may differ from the content of similar categories obtained by other researchers elsewhere.

Such a claim is made on the basis that there is a degree of uniqueness about the South African context of curriculum change that may be radically different from other contexts of educational change as expressed in Chapters One and Two of this dissertation. I also believe that it is not essentially the emerging categories that contribute to the generation of theory as presented in the level one analysis of the next chapter. It is also the continued analytic process upon which I embarked that supports such a development. This process in the context of this research alludes to the further development of themes from the categories and the extension of these themes by

representing them as stories in support of the level three analysis presented in Chapter Eight. Such an approach appears to conform to Patton's (ibid) view that 'building theory through induction and interpretation through qualitative synthesis supports scholarly inquiry'.

It was deemed necessary to skirt the tension between a grounded inductive strategy (which is interpretive and to an extent critical) and a positivist comparative method. I undertook this by giving the respondents free reign to say what they thought was important through the open-ended nature of some of the questions in the interview schedule. The qualitative data acquired in this way was then quantitatively represented as explained in the following section. My starting point was from what was known and established about curriculum change using the comparative method and wherein I asked all the science teacher educators the same questions. Such an approach is positivist because I had to anticipate the details they could provide. I further assumed that I would be receiving the story they would like to tell. But this did not end there. It also led me to begin the probing process related to beliefs about change from the differing perspectives of the respondents. I gave them the freedom wherever possible to elaborate further on pertinent issues as these arose. But, I also am aware that some questions in my interview schedule and some aspects of my observation schedule were structured in advance of my collection of the data and often in quite closed ways. This was an attempt to move from the known to the unknown which is characteristic of an inductive approach.

I felt compelled to function in an apparent mixed mode of data collection using multiple methods because expectations of the curriculum change process were already preset in bold in curriculum policy documents. However, the symbolism associated with the delivery of policy was also subject to differences of interpretation and implementation by the science teacher educators. I therefore had to adopt both and find a balance between a positivist and a critical stance when designing the research instruments and collecting the data.

I further did not engage in full case studies as is characteristic of ethnographic studies. Cohen et al (2000), as indicated earlier in this Chapter, advise researchers that full case studies should not be combined with cross-case comparative studies due to

confusion that might arise when representing the analysis. I also decided that to follow a full case study approach involving eleven individual case studies would not be feasible and might defeat the purpose of using a comparative analysis for reasons already explained. Also, I concur with Patton (1990) that culture is central to ethnography – an issue that does not conform to the purpose of this study since I did not use participant observation techniques so characteristic of ethnographic studies as these pertain to the tradition of anthropology.

Conrad (ibid) states that there are several reasons for the selection of the comparative method. One reason is that it is a methodology particularly well-suited to the task of generating, and not simply verifying theory. Instead of relying on pre-selected groups, as in most methodologies that place relative emphasis on verification, it includes the comparison of similar and different groups to facilitate one's attempts at theory building (see level 3 analysis in Chapter Eight). The three institutions studied comprised science teacher educators who appeared to belong to similar and different groups. Science teacher educators from Institutions A and B were more or less similar in terms of race by being mainly Black African. Their institutional history in the South African context can be described as being historically Black. Alternatively, science teacher educators from Institution C were generally White and that institution was historically White in the South African context. Considering previous imbalances of educational provision in South Africa with Whites being privileged over Blacks, I especially chose to study the differences among the groups of science teacher educators in terms of how they would have responded to the curriculum change process which was aimed at developing equity. I therefore viewed the comparative method and the cross-case analysis used in this study as being an essential means of enhancing the purpose of my research. However, I do contend that it is not the intention of this research to focus essentially on race differences, but will allude to these as I perceive them to appear in the data.

Theoretical sampling or purposive sampling relates to a sample in which the wider population being selected for the sample is unknown. Such a sampling procedure applies to the sample in this study. This is due to the sample of science teacher educators involved in PRESET science teacher education during a given period of time being chosen from one province only. Science teacher educators from other

provinces in South Africa were excluded from such a sample. Such a sample represents a non-probability sample since it has not been randomly selected from all the provinces. At the same time, despite being confined to one province, the sample is further delimited by being confined to science teacher educators who specifically prepare student science teachers at the PRESET level and excludes those who do not function at this level. I am aware that the qualitative nature of the case study that defines this thesis cannot be supported by such a positivist approach that characterizes a purely quantitative study. However, the mixed mode approach used in this study in which the quantitative aspects of the study are highly limited to simple numerical statistics can be used to support my argument for my reference to purposive sampling.

Erickson (1986) and Patton (1990) recommend an inductive approach to interpretive research. Later in this dissertation I shall outline how an **inductive approach** was used when I summarizing the data. Such data was used to create categories of codes as well as to develop both qualitative and simple quantitative representations of the data for analysis of the findings in this research.

4.2 Quantification of aspects of a qualitative study

My decision to engage in a quantification of the qualitative data (see later in this Chapter and the next) produced through the research instruments used in the study was an attempt to serve the needs of the constant comparative approach as suggested by Conrad (1978). This approach enhances the credibility of the research by not being confined to a purely qualitative approach as opposed to a purely quantitative approach. It is also an attempt to integrate both approaches despite the low profile numerical statistics used to quantify the qualitative data. Also, a mixed mode approach would only serve to enhance my understanding of the responses of the science teacher educators to the curriculum change process. This is explained further in the paragraph that follows the next.

I decided also to make a comparison of the cases across data sources obtained from the three research instruments used in order to develop the necessary consistency expected of an empirical study. Such an approach conforms to Erickson's view that

‘using a comparative technique that allows for similarities and later differences between groups becomes possible when qualitative data are sought from a variety of sources to ensure a rich comparative data base’. It also provides credence to Argyris’ (1996) theory of action in which the espoused theory may not be congruent with the theory in use. In the context of this research, this implies that a science teacher educator may or may not implement claims presented in an interview when related curriculum documents are examined or when they teach.

A significant aspect of using low profile numerical statistics is that it permitted analysis of the data to determine the frequencies of different kinds of responses of the science teacher educators and to classify these in terms of relevant categories. It also enabled patterns to be identified across cases and as well as patterns within cases through the use of the tables as presented in the next chapter. In the process of “ticking off” the responses in the table, I became aware of the existence of “special insights” or instances of change that may have been elicited as restricted responses from some informants in crystallizing a response to a problem. It also enabled me to identify aspects that others over-looked concerning the new curriculum, or who may have adopted a traditional or non-critical approach to the new curriculum. My choice to provide a numerical basis for the research was not only intended to provide a first level analysis. It was also intended to serve as a guide to look into cases more deeply. The latter is given exposure in Chapter Six during the representation of the level two analysis. These were extended further as stories of change and are represented in Chapter Seven where three science teacher educators represent the most outstanding views about change and its complexity.

4.3 The unit of analysis

The unit of analysis comprised individual science teacher educators from the faculty or school of education of each of the three universities in the province under study. I chose them as individuals and not entire faculties or departments or both because this study was focused on how individual science teacher educators had been changed by the curriculum change process. I also chose them as individuals because I believed that they experienced change differently due to individual backgrounds and

experience in the South African context. I realized that since they were responsible for preparing science teachers at a PRESET level, they could be most suited to enable their response to curriculum change as a community of science educators to be studied. My decision to focus on the Natural Sciences Learning Area of the new curriculum for schools could also best be addressed through their responses. They were the only staff at universities who catered for science teacher education within the context of curriculum change. As a result, teacher educators from other disciplines may not have been in a position to address issues directly related to science education, and specifically science teacher education. At a personal level, I felt that it would be more appropriate to study the unit of analysis as described here due to this field being my own specialization as a science teacher educator.

The sampling process involved in the study cannot be described as purposive or even random since it included the entire small community of 11 science teacher educators present in the province under study and involved with pre-service science teacher education at the three universities. I have confined my sampling frame to one province due to recent policy changes in South Africa (see Chapter Two) that relegated initial teacher education to the 17 universities nationally. Therefore science teacher educators involved with PRESET in one province may be construed as representing a meaningful wider population. This is due to uniform national implications of policy implementation related to the introduction of C2005 as a new curriculum as well as other policy developments which affect all universities. The systemic reform process and its associated quality assurance mechanism in education in South Africa is aimed at ensuring such uniformity. I also could not conduct my research nationally with science teacher educators from all the universities due to funding and other resource implications.

It is possible to compare similar groups of science teacher educators at all other South African universities that offer science teacher education at a PRESET level. The existence of such a status quo enables meaningful comparisons to be made with other groups engaged with the development of a similar discipline at universities in other provinces in the country. This is due to all such groups being subject to the same curriculum change process and its mandatory expectations. It therefore may be

possible in this case study to make generalizations from the sample about the population to which the individual unit of analysis belongs.

The closure of most of the colleges of education in South Africa and the decision to incorporate the remaining colleges of education into universities in the year 2000, a year prior to the data collection phase (see Chapter Two), prompted me to restrict the case study to science education departments in schools or faculties of education located at the three universities in the province under study as the sites for the research design. Science teacher educators from the three institutions chosen for this study participated in the comparative case study on which this research is based. These individual cases are subject to a cross case analysis in the following chapter in terms of their specific and generic properties and the extent to which they are particular and unique in enabling me to find answers related to the three critical questions proposed for this study.

4.4 Ethics and Credibility in the Research

4.4.1 Ethical Issues

I made a formal application to the Ethics Committee of the university where I registered for my research degree. Ethical clearance to conduct the research was granted on condition that the three institutions agreed to their staff being participants in the study. I also consulted with the participants in the study to gain their consent to study their practice. Every participant agreed to support my research fully after obtaining clarification concerning my research intentions.

In order to obtain data without implicating the lecturers in any way and to ensure anonymity, I decided that I would not refer to their names nor the names of their institutions in this thesis. Institutions cannot be guaranteed anonymity simply by changing names and places. However I did not receive any resistance to such an approach from participants in this study, nor from their institutional heads of department. As university-based researchers themselves, they accepted their anonymous status in the representation of the research in my thesis after I had

obtained official permission from their institutions in a letter (see Appendix 3) that clarified my intentions concerning ethical clearance and how their interests could be protected. This promised confidentiality could serve to reduce any threat to their credibility as lecturers in the face of information of a sensitive nature received from them. It could also promote a spontaneous response to data collection, especially during interviews.

Anonymity is maintained in this dissertation by referring to the universities and the subjects who participated in the research in the following way:

- i. Institution A: Subjects A1, A2, A3.
- ii. Institution B: Subjects B1, B2, B3, B4.
- iii. Institution C: Subjects C1, C2, C3, C4.

In addition to the steps taken above to ensure confidentiality and aware that Cohen et al.(2000) maintains that fidelity requires the researcher to be as honest as possible, I also invited two research participants to attend a paper presentation at a national conference based on this doctoral research. The conference is held annually in Southern Africa by the Southern African Association for Research in Mathematics, Science and Technology Education (Pillay, 2003). The two science teacher educators (C1 and C2) did not make adverse comments about anonymity, but were very curious to know which letter or number represented them in my research report and those of their colleagues who did not attend the conference. I informed them that in the interests of confidentiality promised to all subjects, I could not compromise on the issue of anonymity. They appeared to respect this. This served as a good test in a reality situation.

I am further aware that despite the steps mentioned above, anonymity becomes difficult with such a small community of lecturers. The history of each institution in the South African context makes them unique and easily identifiable. I therefore had to take the following additional steps to protect the respondents' lives and futures:

- excluding race as an issue, although I made brief reference to the race of individuals where necessary;

- taking personal responsibility for claims made in the research that have negative implications for respondents;
- being extremely true to my anonymity claims when questioned by persons interested in this research;
- be accountable to the respondents in the event of tendencies for other interested persons to recognise the identity of participants.
- in reporting the research in public fora, to be extremely cautious concerning institutional and personal identities without compromising their credibility.

In studying pressures that influenced change among the respondents, I believe that the respondents would be minimally implicated due to all institutions being influenced by similar pressures. In responding to the changes in terms of materials developed and teaching strategies, a sensitive approach needed to prevail. For example, it may be a sensitive issue to expose tendencies by some science teacher educators to adopt a traditional teacher-centred stance while others may use preferred learner-centred strategies proposed by the NQF through the modularization process. I decided that I would be adamant not to disclose such identities to persons outside the research, the exception being my research supervisors who needed to be au fait with my research. The maintenance of confidentiality and anonymity is a difficult task and an issue that I will have to address depending on the circumstances both present and the future.

4.4.2 Establishing additional credibility

Several authors of research methodology claim that to establish reliability and validity during research procedures related to qualitative studies detracts from the subjective nature of the field of study. Lincoln and Denzin (1998) refer to trustworthiness as being a more appropriate replacement for such conventional constructs that pertain more to studies of a purely quantitative nature and true to the scientific method. They have defined trustworthiness in terms of credibility, transferability, dependability, confirmability and authenticity. Considering the nature of the interpretive paradigm of qualitative research that characterizes my study, I have chosen to refer to trustworthiness as a means of maintaining credibility (in place of reliability) and authenticity (in place of validity) in my study.

In an effort to obtain credibility and fidelity for the interview data, a copy of the interview transcript was handed to each science teacher educator to serve the interests of respondent validation of the data. Such a move was necessary as I concurred with Cohen et al's.(2000:190) view that respondents may not agree with an interpretation and should have negotiated rights of veto. Of the 11 informants, only one responded to point out a few typographical errors in the transcripts. I contacted the other science teacher educators by telephone after a week and requested feedback on the interview transcripts. They indicated that the transcripts and associated summaries were an accurate record of the interview.

Cohen et al (2000:182) assert that 'it is important for events and situations to speak for themselves rather than to be largely interpreted, evaluated or judged by the researcher'. Despite the interpretive nature of this study, the data has been presented and analyzed in terms of the viewpoints of the science teacher educators as these relate to their respective institutional contexts and possible political and social backgrounds pertinent to the South African situation. The use of the terms 'quantification of qualitative judgments refer to the respondent's judgments. I have further used interpretive frameworks, derived from theory, to inform any apparent personal judgments that creep in and especially in Chapters Six and Seven wherein I develop interpretive commentaries based on my interpretation of the data obtained from the interviews, documents and observations of teaching. These interpretive frameworks have been informed by the South African context of curriculum change as established in Chapters One and Two and the theoretical frame developed and presented in Chapter Three.

Multiple methods were used to acquire the data to find possible answers to the research questions as these related to the 11 science teacher educators in the sample. These were in the form of interviews ("what they said"), documents supplied ("what they wrote") and observations of teaching ("what they did"). Triangulation formed a significant aspect of study because it enabled me to see the consistency (or not) between rhetoric, course outlines, classroom practice, and assessment. It was considered a good research strategy to establish whether espoused views of science teacher educators were put into use in reality (Theory in Action). Triangulation was also a means to enhance the comparative nature of the study by enabling me to

establish consistency between individuals and also between institutions with respect to the influence of the curriculum change process. It enabled me to secure an in-depth understanding of how the science teacher educators responded to the changes.

While triangulation is claimed as a strategy to enhance the trustworthiness of qualitative research (Patton, 1990; Cohen et al 2000), some authors view it as a positivist notion of attempts to establish the truth. This is typical of nomothetic or purely quantitative studies. I do not view triangulation as a tool or strategy of validation, but as an alternative to validation. It is still a positivist position suggesting that 'the truth' exists and can be found by triangulating. However, it does enhance credibility to the research in seeking what may appear to resemble a fair interpretation of social reality from an educational perspective. The use of three research instruments in this study also enables a multiplicity of perspectives in a social situation, such as education, to be discerned and enhances the research rigor.

I prefer to engage in the process of triangulation of data across cases (individual science teacher educators) and different methods used because according to Cohen and Manion (1989) it enables a multiplicity of perspectives present in a social situation to be discerned. This is relevant to my intention in this study to establish whether science teacher educators shared similar or different views about the curriculum change process considering their diverse backgrounds. This also conforms with Denzin and Lincoln's (1998:15) perspective that triangulation serves to clarify meaning by identifying different ways in which the phenomenon is being seen. The use of two or more methods serve to enhance the credibility of findings. I also agree with Cohen et al (2000:112) that using a single method provides a limited view of human behaviour and of situations in which human beings interact.

4.5 Justification for choice of research instruments

The analysis is primarily interpretive involving descriptions of phenomena. According to Denzin and Lincoln (ibid) research approaches concerned with reality-constituting interpretive practices examine how human beings construct and give meaning to their actions in concrete social situations. Many researchers in this tradition use participant

observation and interviewing as ways of studying the interpretive practices persons use in their daily lives. In this study I was not a participant, but observed from a distance and carried out the interviews.

The positivist version of research contends that there is a reality out there to be studied, captured, and understood, whereas post-positivists argue that reality can never be fully apprehended, only approximated (Denzin and Lincoln, 1998: 9). Post-positivism relies on multiple methods as a way of capturing as much of reality as possible. At the same time, emphasis is placed on the discovery and verification of theories.

Qualitative researchers aim to get closer to the actors perspective through detailed interviewing and observation in order to capture the individual's point of view. I consider the three research instruments chosen as being appropriate for this purpose due to their role in enabling me to find answers pertinent to the three critical questions. These guidelines were posed as attempts in this research to be as interpretive as possible of the curriculum change process that my subjects experienced in the South African context. The reason for my choice of particular approaches and research instruments are outlined in this section following an elaboration of the main research questions. This elaboration will contribute to my justification for the use of the research questions.

In addition to the above, I will use the theoretical frame developed in Chapter Three, the theoretical underpinning for the choice of research methodology, and an elaboration of the critical questions posed in Chapter One to justify my choice of the three research instruments used in this study to produce data.

In order to find answers to my critical question posed in Chapter One I realized that a semi-structured interview schedule (see Appendix 4) would be an appropriate choice as a research instrument. Such an instrument, while ensuring that the data is framed within the purpose of the research, could also provide flexibility of responses to enhance the comparative study. Its flexibility could also enable me to take an interpretive position in my analysis of the comparative responses of the science

teacher educators. Espoused views on change could be established through the use of such an instrument. It would also enable me to probe science teacher educator beliefs about change and the complexity associated with these beliefs. The influence of external pressures to change can also be partially established through the use of interviews.

The interviews were used as a means to establish whether the science teacher educators had intentions to change. In order to determine what instances of a curriculum change process are evident, a document analysis and observation schedule could be most appropriate for this purpose. The kind of curriculum science teacher educators in PRESET education developed for the Natural Sciences Learning Area as a response to C2005 were also partly answered through an analysis of documents and observations of actual teaching. The implementation of espoused views obtained through interviews could be confirmed through documents supplied, and the ultimate reality of these through observations of science teacher educators teaching in their lecture rooms. The two research instruments could also be useful in establishing whether they changed traditionally or whether they adapted to the changes prescribed by policy.

Further justification for the use of documents and observations are supported through the following questions related to curriculum change. The choice of these questions are based on the theoretical and analytical framework developed in the latter part of Chapter Three and are informed by my main research question posed in Chapter One:

- 2.1 Did the science teacher educators adapt their curriculum materials (course packs, assessment documents, work sheets, etc.) to suit the curriculum change policy for the Natural Sciences Learning Area? Did they incorporate the rationales of C2005 in their documents?
- 2.2 Was there evidence of modularization as per higher education policy development in their curriculum materials?
- 2.3 What was their approach to developing learner-centred strategies? Did they Role-model their teaching to conform with such a strategy?

- 2.4 How did their teaching conform with the new Norms and Standards for Educators?
- 2.5 What was the nature of the process of curriculum development for science teacher education? Were there significant changes in the process?

The rhetoric about curriculum change expressed in interviews was traced through documents produced and actual teaching to establish the credibility of claims made by science teacher educators. The teaching provided evidence of the reality of change.

In the light of how the science teacher educators changed and the kind of curriculum produced, a need arose to use the three research instruments to establish whether the complexity of the change process in the South African context played a significant role in influencing change among the science teacher educators. The complexity of the change process in South Africa is adequately captured in Chapters One, Two and Three of this thesis. External pressures from the NQF, the School/Faculty/Science Education Division at the universities, and the schools had to serve as forces influencing change in some ways. Establishing the reality of such a claim could be established reasonably through the use of semi-structured interviews, document analysis and observation of teaching in lecture rooms. This may not be possible through the implementation of one instrument alone. The use of complexity theory in interpreting the effect of these forces of change on science teacher educators and their individual responses to them sufficiently validates the data obtained through the use of multiple methods.

The data sources contribute to an enrichment of the interpretive process. With respect to the issue of complexity, additional and relevant data was obtained through finding responses to questions of the following nature:

- 3.1 How have espoused views of science teacher educators obtained during the interviews been translated into reality in terms of their theories of action?
- 3.2 In what ways have the documents been influenced by the complexity of the change process? Has complexity inhibited or accelerated the change process as recorded in the curriculum development process related to the development of documents?

- 3.3 How have the science teacher educators changed in relation to the curriculum change process and its associated complexity emanating from external pressures for change? Did they adopt a learner-centred strategy in their lecture rooms, or did they retain traditional teacher-centred approaches?

Finding answers to the elaborated questions requires the use of all three research instruments.

4.6 Designing the research instruments

4.6.1 The Semi-structured Interview Schedule

The semi-structured interview schedule focused on responses of science teacher educators in terms of their practice, their psycho-social and political responses to curriculum change and especially the influence of the critical outcomes. It was sufficiently open-ended (see Appendix 4) to provide flexibility to re-visit issues already covered earlier in the interview. This was with a view to enable further probing to occur in the event of new and relevant ideas not envisioned by myself, or that emerged during the interview, and that contributed favourably to obtaining a deeper insight into science teacher educator beliefs concerning the curriculum change process. I also attempted to identify feelings and motives as suggested by Cohen et al. (2000).

An additional purpose in developing flexibility through the semi-structured interview schedule was to conform with Cohen et al's (2000:22) view that 'to retain the integrity of the phenomena being investigated efforts are made to get inside the person and investigate from within'. In choosing to function within an interpretive paradigm, I realized that I needed the open-endedness of a semi-structured interview schedule to understand the subjective world of human experience that is usually constrained by a positivist, quantitative (nomothetic) study that may rely on questionnaires which might not elicit such information. My level two analysis in Chapters Six and Seven presents excerpts from interviews that indicate the extent to which I attempted to take

advantage of such an open-endedness in probing beliefs about change as well as other issues pertinent to this research.

The semi-structured interview schedule was designed to produce data related to its content in terms of the following issues that are represented with greater detail in Appendix 4 and were derived from the theoretical frame developed in Chapters One to Four:

- a) confirmation of having changed
- b) reasons for having changed
- c) the need for change
- d) the institution and change
- e) institutional pressures for change
- f) facilitating change for students
- g) rationales for C2005
- h) lectures, workshops and change
- i) the challenges of C2005 for science education
- j) the meaning of learner-centredness
- k) issues of diversity and change
- l) the influence of outcomes on the science curriculum
- m) the school context and change
- n) assessment and OBE
- o) response to the Norms and Standards for Educators
- p) resistance to change
- q) key turning point and change

I have related the theoretical underpinning for the content of the interview to issues relating to the South African context of post-Apartheid curriculum change. This is expressed in Chapters One and Two in terms of C2005 and its outcomes-based methodology as well as other rationales, modularization of courses at higher education institutions to incorporate outcomes, and the Norms and Standards for Educators.

The turmoil and confusion faced by science teacher educators in understanding the expectations of the new curriculum, and the subsequent decision to change or not to change their practices accordingly, forms an integral basis of the content of the interview schedule. I have also attempted to gauge the influence of curriculum change on the institution and its impact on the science teacher educators in terms of forced compliance related to the systemic reform process (Barnes et al., 2000). The theory of constructivism as a key rationale for C2005 also features in the interview process wherein I attempted to determine whether science teacher educators had adopted it in informing their changed practice, if this has changed at all. I also attempted to establish whether the responses of science teacher educators conformed with traditional, adaptive, and advanced change (theories).

4.6.1.1 Introducing the research to the interviewee:

I explained the nature of the project to the interviewee and clarified the research agenda and its purpose. I also discussed the reason for collecting the data and how it will be used. The issues covered in the interview schedule (see above) are too many to elaborate further at this stage and can be established by referring to Appendix 4. These issues were informed by the theoretical frame and research questions stated in Chapter One and elaborated further in this chapter.

4.6.1.2 Interviews with student science teachers

My data collection plan included interviews with student science teachers. I followed-up my observation of the science teacher educators teaching by conducting a short interview with up to six student science teachers. This was in part to gauge student's perceptions of the teaching by the science teacher educators I had observed, and in part to see whether the lesson/"lecture" I had observed, was "typical" of a traditional lecturing style or whether it embraced a learner-centred (constructivist) strategy as perceived by the student science teachers. I was also concerned that my decision to observe only one 90 minute session of teaching by the science teacher educators may not have been a fair representation of their daily formal engagement with student science teachers. I hoped that the student science teachers would be in a better position to inform me about other approaches and patterns of teaching used by the science teacher educators due to their regular attendance at lectures. I am aware that

not every lecture usually provides scope for innovative teaching and that traditional lecturing becomes necessary in some instances. However, adopting a traditional lecturing stance with prospective science teachers may defeat the purpose of the need to provide them with role-modelling experiences.

I obtained ethical clearance to interview student science teachers from the Dean of the Faculties of Education of the three Institutions. Permission for such an intrusive and sensitive approach to data collection was also negotiated with each science teacher educator. Being university-based researchers themselves, none of them objected to such an approach to data collection. I explained to them that I viewed it as a process of triangulation.

The following questions were posed to the students after I observed their lecturer teaching them:

1. Do you have opportunities to participate during lectures? Describe your participation.
2. Does your lecturer provide you with experiences to enable you to change in respect of OBE and C2005? Describe the experiences.
3. Did you have curriculum development opportunities related to OBE for diversity? Elaborate.
4. Do you prefer a student-centred or lecturer-centred mode of delivery?
5. Did your science teacher educator's input during lectures enable you to teach for OBE?
6. Were the Norms and Standards for educators workshopped with you?
7. Did you accept OBE fully or did you resist it?

Responses to these questions were used in the level 2 analysis in Chapters Six and Seven to support or dispute my claims.

4.6.1.3 Focus Group Interviews

On the basis of the interview data produced through the semi-structured interview schedule, I identified trends and patterns and used these as inputs to a focus group

interview with science teacher educators from each institution, especially since the participants selected shared common experiences in each institution. I did this in order to understand individual and institutional uniqueness about some issues and to establish the general views of the group on discrepant cases and instances that featured when I interviewed the science teacher educators individually. I also used the focus group interviews to assist me in understanding common perceptions about curriculum change issues. Some aspects of the data obtained were also used to support pertinent aspects of the level two analysis presented in Chapter Six.

I chose to engage with a focus group interview because its interactive format is unique to providing qualitative data for educational research (Rikard, 1996). Such a technique affords researchers alternative ways of understanding educational problems and issues.

According to Rikard (1996:249) focus groups

encourage participants to exchange ideas and opinions. This discussion of ideas in a group setting increases the external validity of the focus group methods and provides data that is more ecologically valid compared to individual interviews.

However, one should be cautious about viewing group data as being more credible than individual data. Malcolm (Malcolm, personal communication, April 22, 2003) claims that group dynamics can suppress important ideas that individuals might provide and that there are different consequences for the individual speaking out in the public forum than the private one. However, my contention is that it is the responsibility of the researcher to use interviewing skills to overcome such a dilemma in order to subvert such threats to the credibility of the research.

I was especially concerned during individual interviews that some interviewees made claims which did not appear to be an authentic interpretation of a specific situation and depended on the focus group to assist me to make sense of the claim and to possibly establish its origin. For example, if I found that only one science teacher educator from an institution made a statement that did not feature when their

colleagues were interviewed, I decided to field such acclaim among their colleagues during the focus group interview. On the other hand, I tried to reduce possible threats to the internal credibility of this research method in the following ways:

- a) I assured interviewees that their own names and that of their Institutions will not be divulged in my research report. I hoped such a strategy could ensure that they would refrain from presenting socially desirable responses at the expense of expressing the reality of a situation by being polite;
- b) participant deception observed during individual interviews was overcome by my attempt to obtain peer consensus in a focus group interview. For example if I believed that an individual science teacher educator made a claim of apparent apathy about senior staff and the change process, and that this appeared to resemble personal difference, I presented this issue to all the informants during the focus group interview to confirm such a claim;
- c) despite a personal leaning towards C2005 and OBE as a teaching methodology, I depended on the research culture of the group as university teachers to observe any tendency on my part to coerce my personal preferences and introduce subjectivity into the research. This was achieved by making it clear to the science teacher educators that I should not be regarded as an expert and that I depended upon their collective expertise as a group to inform this research.

4.6.2 The Observation Schedule

This document (see Appendix 5) was developed to enable observation of the science teacher educators in action in their lecture rooms or laboratories while facilitating the development of their student science teachers.

The observation schedule was structured to determine the extent to which science teacher educators integrated aspects of the curriculum change process into their lecture programmes. The focus was on the following aspects:

1. which role or competency of the Norms and Standards for Educators is the science teacher educator attempting to address or develop?;
2. which of the rationales for OBE are being achieved?;

Cooperative learning techniques,
Constructivism,
Assessment,
Interpretation of outcomes,
Achievement of outcomes,
Environmental education as a phase organizer,
Teaching for OBE;

3. a description of the learning environment;
4. a description of the seating arrangement of the students;
5. a description of the race groups of the students;
6. a description of the observed teaching pattern;
7. are pertinent issues related to C2005 being addressed?;
8. does the science teacher educator facilitate change for the students in respect of C2005?;
9. are contextual issues for diversity being addressed and are there curriculum development issues related to these?;
10. did the science teacher educator use any teaching materials?

I do concede that some aspects of the Norms and Standards for Educators have been implemented in science teacher education programmes prior to the curriculum change process. However, these programmes have been reported to be weak in developing a reflexive competence (Brookes et al, 1993). Appended to the schedule were interview questions for student science teachers who attended the session (see later for purpose).

The purpose of my observations of their teaching was also to seek consistency in terms of claims made by science teacher educators during interviews. This concerned teaching and learning and whether they translated their beliefs concerning this in practice as teachers or lecturers themselves (Theory in Action). This involved an attempt to make sense of the extent to which they were influenced by developments related to the curriculum change process. This influence was to be analysed in terms of policy expectations of the NSE, and other rationales of C2005, issues of diversity, etc., during their teaching.

4.6.3 Curriculum documents and content analysis

I was interested in collecting curriculum documents for analysis because these could serve to provide data pertinent to my second research question. This relates to the kind of curriculum produced by the science teacher educators as a response to the change process. The documents included curriculum documents developed since the introduction of the curriculum change process related to C2005. Among these were science examination papers, course outlines, course packs, assignment questions and portfolio assessments. It was necessary to reiterate my promise of confidentiality that these documents would not be exposed to public scrutiny. This became necessary in order to gain the confidence of some of the science teacher educators in the study who indicated that they were not keen for these documents to be viewed by others.

These curriculum documents could be useful in providing a sense and knowledge of change that could reflect what science teacher educators wrote as a response to the new curriculum and their expectations in developing materials for student science teachers. The documents could also enable me to gauge the extent to which views about curriculum change espoused during interviews were congruent with the contents of relevant curriculum documents and, in terms of observations indicated above (theory in use), about the context in which change occurs. A study of the documents could also serve to indicate the extent to which the science teacher educators have or have not changed, i.e., whether they adopt a positivist view of change (social reproduction), or whether they adopted a progressive stance towards change. They could also identify whether institutional changes related to curriculum change were followed by the science teacher educators. The following section will outline how these documents were analysed.

With respect to the observation process and document analysis, the following criteria were used to make sense of the change process in terms of how the science teacher educators conducted their own teaching and what their curriculum documents revealed in capturing the change process. The analytical framework informing the choice of criteria was related to adaptive change and models of curriculum.

1. preparing student science teachers to undergo a paradigm shift from a

- traditional pedagogy to the new and improved pedagogy of Curriculum 2005;
2. preparing student science teachers to develop strategies for science teaching which are both behaviourist and constructivist;
 3. enabling student science teachers to engage with an objectives model and an outcomes-based model;
 4. Preparing student science teachers to become curriculum developers instead of curriculum implementers.
 5. enabling student science teachers to function as reflective teachers;
 6. enabling student science teachers to teach a contextualised science;
 7. sensitivity to culture and science;
 8. integrating indigenous knowledge systems;
 9. role-modeling of teaching for OBE.

The following chapter presents the findings of the document analysis and the teaching observations. These are in the form of a comparative analysis and also show the extent to which they conform to C2005 and the expectations of modularization – the pressures influencing change.

4.7 Data Collection and Data Capture

4.7.1 The interviews

Prior arrangements were made with the science teacher educators because the interview required a one and a half hour time slot. The duration of the interviews was confirmed after I did a pilot with a retired science teacher educator. The interview with some of my participants usually lasted only an hour and ten minutes because in some instances, the interviewee was in a hurry to attend to other commitments in their busy schedules as university-based science teacher educators. I tried to keep to the format of my interview schedule without compromising its main intentions. Other participants were more relaxed and willing to participate in what they claimed to be a relevant interview on curriculum change.

I introduced the research proposal to the interviewee without providing too many details of the content and purpose. The intention was not to influence their responses. The reason for collecting the data and its use was also discussed. As indicated above, the interviewee was made aware of ethical issues related to the research. The research agenda was clarified and the purpose and need for confidentiality was conveyed to enable the interviewee to be in a relaxed state prior to the interview.

I used an audio-recording device to obtain the individual and collective views of informants during interviews. Permission was obtained from them before audio-recording their responses. I was especially conscious of Cohen et al's (2000:279) view that the interview 'is a social, interpersonal encounter and not merely a data collection exercise' because all the science teacher educators in the study were known to me either as colleagues or friends. Precautions were taken to ensure that I conducted the interview carefully and sensitively. I found that recording their actual words was important for capturing and conveying their personal and collective meanings during focus group interviews. The interpretive, descriptive, analytical and critical nature of my qualitative study was dependent on verbatim transcriptions from audio-cassettes to provide accurate written accounts for an in-depth critical analysis of the responses of science teacher educators to the curriculum change process in South Africa.

I refrained from videotaping interviews because of my concurrence with Rikard (1996) that audio-taping is less intrusive than videotaping and provides a mechanism for accurately reconstructing the interview for coding during the analysis process. However, I also concur with Cohen et al (2000) that the social nature of the interview cannot be captured by an audio-tape alone. The obtrusive nature of videotaping enables non-verbal communication in the form of facial expressions and gestures to be recorded. I overcame this problem by making additional notes that were included in parenthesis in the interview transcripts.

However, Malcolm (C. Malcolm, personal communication, 2 August, 2003) claims that there are also problems with either video or audio-taping, that an "accident of prose in a particular moment" becomes frozen as "truth" when, in a different setting the respondent might have said something quite different. I attempted to overcome such a problem by providing a copy of the interview transcript together with

descriptive codes to the respondents for comments. I also invited two respondents to attend a conference presentation based on my findings (see earlier in this draft).

I decided to capture the data from interviews without assistance despite the process being tedious. I captured the data in handwritten form and later used a word processor to develop the final transcript. My experiences during the actual interview coupled with the two additional textual accounts assisted me in becoming familiar with the data. This approach also assisted in the pre-analysis while listening to the interviewee via the audio-recorder, hand-writing their words, and then typing it using a word processor. The pre-analysis served to inform the need and content for focus group interviews per institution (see below). The transcript or interview text generated through this process was then used for coding purposes.

4.7.2 Observations of teaching

Prior arrangements were made with the science teacher educators to observe their teaching. I tried to remain in the background after the science teacher educators introduced me to the class. This gave me an opportunity to explain my presence to the student science teachers. I used my observation schedule (see Appendix 5) as a check list for my observations of the science teacher educators in action as university teachers during their “lecture”. While the check list approach may appear to be a positivist approach to recording my observation in an interpretive study, it was useful as a guide to some of the criteria that the new curriculum endorses as good practice. Learner-centredness as opposed to teacher-centredness was one of the criteria.

4.7.3 Documents for content analysis

Prior arrangements were made with the science teacher educators to collect relevant curriculum materials to investigate the influence of the curriculum change process. It was difficult to obtain these due to spurious claims that they were misplaced. After several telephone calls reminding the research participants of the urgency of this request, a variety of documents were made available. I selected relevant documents commonly available from all the participants. These included science course packs, course outlines examination papers and portfolios in science education. With the

exception of one science teacher educator, portfolio assessments were not forthcoming (see Chapter Five and Six).

4.8 The Method of Analysis

The analysis of the data is represented in Chapters Five to Eight. There are three levels of analysis:

4.8.1 Level One analysis (see above and Chapter Five) in which I produced qualitative categories from the data and presented these as a quantification of my qualitative judgments of science teacher educators responses to curriculum change. I chose to present the analysis in this sequence as a focusing experience for the reader of this dissertation. This was also to present the findings as a summary of the complexity of change that has been extended further in the level two analysis presented in Chapters Six and Seven and Eight.

4.8.2 Level Two analysis (see Chapters Six and Seven) – Themes that I identified from the categories are elaborated in more detail to show the complexity of change. Stories of change of selected science teacher educators are also presented and analysed to provide a more complete picture of the complexity of change that the themes failed to reveal.

4.8.3 Level Three analysis in which I attempt to theorize about change. This is captured in the final synthesis chapter (see Chapter Eight). Here I extend the findings in terms of complexity and relate these changes in higher education and school-related changes and the teacher education curriculum.

4.9 A Framework for the analysis

I used the research questions and the theoretical frame to inform the methodology as presented in this chapter. The analytic frame emerges from the methodology and is aimed at providing answers to the research questions through the methodology proposed. I analyzed the data produced during the interviews using the same issues

that informed the designing of the interview schedule as presented in section 4.6.1 of this chapter. I also used the criteria presented in section 4.6.3 to analyze the documents and observations of teaching in capturing the change process.

The framework for the analysis of the curriculum change process derives from the following conceptual ‘tools’ used to analyse data produced from research instruments such as interview schedules, documents and observations (also see Chapter Three):

- a) the age, gender, race and experience of the science teacher educators studied,
- b) pressures from the NQF in relation to:
 - i) university based changes in terms of modularisation and the NSE;
 - ii) responses of science teacher educators to school-related changes in respect of C2005.

4.9.1 Age, Gender, Race and Experience

The data were analysed to provide information about the extent to which age, gender, race and experience influenced responses to change.

4.9.2 University-based changes

The extent to which the institution applied pressures for change is also the basis for the analysis of data. The modularization process in which courses were converted to outcomes-based modules was investigated with a view to establishing how science teacher educators related to this process. The data was also analysed to establish how they related to the National Norms and Standards Framework prescribed by the NQF in terms of whether they had any institutional support for curriculum change or reform and the need for them to collaborate for this purpose.

4.9.3 School-related changes

One of the responsibilities of science teacher educators is to prepare student science teachers for school contexts. Therefore, beliefs about teaching and learning science and the role of constructivism as a learning theory for school science constitute significant aspects of the analysis. The rationales of C2005 (see Chapter Three) as

these pertain to the Natural Sciences Learning Area are key elements of the new curriculum. Science teacher educators were not directly mandated to engage with these rationales, yet these expectations of C2005 for the preparation of student science teachers cannot be ignored.

An attempt has been made during the analysis to ascertain how science teacher educators have changed (or not changed) as a response to C2005 and the post apartheid systemic reform process in South Africa. The nature of their personal change has been analyzed in terms of the theories, processes and aspects of change which have already been elaborated in Chapter Three. These theories, processes and aspects of change form a significant focus that serve to inform the analysis of the data.

4.10 Conclusion

The qualitative data produced through the research instruments chosen, described and justified as appropriate to supporting my thesis will be analysed in the chapters that follow. In the next chapter, I will attempt to numerically classify the data prior to engaging with an interpretive approach to continuing the analysis on a higher level in Chapters Six, Seven and Eight.

CHAPTER FIVE

LEVEL ONE ANALYSIS

This chapter represents a first level of analysis of the data produced from interviews with the science teacher educators from the three universities, their documents and observations of their teaching. It is a descriptive account of the results of what they “said”, “wrote” and “did” as part of the school-level curriculum change of C2005 and changes related to the higher education system such as modularisation and the Norms and Standards for Educators.

The data analysis is presented in three different ways in Chapters 5, 6 and 7. This chapter, Chapter 5, presents an overview by classifying the data into categories, and counting the frequencies in each category. The codings are elaborated to indicate the range within each category. In the next chapter, Chapter 6, the data are presented instead in terms of themes, in an attempt to reflect the complexity of changes and contexts more clearly. This approach is extended in Chapter 7 by presenting the stories of curriculum change of three selected science teacher educators. The stories have been developed from the data.

5.1 Analysis of the interview data

I have chosen to explain how I coded the data and developed categories in this chapter (rather than the methodology chapter), because I wanted to use examples from the texts to illustrate the approach.

5.1.1 Coding the Interview Data

I began by reading the interview (and other) texts and developing brief summary of excerpts as these pertained to the objectives of the research. The framework for the summaries was thus closely related to my research questions and the issues identified in designing my semi-structured interview schedule (see Chapter Four). An example of an excerpt with an appended summary is presented below:

Q: To what extent have you been given the opportunity to experiment with the curriculum at this Institution? Is the curriculum highly prescribed or did you develop your own curriculum?

A: In Science Education One it was necessary to develop my own curriculum and of course I had to teach my own curriculum as in the Special Method Natural Science. So it has exposed me to that pressure, which is internal pressure to say: “Hey how do you develop an holistic curriculum and hence also have this bias towards the new curriculum policy other than the normal teaching that I possibly had if you did not have the changes that are currently happening.” That’s what made me begin to experiment with a number of ideas which I read in journals and books; “Let me see how this works in my own classroom and how could I make it work best”.

Brief summaries as descriptive codes:

Was given the autonomy to design his own curriculum

Used a reflective approach to design his curriculum

Curriculum informed by his reading

These summaries were used for two purposes:

- a) to classify the items/propositions in the summaries into categories.
- b) to identify and build descriptive codes for quantification purposes.

I identified the following categories from the interview data:

Strategies, Perspectives, Process, Participation, Resistance, Curriculum change, Apathy, Equity/Diversity, Leverage, Psychological, Social, Political (issues), Threats, Events/Turning Points, Dramatic Change, Adaptive Change, Advanced Change, Definition of the Situation, Context/Setting.

Thus the codes were developed from the summaries and then elaborated into descriptive codes. This is shown in one instance below and in Table 1, for the category ‘strategies’.

- a) **Strategies:** I looked for instances in the data that showed that the science teacher educators used specific techniques for meeting their needs in adapting to the curriculum change process related to C2005 and created the following descriptive codes.

STRATEGY FOR CHANGE

Role modelled teaching for OBE

Analysed outcomes with SST

Read OBE documents

Collaborated with colleagues

Attended workshops

Conducted workshops on OBE

- b) **Perspectives.** I chose this category to classify definite ways of thinking that the science educators had about their setting and the changes.
- c) **Process.** I chose this category when the science teacher educators indicated sequences of events, transitions and turning points and changes over time.
- d) **Participation.** I placed data in this category as evidence of the science teacher educators' holistic involvement and adaptation, especially through working with others and experimenting in curriculum and teaching.
- e) **Resistance.** As a category, resistance allowed me to classify evidence that the science teacher educators were opposed to aspects of the curriculum and/or the change process.
- f) **Curriculum change.** Here I placed responses from science teacher educators that indicated a changed focus since the introduction of C2005 and the NSE in respect of content, assessment, outcomes, constructivism, cooperative learning, educators' roles, etc.
- g) **Apathy.** I placed here evidence of lack of interest or indifference to aspects of the change process.
- h) **Equity/ Diversity.** This category was for evidence of concerns pertaining to gender, culture, race, class, language, resource distribution, etc., as they related either to the policies or changed in their practices.
- i) **Leverage.** I used this category for evidence showing that science teacher educators had to respond in some way to external sanctions, whether from

within the institution, from the policies and regulations, or from students and schools.

- j) **Psychological.** This category was to group emotional responses of science teacher educators to the policies and related pressures.
- k) **Social.** In this category I classified evidence that indicated science teacher educators social conscience and/ or social consciousness for political and social redress.
- l) **Political.** This category relates to data that portrayed science teacher educators' sensitivity to dramatic political change and its impact on corresponding teacher change for redress.
- m) **Threats.** Some science teacher educators were sensitive to the requirements of their own change, and the time and resources they had available for the changes.

Note that the categories are not mutually exclusive: a particular comment might belong to Equity, Social, and Political, for example. And within any category, different positions and meanings applied: comments classified as 'Threat' for example, could refer to a variety of different threats. I reiterate that, although the categories arose indirectly from my research questions and research instruments, they were not conceived prior to data collection: they surfaced from the data, in ways that allowed all statements in the data to be classified.

At the same time as I sought codings of the data, I made notes that went beyond individuals statements, seeking to place those statements in the wider context of the science teacher educator's interview, and more widely again in terms of contextual factors. These notes were mostly to help me keep track of reflections on the data during the coding process. For example:

A2: Really, there was that element of compulsion largely because our students had to go out and our Faculty has been known to schools in our surroundings to be at the forefront of new developments in education.

My interpretation and engagement with the theoretical frame:

Science teacher educators at autonomous institutions in South Africa had the flexibility to challenge traditional practices. PRISM (Levy, 1992), an NGO, had liaised with Institutions A and C in challenging Bantu Education, fundamental pedagogics and behaviourist approaches. Integration of C2005 into the teacher education curriculum serves to endorse the influence of this NGO strategy.

At the same time, I tried to avoid being overly influenced by my own prejudices and experiences as a science teacher educator. For example, in my attempt to interpret the evidence statement “*was given autonomy*”, I scrutinized a relevant excerpt from an interview with a science teacher educator. I then related the excerpt to the theoretical frame in terms of “Theory in Action” and looked for additional evidence among curriculum documents supplied for “Theory in Use”. I tried to establish whether there was a match or mismatch between the science teacher educator’s espoused theory versus their theory in use. I also related this evidence to the analytic frame to establish whether the science teacher educator was influenced to act in a given way by changes in higher education or changes at public school level.

The data collection strategy (with its structured questionnaires and schedules) and the coding approach above were designed to enable cross-case comparisons and the constant comparative method. Thus individual responses were compared and analysed for common themes and patterns of similarity and difference, and these comparisons are presented below. It is also worthy of note that the coding of data was peer validated when my research supervisor, Professor Jim Gallagher at Michigan State University (USA), scrutinized and agreed with the descriptive codes that emerged during the process of analysis.

5.2 Interpretation of the analysed data

The “quantified” judgements from the qualitative data of the science teacher educators are presented in three sections:

- a) Interview data;
- b) Analysis of curriculum materials and documents;
- c) Observations of class teaching of student science teachers at a university level.

Table 1 below provides a summary of biographical information on the science teacher educators obtained from a short questionnaire. Summaries of the institutions A, B and C are provided in Chapter 6.

Table 1: Biographical information about the science teacher educators:

STEd.	A1	A2	A3	B1	B2	B3	B4	C1	C2	C3	C4
Institut.	A	A	A	B	B	B	B	C	C	C	C
Age	28yrs	35yrs	38yrs	48yrs	54yrs	35yrs	33yrs	35yrs	53yrs	60yrs	30yrs
Gender	M	M	F	F	M	M	M	F	F	F	F
Race	Afr.	Afr.	Ind.	Afr.	Afr.	Afr.	Afr.	Col.	Wh.	Wh.	Wh.
Exp. T	2 yrs	6 yrs	1 yr	5yrs	17yrs	5 yrs	4 yrs	4yrs	10yrs	21yrs	4yrs
Exp. L	4 yrs	5 yrs	5yrs	19yrs	13yrs	6yrs	5yrs	7yrs	20yrs	15yrs	3yrs
Ac. Qual	BPaed, BEd, MEd	MA, BPaed, BEd, MBA	DEd, BSc, BEd, MEd, HED	DEd, MA, BSc, UED, DTE	MSc, BPaed, SSTD, BEd	BSc, HDE, MEd	BSc, BEd, STD	BSc HDE MEd	MSc, HDE	BSc, HED	BSc Hons, HDE

Key:

- STEd. = Science Teacher Educator
 Institut. = Institution
 Exp. T = Experience as a school teacher
 Exp. L = Experience as a lecturer
 Ac. Qual. = Academic qualifications
 Afr. = Black African
 Ind. = Indian
 Col. = Coloured
 Wh. = White
 M = Male
 F = Female

The purpose for representing the biographical details as expressed in Table 1 is to indicate the effect of historically inherited apartheid segregation policy on racial distribution in the three institutions. It is also used as an indicator of academic qualifications and teaching experiences of the participants. Since the number of universities in South Africa is outnumbered by schools, I tried to maintain anonymity

by referring to the three institutions in the study as belonging to a province in South Africa. I did not specify the province!

In the table under the section 'STEd', A1, A2, and A3 are from Institution A, B1, B2, B3 and B4 are from Institution B., C1, C2, C3 and C4 are from Institution C. The ages in this table give clues about the science teacher educators' experience in education, and their experience of Apartheid. In both domains, race is also pertinent. Under Apartheid, Institution A was created as an Indian university; A1 and A2 are Black African males while A3 is an Indian female. Institution B was a Black African university, and B1, B2, B3 and B4 are Black Africans. B1 is female, B2, B3 and B4 are male. Institution C was originally a White College of Education. C1 is a Coloured and C2 is a White Afrikaner. C3 and C4 are White and English speaking.

All the science teacher educators from Institution C are female. C3, the most senior member from Institution C, taught part-time at Institution C and part-time at a local school. Table 1 shows that all of the science teacher educators had teaching experience in schools, and all had at least 4 years experience lecturing. All had post-graduate qualifications, including qualifications in education. B1 had a doctoral qualification, and A3 was midway through a doctoral degree.

Further descriptions of the institutions and the science teacher educators are provided in Chapter 6.

5.3 The interviews

Table 2 summarises what the science teacher educators from the three institutions stated when interviewed about the curriculum changes. Some of them experienced problems with the changes, and some were initially uncomfortable, but began to accept the changes over time. They generally appeared to engage with the rationales for C2005 and used systematic processes and strategies to achieve them with their student science teachers. Leverage for systemic reform for change appeared in the form of institutional pressures for modularisation and through the application of deadlines. These were met with some degree of resistance. Pressures to respond to

C2005 came more from responsibilities to teachers and schools than from institutional management. The data also revealed science teacher educators' perceptions of the redress role of C2005 in promoting social change in South Africa.

Table 2 shows 'Yes' (Y) and 'No' (N) responses per code, depending on whether the science teacher educator as respondent matched or not the code as summarized in the table. For example, for the category 'Problems Related To Change', a 'Yes' indicates that, in coding the data, I interpreted a science teacher educator's response as meaning he/ she found it difficult to manage changes related to C2005. The table, read horizontally for each category, shows comparisons across the individual cases and possible similarities or differences within an institution. The vertical representation shows individual profiles. The meanings of the coded statements in terms of their details and their relationships to other statements and institutional contexts are taken up in Chapters 6 and 7.

Table 2: A cross-case quantification of qualitative judgements obtained from interviews

	A 1	A 2	A 3	B 1	B 2	B 3	B 4	C 1	C 2	C 3	C 4	T 11
A VIEWS AND CHANGE:												
Viewed change as a threat initially	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	8
Became positive about change with time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Accepted change as a challenge	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	9
B CHANGE AND C2005												
Changed prior to C2005	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	9
C2005 accelerated the pace of change	N	N	N	N	Y	Y	Y	Y	Y	N	N	5
Autonomy facilitated change	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
C PROBLEMS RELATED TO CHANGE												
Difficult to manage change	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	9
Initially uncomfortable with change	-	-	Y	-	Y	N	N	Y	Y	Y	Y	6
Terminology of OBE a problem	-	-	Y	Y	Y	N	N	N	N	Y	Y	5
Complained about time constraint	Y	Y	Y	Y	Y	Y	Y	N	N	Y	-	8
No institutional support to manage change	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
D SOME RATIONALES OF C2005												
Practised constructivism	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Completed a module on constructivism	N	N	N	N	N	Y	N	N	N	N	N	
Practised continuous assessment	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Referred to portfolio assessments	N	Y	N	Y	N	N	Y	Y	Y	N	Y	11
Addressed issues of diversity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	5
Used cooperative learning techniques	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11

													11
E	PROCESS OF CHANGE												
	Incorporated C2005 in curriculum	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Informed by intuition	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Informed by theory	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	10
	Prepared teachers for learner-centredness	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Read Norms and Standards Document	N	N	N	Y	Y	Y	Y	Y	Y	N	N	6
	Used Norms and Standards with SST	N	N	N	Y	Y	Y	Y	Y	Y	N	N	6
	Used SOs of Nat Sc LA for social redress	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	8
	Used COs of C2005 for social redress	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	8
F	STRATEGY FOR CHANGE												
	Role modelled teaching for OBE	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	8
	Analysed outcomes with SST	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	8
	Read OBE documents	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Collaborated with colleagues	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Attended workshops on OBE	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	7
	Conducted workshops on OBE	Y	N	N	Y	N	Y	Y	Y	Y	Y	N	7
	Wrote books/articles on OBE	N	N	N	N	N	N	N	Y	N	Y	N	2
	Studied specific modules												
G	LEVERAGE AND CHANGE												
	Influenced by the changing school context	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Modularization and change	Y	Y	-	Y	Y	Y	Y	Y	N	Y	Y	9
	Institutional forced compliance/pressure	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	9
	Discipline level pressure and change	N	N	Y	Y	Y	Y	N	N	N	Y	N	5
H	RESISTANCE AND CHANGE												
	Resisted change initially	Y	N	N	N	N	N	N	N	N	Y	N	2
	Sceptical about change initially	Y	N	Y	Y	N	N	N	N	N	Y	Y	5
	Apathetic about change	N	N	N	N	N	N	N	N	N	N	N	0
	Resented institutional deadlines for change	N	N	N	Y	N	N	Y	N	N	Y	N	3
I	PSYCHOLOGICAL ASPECTS												
	Confident about change	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	9
	Change was frustrating	Y	N	N	Y	N	N	N	N	N	Y	Y	4
	Change was frightening	Y	N	N	N	N	N	N	N	N	N	N	1
	Change was traumatic	Y	N	N	N	N	N	N	N	N	N	N	1
	Collaboration helped to overcome anxiety	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	7
J	SOCIO-POLITICAL ASPECTS												
	Change is relevant to the SA context	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Change will produce an improved society	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
K	CHANGE THEORY												
	Response conforms with Advanced CT	N	N	N	N	N	N	N	N	N	N	N	0
	Response conforms with Adaptive CT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11

Note:

Y = Yes

N = No

- = No response/indication (a silence)

SST = Student Science Teacher

Nat Sc LA = Natural Science Learning Area

Educ. = Education

SOs = Specific Outcomes

COs = Critical Outcomes

CT = Change Theory

T = Total

The following analysis relates to Table 2 above and provides clarity based on the qualitative data that have been analysed further in Chapters Six and Seven. It therefore should be read in conjunction with Table 2. I also wish to emphasize that the information in the table was obtained after the data was qualitatively analysed.

5.3.1 Views about change

Of the eleven science teacher educators, nine were generally positive about the changes related to C2005. C3 and C4 did not appear to be very positive about C2005, but this is possibly because their primary responsibilities were to teach Chemistry and Physics for student teachers who would work at the senior secondary level, to which the principles of C2005 did not apply at that stage of data collection. They claimed also that change in these subjects was constrained by external examiners who insisted that issues in education related to science should not be included in their science syllabus. C3 was adamant that she had taught to an outcomes-based approach emphasising skills development, so that C2005 simply endorsed her practice. She saw as important the role of teachers in improving society, and hence sought to provide varied experiences for student science teachers to enable them to cope with different contexts. For example, she promoted improvisation of science equipment when working in schools that had limited resources.

Eight out of eleven science teacher educators viewed change related to C2005 as a threat, especially initially, even though most felt that they had changed prior to the introduction of C2005. B3 and B4 did not view change as a threat because they saw it as being very relevant to the South African context of social and political change. A3 felt that her exposure to well informed science teacher educators at Institution A over a long period of time was sufficient to enable her to engage with the change process. Collaboration with colleagues and participation in workshops served to develop confidence among those who felt threatened when C2005 was introduced.

Nine of the eleven science teacher educators accepted the change process as a challenge. B3 did not see the changes as a major challenge because he saw them as part of social change in South Africa. He was very inclined towards changes leading

to an egalitarian society based on equity and social justice. In part this may have been because his Institution was located in an economically depressed rural area, an area that was generally marginalized by the Apartheid Government. In part it was because he was familiar with many of the changes suggested. C3 did not see change as a challenge because she believed that her teaching had long been outcomes-based and learner-centred. During her career, she made many contributions to uplifting the oppressed in South Africa through conferences where she served as conference organizer. A1, A2, B2, C1, C2, and C4 claimed that they became positive about change with time. The general feeling was that the almost sudden confrontation by change was a threatening experience which involved more work on their part. It also meant finding ways of interpreting the expectations of change through collaboration with colleagues. They became positive after reading policy documents and attending workshops based on the new curriculum.

5.3.2 Change and C2005

Nine of the science teacher educators claimed that they had already changed from traditional practices before the introduction of C2005. The curriculum autonomy they had in their institutions and their knowledge of the science education research literature provided opportunities to change, but did not guarantee change. B2 and B4 felt that they were mainly traditional in their approach to science teacher education and had a tendency to adopt teacher-centred approaches prior to the introduction of C2005. B4, on the other hand, responded strongly to C2005. He felt he had functioned in very traditional ways as a science teacher educator prior to the introduction of C2005, encouraging his student science teachers to adopt similar approaches. With the appearance of the new curriculum, upon personal reflection, he sought to build his abilities to manage the change process and the new curriculum. B4 had begun lecturing with a science degree and no education qualification. It was through his studies for an honours degree in education and the introduction of C2005 that he began to think deeply about educational change, and C2005 accelerated the process.

While some science teacher educators acknowledged that the changes related to C2005 had occurred in different ways prior to the introduction of C2005, Malcolm (C. Malcolm, personal communication, 10 May, 2001) has noted that the rationales of

C2005 are consonant with the international literature in science education), five had particular reasons for their claim. A1, A2, and A3 from Institution A considered their institution 'to be at the forefront of change' prior to C2005 and hence that they were well-placed to critique and work with the changes. B1 had spent long periods in another African country and overseas and felt herself well acquainted with the changes. C3 and C4, as Chemistry and Physics educators for the senior school, on the one hand felt themselves already familiar with the ideas in the policy and on the other hand were not working so much with student teachers who would be responsible for implementing C2005.

5.3.3 Problems related to change

None of the science teacher educators expressed concerns about the purposes, theories and principles underlying C2005. However, they did have problems with the terminology of the policy, and with managing the change processes for themselves and their institutions. Nine science teacher educators claimed that they experienced difficulty, due in part to a lack of institutional support for the introduction of C2005 as such.

As noted earlier, A3 and B4 felt they did not experience problems. A3 and B4 are younger members of the eleven science teacher educators interviewed. On the other hand, B3 was considerably older, but felt no great problems. He served on the Restructuring Committee at Institution B and was in a favourable position to guide and manage the changes. Of the six science teacher educators who were initially uncomfortable with the changes, B4 reported that C2005 was an "eye-opener" which served to underline the paradigm shift needed. He attributed his shift to learner-centredness to the new curriculum. A1, A2, and B1 flowed with the change due to their previous experiences of curriculum development and change.

Five of the science teacher educators said that a major problem they had with C2005 was with the terminology of outcomes, assessment criteria, range statements, phase organisers and so on. This problem was widespread among teachers, curriculum writers and teacher educators, as was clear from the Chisholm Review of C2005, completed in 2000 (Chisholm, 2000). B3, B4, C1 and C2 had addressed this problem

by attending workshops and discussing issues with their colleagues. C3 was opposed from the beginning to the new terminology. As C4 explained, even as a person for whom English was her first language, she experienced great difficulty interpreting the “jargon”. Consistent with these critiques, the Chisholm Review recommended major simplifications and ‘streamlining’ of the policy.

Eight science teacher educators cited time as a constraint in managing the change process. This related especially to institutional pressures to revise their curriculum documents for submission to SAQA for accreditation, and the extent to which some institutions and individuals made major efforts to bring their curricula into line with C2005 as part of the revision. C1 and C2 claimed that they were not affected by such time constraints.

All eleven science teacher educators claimed that they were not given sufficient institutional support to manage the change to C2005. The primary concerns of the institutions appears to have been for the modularisation of units according to the SAQA templates, not changes in content and approach. This may have been due to managers leaving the science teacher educators to make the curriculum changes, as experts in their field. Even so, the institutions put structures in place to support the changes: the Restructuring Committee (Institution B), a Curriculum Officer (at Institution A), and involvement with the Department of Education’s Learning Area Committees (at Institution C) all operated to support the modularisation process and curriculum change. As well, other forms of collegiality existed or came into place.

5.3.4 Some rationales of C2005

This category in Table 2 refers to the extent to which science teacher educators related to or engaged their student science teachers with the theoretical bases of C2005, such as outcomes-based learning, constructivism, continuous assessment, diversity and redress.

Especially those science teacher educators whose modules addressed or included the ‘method’ aspects of science education said that they exposed their students to the specific outcomes in the Natural Sciences Learning Area of C2005. All eleven science

teacher educators claimed that they practised constructivism, role-played continuous assessment techniques, addressed issues of diversity and used cooperative learning techniques with their student science teachers. Nine science teacher educators indicated that they had developed these approaches as part of their responsibilities in improving science teaching in school contexts: as university-based academics, they felt responsibilities to be familiar with the science education literature. B1, for example, was emphatic that the rationales of C2005 were not new to her. B3 indicated that aspects of both the Norms and Standards for Educators and the C2005 served to ensure that science teacher educators could now become more focused on these principles. However, few demonstrated most of the principles of C2005 during my observations of their “lecturing” (teaching). The extent to which the science teacher educators practised (or did not practise) these rationales in reality and in terms of their theories in action is the subject of discussion in a later section.

In terms of assessment, A3 used various approaches and developed portfolios with her students. A2 claimed that while portfolio assessment was a widely discussed concept, very few lecturers used it in tertiary education. He used it in the technology education learning area programme where he believed it was especially appropriate as a tool to track development. He did not use portfolios in his science education courses, although he did use continuous assessment through a variety of assessment instruments. He saw time constraints as problematic, especially when contending with a double period per week in a science methods class. He, like A3, could not see portfolios as a feasible instrument for use by student science teachers during their school-based teaching practice, because the time in schools was short and the schools had their own assessment policies. A2 saw as important informal assessment with his students during consultation sessions outside of actual lectures. B1 used portfolio assessment for a large class of 196 students, but found the process of tracking and marking very stressful. She wished that SA had the necessary technology, prevalent in the USA, to facilitate portfolio assessment and reduce the stress on the assessor. She claimed that she used portfolio assessment at all levels, including the undergraduate and postgraduate. She reported that she had collaborated with UNISA in developing portfolio assessments. C2 has used portfolios and a range of assessment tasks with her Natural Sciences Method students in the PGCE programme, but was not sure about

whether she used it correctly. She stated that the Institution emphasized the need for portfolios. C4 did not use portfolios.

5.3.5 The process of change

This refers to the course of action taken by science teacher educators in engaging with curriculum change. All the science teacher educators claimed that they had incorporated C2005 into their science teacher education curriculum and, in this, were generally informed by intuition/experience and theory. C3 felt that her personal intuition and experience were more important in informing her actions than theories and policies. As noted earlier, most indicated that they had moved away from traditional practices before the introduction of C2005.

Most of the science teacher educators claimed that they agreed with the social redress intentions of policy. However, there were different views on what this meant in the classroom context. C3 and C4, for example, saw it as vital that their students understood Physics and Chemistry well, and could teach them well, but were disinclined to discuss issues of redress in their classrooms.

The Norms and Standards document for educators appears to have been much less influential in curriculum revision in science education than C2005. A1, A2 and A3 reported that they had not read the document or ventured to use it with their student science teachers. However, all three Institutions ran workshops related to the document. The science teacher educators offered three explanations for not using the document directly: they saw it as 'not new', they saw it as implicit in C2005, or they left it to other modules, especially modules in education.

The critical outcomes of the NQF and the (related) specific outcomes of the Natural Sciences Learning Area are viewed in the policy documents as central to social transformation. A1 said he did not analyse the critical and specific outcomes of C2005 with his students, but nevertheless saw the potential of science in enabling social and economic redress. A2 analysed the critical outcomes with his student science teachers, emphasizing that they were basic to the Constitution of South Africa. He claimed that he spent more time developing the critical outcomes with his student science teachers

because they found the specific outcomes of the Natural Sciences Learning Area more difficult to grasp. A3 did not engage her students with the outcomes or the policy documents directly, explaining that her doctoral studies and sabbatical limited her involvement in C2005 for a while. B3 viewed the outcomes as being relevant to change. B1 emphasized the critical outcomes even though she viewed change as having taken place before the introduction of C2005. B2 said he struggled to understand the outcomes, but viewed them as useful for change. C1 saw the potential of the critical outcomes for social development in multiracial classes. C2 analysed the critical outcomes in relation to the rationale for social and political change in the South Africa. She feared that the assessment standards of the revised curriculum emphasized Science learning outcomes to the extent that the critical outcomes became marginalized. Although C3 did not analyse the critical outcomes with her students, she worked on them herself, and saw their potential. C4 too was impressed with the critical outcomes, but she was sceptical about their translation into reality, and concerned about the lack of employment opportunities that school-leavers would face.

5.3.6 Strategy for change

The term strategy is used here to capture the tactics used by the science teacher educators in implementing the curriculum expectations of C2005 in their institutions and courses.

According to Table 2, eight science teacher educators claimed that they role-modelled the learner-centred strategies of C2005, many insisting that they had been doing that before the policy was introduced. As science teacher educators they claimed that they were always discouraging totally teacher-centred approaches. A2 felt that he was not a good role model for OBE, and had a tendency to describe good teaching methodology for OBE according to the outcomes of C2005. In this context, he gave his students opportunities to prepare lessons in groups and team teach while their peers offered critique and comment. B2 did not give any indication that he role modelled OBE. B3 was quite enthused by the new curriculum and claimed that he had a strong background in constructivism as a teaching and learning strategy in science.

All the science teacher educators interviewed claimed that they read OBE policy documents to develop an understanding of the change. They stated that they collaborated with their colleagues in order to come to terms with C2005 and the Natural Sciences Learning Area. The collegiality stemmed from their own initiatives (rather than institutional initiatives). C2 and C3 had begun to write a book on OBE, partly as a way of coming to understand the policy. C2 wrote a paper in which she critiqued C2005 and its relevance in South Africa. She presented the paper at a national conference. Seven of the science teacher educators (including C2) reported that they attended workshops, and that they had also conducted workshops on C2005. Institution C had particular opportunities in that they hosted meetings of the provincial Natural Sciences Learning Area Committee, which some of the science teacher educators attended regularly. All of the science teacher educators reported that they consulted with their colleagues, formally and informally, in interpreting the changes, except for B3 who claimed that he was more inclined to turn to additional reading. In Institutions B and C, more than in A, science teacher educators often worked together in designing modules and teaching.

While the institutions, generally, did not organise or conduct workshops on C2005 for staff, it appears that they did notify staff about dates and venues for workshops held by the Department of Education, encourage attendance, and permit absence from the institution in order to attend.

5.3.7 Leverage and change

Here I consider the extent to which science teacher educators were subjected to:

- (a) indirect demands from schools to change, and
- (b) institutional pressures (from the university, the Faculty and the science education division) and sanctions from accrediting bodies (especially SAQA).

The science teacher educators were in general agreement that the changing school context was a major pressure to change. They viewed it as a responsibility to their student science teachers who would end up in their employment. Eight science teacher educators acknowledged that the process of restructuring (modularization) was a pressure on their institutions and hence themselves to revise their curricula. Several of

them stated that while they realized the need to comply with the changes in higher education, they resented the deadlines related to its implementation. They accepted the role played by management in governance, but felt inundated with the many changes they had to endure. However, they accepted the changes and, to varying extents, married the restructuring process with incorporation of C2005 and the NSE.

It is interesting that Table 2 shows that fewer than 50% of the science teacher educators perceived the science education discipline level in the hierarchy as a pressure for change: they tended to see the science education division more as a collaborative team effecting the requirements of the faculty and the university. Their perceived autonomy in making the revisions was welcomed by the science teacher educators and had an empowering effect.

5.3.8 Resistance to Change

The interview data revealed that resistance by the science teacher educators was limited. Only two were vociferous about their initial negative views about change related to C2005. A1 claimed that school-related change was initially frightening and that he was traumatised by it, though he changed his views later. C3 stated that she was opposed to a few aspects of C2005. She disliked the record keeping associated with continuous assessment and objected to the jargon associated with C2005. Even so, she adapted in positive ways to the changes. The data also indicated that three science teacher educators did not resist change per se, but resisted the deadline dates that infringed on their time.

5.3.9 Psychological aspects

Table 2 shows that none of the science teacher educators reported that he/she had experienced severe psychological strain as a result of the new demands. Nine of the eleven claimed that they became confident about change with time. As explained earlier, the new and “strange” terminology of C2005 and the difficulties of deciding what it meant and how to apply it were a source of frustration and fear. A1 and C3 said they found the changes frightening, but for different reasons. A1 was a young teacher when C2005 was introduced, while C3 was at the end of her career. Most of

the science teacher educators found that collaboration and reading helped them to overcome anxiety related to the curriculum change process.

5.3.10 Socio-Political aspects

There was general agreement by the science teacher educators (9 amongst 11) that change was relevant and could produce an improved society. C3 believed that the potential of C2005 to enable political and social change may be compromised by its jargon, which would confuse teachers. A number of them expressed concern that it could not be implemented in schools with the current levels of resources and training. The sentiments of the science teacher educators to this aspect of change varied considerably and are considered in some detail in the next chapter. They contribute an important element in terms of the complexity of change.

5.3.11 Change Theory

The organizing frame for this category relates to my perception of how the science teacher educators could be viewed in terms of adaptive and advanced change theories as described in Chapter Two. I have excluded Traditional Change Theory from the organizing frame because there was no evidence of coercion from management or severe resistance to the changes. Most of the science teacher educators felt that the rationale for the changes enabled their ideals to be realized in more focused ways.

All the science teacher educators conformed to “Adaptive Change” and an Adaptive Change Theory (see Chapter Three). They have transformed themselves in ways that empower the self as they align with a vision for ‘the common good’. However, there are elements of Advanced Change too, such as taking up leadership roles related to the new curriculum. Several of them ran workshops on OBE for school-based teachers. A1 ran workshops for grade one teachers in Pretoria, South Africa and served as UNESCO representative to run OBE workshops in the Northern Province. A1 and A2 played leading roles when they were commissioned by the State to evaluate the implementation of the related Technology 2005 curriculum (also part of C2005). B3 was a key member of the Restructuring Committee at Institution B. C1 presented a paper at a national conference during the early stages of the introduction

of OBE. C3 played a significant role as an organizer of science education conferences provincially and nationally. She was invited by an Australian university to share her experiences of science education curricula in the South African context. She has also produced videos on science practical work in South African schools. B1 has international experience in curriculum development for science teacher education, an indication of the degree of advanced change she had developed.

The fact that the State transferred responsibilities of teacher education from colleges to universities emphasizes the expectations that science teacher educators will provide leadership in the field. Science teacher educators claimed that they had been preparing teachers for learner-centredness prior to the introduction of the new curriculum for schools, indicating that several of them embraced the opportunities for leadership as part of educational and social change. At the same time, I could not see any evidence that any science teacher educator had needed to greatly change their own ideals as part of the change, or choose highly courageous paths of action, as suggested in Advanced Change Theory. Rather, the new curriculum served to focus their actions more deliberately.

5.4 Curriculum materials developed by the science teacher educators

This brief descriptive analysis is based on findings of a content analysis of examination papers (Table 3 below) and course outlines supplied by the science teacher educators (Table 4 of this section). B2 could not make his documents available, because of illness that extended for a long term.

The percentages in Table 3 indicate the percentage incorporation of C2005/OBE per se into Examination papers for Science Teacher Education. The discussion that follows serves to describe and explain from the qualitative data the possible reasons for such developments as per science teacher educator. Reference will be made to Table 3 as the discussion develops. For ease of reference, I have also included as appendices examination papers that varied in the degree of integration of principles of C2005. Appendix 6 shows C1's paper with 100% integration of C2005. Appendix 7 is

a copy of B3's paper which shows a zero percent integration of C2005, but with pure science questions constituting a mixture of SO1 and SO2. Appendix 8 shows A3's paper with a 13% integration of C2005 issues.

Table 3: Percentage incorporation of C2005/OBE into Examination papers for Science Teacher Education

	Documents analysed	<u>A</u>	<u>A</u>	<u>A</u>	<u>B</u>	<u>B</u>	<u>B</u>	<u>B</u>	<u>C</u>	<u>C</u>	<u>C</u>	<u>C</u>	T
		1 %	2 %	3 %	1 %	2 %	3 %	4 %	1 %	2 %	3 %	4 %	
A	Exam Paper 1	40	1	13	23	-	12	0	100	20	0	0	7
	Exam Paper 2	20	1	0	0	-	24	25	100	0	0	25	6
	Exam Paper 3	0	30	0	70	-	70	28	100	32	0	0	6
	Exam Paper 4	0	68	0	25	-	0	0	-	45	0	0	3
AVERAGES		15	25	4	30	-	27	13	100	23	0	6	

Note:

T = Total number of science teacher educators who incorporated changes in each exam paper analysed.

Evidence for some of my claims can be obtained from exam papers represented in Appendices 6, 7 and 8 supplied by A3, B3 and C1. This is by no means comprehensive due to the lack of space in this thesis. The purpose of such an analysis is to serve as an indicator of the degree of incorporation of some of the principles of C2005 in the exam papers as support for my qualitative case study.

The issues related to C2005 that were assessed in the exam papers by the science teacher educators were as follows.

- critical outcomes;
- specific outcomes of the Natural Sciences Learning Area;
- constructivism and cooperative learning as strategies for learner-centredness;
- variety in assessment, portfolio assessments, assessment criteria, performance indicators, etc.;
- themes of the Natural Sciences Learning Area;
- programme organizers and phase organizers.

Science teaching methods examination papers were analysed for the appearance of all of the above, while pure science examination papers that appeared to exclude the above issues were analysed for the relevance of the questions to the Specific Outcomes of the Natural Sciences Learning Area. For example, a question such as 'Explain the process of Photosynthesis' was viewed as SO2, viz., "Demonstrate an understanding of concepts and principles, and acquired knowledge in the Natural Sciences". Note that SO1 (investigative processes) and SO2 (science concepts and theories) are traditionally addressed in the science curriculum; the remaining 7 SOs are relatively 'new' (see Appendix 1).

No exam paper referred to every aspect of C2005 listed above. A3 had limited incorporation of C2005 in her examination papers (see Appendix 8) and in other curriculum materials supplied (see below). She included a question related to Critical Outcome 2 in one paper, but the assessment was dominated by SOs 1 and 2. Papers submitted by C3 were 100% SOs 1 and 2. B3 (see Appendix 7) and C4 was in an almost similar situation. The science education and science method papers developed by the remaining science teacher educators showed a fair incorporation of C2005 in courses where the 'education' aspects of science education were attended to. Table 3 shows that C1 had developed an exam paper that had an almost 100% incorporation of C2005 issues (see Appendix 6). 'Pure science' papers (eg., Physics, Chemistry, Biology) seldom had reference to C2005, and seldom addressed outcomes beyond SO1 and SO2 (see Appendix 7). Some of the the science teacher educators claimed that this was in order to conform with syllabus requirements, and/ or the expectations of external examiners. Science education and teaching method papers had greater flexibility for incorporation of curriculum change.

Contradictory to this general finding was documentation from Institution C from as early as 1998, where even the Chemistry and Physics programmes appeared to be outcomes-based, and included issues of diversity and society. Thus there would appear to be individual latitude, regardless of external examiners: C4 felt she had no choice but to conform to the expectations of an external examiner, but C1 did not appear to have such a problem with her modules for the Biological Sciences. The incorporation of C2005 into exam papers shows a range of 4% to 100%. Table 3 shows that B1 (70%), B3 (70%) and C1 (100%) succeeded in maintaining an high

levels of integration of C2005 issues in at least one examination paper. It also shows that C1 achieved almost 100% in all the papers supplied. The variability within and across institutions suggests that the choice of incorporation of C2005 were largely individual.

I further analysed papers that were dominated by pure science to establish whether the nine specific outcomes of the Natural Sciences Learning Area (see Chapter Two) were reflected. A1's Science Education One paper (2001) showed one question (10% of the paper) was related to SO7. The remaining 90% comprised a mixture of SOs 1,2,3 and 5. Seventy two percent of A2's Science Education Three paper comprised pure physical science questions that related to SO1 and SO2. The remaining questions (28%) were related to science education issues, including one related to the use of portfolio assessment. B1 and B4 were co-examiners of a General Science paper (2001). They focused fully on SO1 and SO2. The same observation pertained to a Primary Science paper (1999) and a Physical Science paper (2001) set by B3 and B1. All exam papers related to the pure sciences included questions related to SO1 (science processes) as well as SO2 (conceptual knowledge).

Only one example of a portfolio was submitted, by B1. It was compiled by a science teacher as part of an INSET programme facilitated by B1, and consisted mainly of work from her school learners. I found that it was competency-led, with evidence of an outcome-based learner-centred approach. For example, it reflected exit level outcomes. It also showed the progress of learners, though more in technology education than science. There were 200 pages of assessment records of learners with comments from B1 as the supervisor. (B4 was also involved in one aspect of supervision).

It seems that portfolio assessment was a trend in Institution B and stemmed as a directive from its Restructuring Committee. Institution A did not practice portfolio assessment, although it encouraged continuous assessment. In Institution C, documents from as early as 1998 indicated the following expected record for assessment in science education which appeared to conform to the expectations of modularization:

:

Written work, practical work/investigations, displays, seminars, guided self study, oral work, debates, cooperative (group) work, field work, reports on excursions, academic reports, research assignments, tests, portfolios of work

It did not compel science teacher educators to follow the expectations: that was left to the individual science teacher educators.

Table 4 shows the extent to which science teacher educators included issues related to C2005 and its OBE methodology in course outlines for their Science Education programmes for science teacher preparation. The issues pertain to the rationales of C2005 and the Norms and Standards for Educators. Science teacher educators, as part of the NQF and accreditation, are to ensure that their student science teachers fulfil the expectations of the Norms and Standards for Educators and the process of modularization. It is not their responsibility to ensure that student science teachers understand C2005 and its OBE methodology due to the imperatives for teacher education being different from that of public schools.

Course outlines from 10 science teacher educators were assessed for evidence of incorporation of issues related to C2005 as these pertain to the Natural Sciences Learning Area. Table 4 in this section shows that more than half of the science teacher educators appear to have presented the following issues in their course outlines:

- Themes from the Natural Sciences Learning Area and associated specific and critical outcomes
- Assessment criteria
- Range statements
- Performance indicators
- Continuous assessment

**Table 4: C2005 issues included in course outlines for
Science Education**

		<u>A</u> <u>1</u>	<u>A</u> <u>2</u>	<u>A</u> <u>3</u>	<u>B</u> <u>1</u>	<u>B</u> <u>3</u>	<u>B</u> <u>4</u>	<u>C</u> <u>1</u>	<u>C</u> <u>2</u>	<u>C</u> <u>3</u>	<u>C</u> <u>4</u>	<u>T</u>
A	Nat Sc LA themes	Y	Y	N	N	Y	N	Y	Y	N	Y	6
B	Specific outcomes listed	Y	Y	N	Y	Y	Y	Y	Y	N	Y	8
	Critical outcomes listed	N	Y	N	Y	Y	Y	Y	Y	N	N	6
C	Assessment criteria	Y	Y	N	N	Y	Y	Y	Y	N	N	6
D	Range statements	Y	Y	N	N	Y	Y	Y	Y	N	N	6
E	Performance indicators	Y	Y	N	N	N	Y	Y	Y	N	N	5
F	Continuous assessment	N	Y	N	Y	Y	Y	Y	Y	N	N	6
G	Reference to portfolio assessment	N	Y	N	N	N	Y	N	Y	N	N	3
I	Phase Organizers	N	N	N	Y	N	Y	Y	Y	N	N	4
J	Problem Solving	N	Y	N	N	Y	N	Y	N	N	N	3
K	Constructivism	N	Y	N	Y	Y	N	N	Y	N	N	4
L	Issues of Diversity	N	Y	N	N	N	N	N	Y	N	N	2
M	Norms and Standards Roles	N	N	N	Y	N	N	N	N	N	N	1
	Norms and Standards Competencies	N	N	N	Y	Y	N	N	N	N	N	2
	Total number of positive responses per science teacher educator among 11 studied	5 of 13	10 of 13	0 of 1 *	7 of 13	7 of 13	7 of 13	8 of 13	10 of 13	0 of 1 *	2 of 13 *	

Note 1:

As indicated earlier, B2 had taken ill since I had requested the documents and did not reported for duty ever-since.

Note 2:

Y = Yes - have incorporated issues related to C2005

N = No - have not incorporated issues related to C2005

T = Total number of science teacher educators who responded to each category.

Themes from the Natural Sciences Learning Area and associated specific and critical Outcomes were either presented in the preamble to the curriculum document or integrated in aspects of the course outline. In terms of specific approaches to curriculum design, Table 4 shows that only four science teacher educators emphasized phase organizers. They expected their student science teachers to plan learning programmes for a given theme by integrating a phase organizer such as the environment across all the learning areas. Table 4 also shows that only four science

teacher educators made a direct attempt to consider constructivism as a learning theory in their course outlines. This is contradictory in terms of the general claim that they used constructivism in their teaching approach and included it in their science teacher education curriculum. A2 included the (constructivist) teaching and learning sequence of the CLIS Model to enable student science teachers to practice constructivism as a learning theory for the teaching and learning of science in school contexts. C1 presented her student science teachers with a task in which she expected them to plan a teaching sequence employing constructivism.

According to Table 4, two science teacher educators included issues of diversity in their course outlines though all eleven claimed in their interviews that they provided students with learning experiences concerning social diversity. Only three science teacher educators indicated roles related to the Norms and Standards for educators, and two stressed its competencies. One science teacher educator (A2) challenged his student science teachers with a problem solving exercise, and C1 made reference to problem solving in practical work related to food tests. In a PGCE course outline for Comparative and Science Education programme, B3 listed the following performance indicators expected of learners for problem solving in high school science:

- make predictions linked to science concepts;
- design investigations that can lead to a valid conclusion;
- record information in a systematic format;
- gather information to enable interpretation to be made;
- draw conclusions that are consistent with the evidence gathered during the investigation.

As indicated earlier, B4, C2 and A2 made reference to portfolio assessment in their course outlines. B4 and A2 emphasized criteria for development of a portfolio. C2 instructed her student science teachers to keep the various assessment tasks in a file which she referred to as a portfolio, but did not assess it as such. B1 was the only science teacher educator who provided me with a copy of a portfolio assessment of one of her INSET students. The others reported that their students had taken away their portfolios for future use.

B4 compiled a general PGCE module called “Assessment in Education”. The document indicated assessment criteria, range statements, performance indicators, continuous assessment, shifts in assessment systems, the use of journals and portfolio assessments as components of the assessment system for the new curriculum. Teacher educators from all disciplines at Institution B were requested to apply the assessment policy in their respective modules.

While none of the course outlines indicated aspects such as assessment criteria, range statements and performance indicators, in some cases they were part of examinations and assignments on lesson planning. For example, in a science education assignment, C1 set the task:

Question 2

2.1 You are expected to design a learning programme. In designing the programme you can decide on the following:

- a) Programme Organizer
- b) Phase Organizer
- c) Natural Science Theme/s
- d) The time period – duration, and the time during the year when the programme will be presented
- e) Specific outcomes
- f) Assessment criteria
- g) Performance indicators
- h) Teaching and learning activities (36 marks)

2.2 Why did you decide on this learning programme? (6 marks)

A part of an examination question set by B4 reads:

Question Four

4.2 How do critical outcomes differ from specific outcomes? (3 marks)

4.3 What is the difference between a phase organizer and a programme organizer?

The course outlines show three trends:

- a) The inclusion of C2005 policy as a vision and motivator, often without following up in detailed discussion or use;
- b) Instances of mismatch between espoused theory and theory in action of individual science teacher educators;
- c) Little direct attention to the Norms and Standards for Educators and Modularization.

These trends will be examined further in terms of actual teaching strategies used by science teacher educators in role-modeling the rationales of C2005 and those of the Norms and Standards for Educators.

5.5 Observations of the science teacher educators' class teaching

Table 5 in this section indicates my observations of the science teacher educators' teaching in their classes of student science teachers. It has to be read in conjunction with Table 2 because it reveals differences between their claimed and practised positions (espoused theory versus theory in use). In describing the teaching, I have called it 'teacher centred' when the approach was essentially transmission of knowledge from the science teacher educator to the students, and 'learner centred' when the students participated in the lesson, contributing ideas and knowledge with a degree of control of the content, pace and development of the lesson.

A2, C2, C3 and C4 presented lessons that reflected a balance between teacher-centredness and learner-centredness. A1 and B3 adopted a traditional stance in their teaching, although it was not totally lecture dominated. While A1 claimed to be a good role-model for learner-centredness, his practice proved contradictory. B3 claimed that he was not a good role-model for learner-centredness, and this was evident in his teaching. B2 presented a traditional lecture and this corresponded with his claim that he did not attempt to role-model learner-centredness.

A2, A3, B4 and C1 engaged their student science teachers using techniques in keeping with principles of constructivism. Like a few others, they also facilitated interactive

dialogue among the student science teachers. In terms of this, A2's performance was contradictory to his claims that he was a poor role model of learner-centredness.

Table 5 also shows that ten of the science teacher educators attempted learner-centred features most of the time, while seven displayed teacher-centred tendencies some of the time. This is an indication of movement from traditional lecturing. It is in keeping with the NQF and the policies of modularization in higher education, as well as being consistent with C2005. Most of the science teacher educators claimed that they had changed to learner-centred approaches prior to the introduction of C2005 and modularization, and that the new curriculum served to focus and accelerate the changes.

The interpretation of outcomes (of C2005 or for their own teaching) was restricted to five science teacher educators. All eleven science teacher educators made reference to or discussed concepts or knowledge related to themes from the Natural Sciences Learning Area. Only three science teacher educators (A2, B4, C2) made reference to or practised continuous assessment techniques during the lectures observed, and such continuous assessment usually meant a number of tasks to be completed and submitted. For others, there were sometimes references to continuous assessment in their course outlines. This observation seems inconsistent with claims by all of them that they practiced continuous assessment. Overall, congruence of claims, course outlines and teaching in relation to continuous assessment existed for A2, B4 and C2, and shows that in this regard their theory of action matches their espoused positions. However, I am wary that my inference is based on only one observation of teaching; course outlines of six science teacher educators showed their intentions to practice continuous assessment strategies with their student science teachers.

Table 5: A quantification of qualitative judgements based on observations of teaching

	CATEGORIES	A1	A2	A3	B1	B2	B3	B4	C1	C2	C3	C4	T
A	Teaching Approach												
	Teacher-centred	Y	Y	N	N	Y	Y	N	N	Y	Y	Y	7
	Leamer-centred	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	10
	Used a questioning technique	Y	N	N	Y	Y	Y	N	Y	Y	Y	Y	8
	Interactive dialogue	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	9
	Role-modelled C2005	N	Y	Y	N	N	N	Y	Y	Y	N	N	5
B	Learning Theories												
	Used constructivism	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	9
	Used cooperative learning	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	8
	Problem solving	N	Y	N	Y	N	N	N	Y	N	Y	Y	5
C	Assessment												
	Continuous assessment	N	Y	N	N	N	N	Y	N	Y	N	N	3
D	Practical Work												
	Practical work in laboratory	N	Y	Y	Y	N	N	N	Y	N	Y	Y	6
	Practical work outside lab	N	N	N	N	N	Y	N	N	N	N	N	1
	No practical work	Y	N	N	N	Y	N	Y	N	Y	N	N	4
E	Issues of Redress												
	Related science to society	N	Y	N	Y	N	N	Y	N	Y	N	N	4
	Covered issues of diversity	N	Y	Y	N	N	N	Y	N	Y	N	N	4
	Referred to cultural issues	N	Y	Y	N	N	N	Y	N	Y	N	N	4
	Interpretation of outcomes	N	Y	N	N	Y	N	Y	Y	Y	N	N	5
F	Norms and Standards												
	1. Competencies												
	Practical competence	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Foundational competence	N	Y	N	N	N	N	Y	N	Y	Y	N	4
	Reflexive competence	N	Y	N	N	N	N	Y	N	N	N	N	2
	2. Roles												
	learning mediator	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Interpreter and designer –	Y	N	N	Y	N	N	Y	N	Y	Y	N	5
	Leader, administrator, manager	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
	Scholar, researcher, lifelong Learner	N	Y	N	Y	Y	N	N	Y	N	Y	Y	6
	Community, citizenship, pastoral role.	N	N	N	N	N	N	N	N	N	N	N	0
Assessor	Y	Y	N	N	N	N	N	N	Y	N	N	3	
Learning Area subject discipline	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11	

The rationales of C2005, science to society, diversity and cultural issues were evident in only three (A2, B4, C2) of the eleven classes observed. In these three cases, links were not made to C2005, but were part of the topic discussed. This conflicts with claims by all eleven science teacher educators that they included issues of diversity in their teaching programmes, but again, it is possible that such issues were addressed in other lectures. An examination of course outlines revealed that two science teacher educators included issues of diversity. When my observations are linked to the C2005 outcomes that the science teacher educators generally emphasized (science processes and science skills), it seems likely that not many of the science teacher educators address the broader issues in their teaching generally.

The prescribed competencies and roles of the Norms and Standards for educators were given little direct attention (see Table 5 above), beyond those roles and competencies which have long been standard practices in science teacher education programmes. All eleven science teacher educators demonstrated and encouraged roles related to practical competence, learning mediator, leader, administrator and manager, and a learning area specialist. There was no evidence of science teacher educators using the lecture as an opportunity to develop in their students “community, citizenship and pastoral roles”. Table 5 shows that there were some attempts by five science teacher educators (A1, B1, B4, C2, and C3) to develop the role of teachers as “interpreters and designers” of curriculum. Six science teacher educators emphasized (incidentally) the roles of student science teachers as scholar, researcher and life long learner. The role of the student science teacher as an assessor was emphasized by only three science teacher educators. Two science teacher educators (A2 and B4) attempted to develop a “reflective competence” in their students.

5.6 Conclusion

Most of the science teacher educators have deliberately or incidentally included curriculum issues and principles related to C2005 in their course outlines and teaching, and all are able to discuss C2005 in some depth. However, issues of

diversity, culture, science and society, and aspects of the NSE received relatively little attention in course outlines and teaching.

Themes that arise in this chapter are taken up in the next chapters, where closer attention to individual science teacher educators and the contexts in which they work show more clearly the complexities of change and relationships between espoused theories and theories in use (theories in action).

CHAPTER SIX

LAYERS OF CHANGE

The purpose in this chapter is to demonstrate complexity in the change process and the importance of context – aspects of change that were veiled somewhat in the generalizations of Chapter 5.

The chapter is organized into the following themes:

- the context of the university as an institution influencing change for individual science teacher educators;
- the school context as an institutional force for changes in teacher education;
- individual aspects of change.

Excerpts from transcripts, descriptions of actual teaching, and details of relevant curriculum documents are included in the second and third themes which formed largely the basis of the quantification of these qualitative judgements presented in Chapter Five. The themes from Chapters 5 and 6 are elucidated further in Chapter 7, through telling the stories of three science teacher educators on a personal level.

I have used Fullan's (2000) description of complexity of change in interpreting the change process for individuals:

Complexity refers to the difficulty and extent of change required of the individuals responsible for implementation. Any change can be examined with regard to difficulty, skill required, and extent of alterations in beliefs, teaching strategies, and use of materials.

In South Africa over the last decade and more, complexity is the result of emerging changes at all levels of education, politics, the economy and indeed all aspects of society since the transition to a democracy as a post-Apartheid strategy. I have described these changes in Chapters One and Two and have commented on the turmoil they have created. Even restricting the discussion to education, the number and extent of changes have been extraordinary. At school-level, policies have ranged

from major ‘paradigm shifts’ in curriculum, governance and accountability through to highly specific and similarly profound changes such as the abolition of corporal punishment, and the educational rights of pregnant girls. So too in higher education, new curriculum policies have been accompanied by new policies of governance and management and new structural arrangements. Pre-service education was greatly reduced and many Teachers Colleges closed, so teacher educators often saw themselves and colleagues deployed or retrenched. In this turmoil, science teacher educators made individual and group responses to change, and these responses are my particular concern: though I describe institutional changes, my focus is on individual science educators, as they experienced change, and as they saw the changes around them.

6.1 Theme One: the university as an institution influencing change

Here I explore academic programmes offered at the three institutions of teacher education, and especially science teacher education, and the tensions related to the threat of accreditation of modules on SAQA. I also present the role of the NQF as a bureaucratic influence on modularization and the Norms and Standards for Educators. Institutional and individual science teacher educator responses to these influences and the role of autonomy therein are then interrogated.

6.1.1. The universities

My research sample comprised eleven science teacher educators who worked at Faculties/Schools of Education at the three universities in one of the nine provinces in South Africa. Brief descriptions of the institutions follow, drawn largely from the accounts of the science teacher educators.

Institution A

Institution A is a university which is peri-urban in its location. It was a historically Indian campus catering for the needs of students from the Indian community during the racially segregated period of the apartheid era. It was originally located on an

island in the harbour of the city and then known as a university college for Indians and administrated by the University of South Africa since 1961. It was staffed at that time mainly by White Afrikaner academics. Institution A gained its autonomy as a university in 1972 after its student population was transferred to its current location. It fought against its exclusive admission of Indian students, and, since 1982 has gradually changed its population, so that Black Africans now outnumber Indians. Its staff is mainly Indian but this also is changing.

A variety of programmes in education are offered from the undergraduate to the postgraduate doctoral level. Initial teacher education is offered in the form of a four year BEd degree and a University Post-Graduate Certificate in Education (UPGCE). A curriculum officer was appointed to supervise the modularization process and other educational policy changes such as the Norms and Standards for Educators.

This institution has been regarded nationally as being at the forefront of change with respect to innovative practices in teacher education. Its science education division enjoyed a similarly high reputation. Science teacher educators A1, A2, A3 and I are responsible for the offerings in science education, especially at the undergraduate level. A1 and A2 are Black African males, A3 is an Indian female and I am an Indian male. None of the staff had a doctorate at the time of the data collection, though A3 has since completed hers, and I am working on mine. As the researcher, I have excluded myself from the data.

Institution A went through a turbulent history of changes in management and structure, during and after the demise of Apartheid. Some of these resulted from policy changes and funding arrangements that affected all tertiary institutions; some were peculiar to Institution A. For example, in Institution A, a Black African woman was appointed Vice-Chancellor, with expectations that she would not only accelerate racial integration and redress, but would put the university on a stronger footing in financial and management terms. Its senior management, initially White and Indian, went through several changes in personnel and structure, with ramifications throughout the institutions. The status and influence of individuals, groups and racial groups changed rapidly, giving rise to staff and student tensions. There were frequent staff strikes over salaries (which were not on par with historically white universities)

and student protests over increased tuition fees and harsher processes of fee collection. Within the science education division, there was a charge of racism against a White academic by a Black colleague, which led to his dismissal by the Vice Chancellor (a decision later judged through legal processes to be unfair). Meanwhile, the Faculty of Education was down-graded to a School of Education and placed in the Faculty of Humanities. However, the survival of the “new” School was threatened by declining income from undergraduate students. The small staff resolved to develop a vibrant research sector, to which they attracted a large number of honours, masters and doctoral students. An existing Centre for Educational Research, Evaluation and Policy (CEREP) was expanded to involve more staff and students in commissioned research, and provide a focus for the research process. The School also developed a Post-Graduate Diploma in Education (PGDE) and a Centre for Teaching and Learning (CTL) aimed at developing pedagogical skills among university lecturers from other faculties.

Thus, for Institution A, changes in government and university policies, structures and financing arrangements and changes in personnel and administrative processes coincided with changes in curriculum policies at the school and university levels. Science teacher educators, inevitably, were caught up in the turbulence, even as they developed new programmes, pursued their own higher-degree studies and maintained existing programmes.

Institution A appointed a Curriculum Officer to coordinate and provide institutional support to staff in the curriculum changes. The science teacher educators at this institution and at Institution C were at an advantage in the sense that these institutions had commenced modularization prior to the NQF’s demands and were in readiness with ‘changes on paper’.

Institution B

Institution B is a university which is rural in its location. It is a historically Black African university catering for students from the local community. It started off as a University College in the early 1960’s, staffed initially by mainly White academics

from an Afrikaans-speaking background. It was controlled by the University of South Africa. It gained its autonomy as a University in the early 1970s. It has a faculty of education with most of its staff currently Black African (following employment practices that began in the early 1980's).

The Faculty of Education offers a variety of programmes from the undergraduate to the postgraduate doctoral level. Initial teacher education is offered in the form of a four year BEd degree and a University Post-Graduate Certificate in Education (UPGCE). Postgraduate programmes include honours, masters and doctoral studies. The Faculty has a science education division which comprises science teacher educators B1, B2, B3 and B4. All of them are Black African, with B1 being a female and the others being male. At the time of data collection, B1 had completed her doctorate.

The modularization process at Institution B coincided with the NQF's bureaucratic demand for modularization of courses. I use the term bureaucratic because the NQF expected forced compliance from the institutions in terms of applying the modularization process. Institution B established a Restructuring Committee to supervise the modularization process and other educational policy changes such as the Norms and Standards for Educators. Subsequently the Faculty of Education instituted a Curriculum Committee with the Dean as the leader to implement the changes within the Faculty. Three members from this Curriculum Committee sat on the Restructuring Committee. The Committee allowed variations between Faculties. For example, the Science and Arts Faculties opted for a splitting their courses into term-long modules, each based on an eight credit points. The Faculty of Education chose 16 credit point modules that were semester long. While Institution A and to an extent Institution C had commenced modularization prior to the NQF's request, the process of at short notice responding to a bureaucratic demand was expressed as a stressful experience for the science teacher educators there.

The curriculum changes in higher education at Institution B were thus led strongly from 'the top', with academic staff following instructions and timelines handed down from a hierarchical system of committees – from Vice-Chancellor to Deans to lecturers. Despite the demands and anxieties, resistance was mild. The idea of the new

flexibility and autonomy was attractive to staff. Some of them dedicated themselves to curriculum redevelopment, which saw an “overnight” proliferation of programmes, with attendant deadlines and more committees to assist with the administrative aspects driving the change. The science Education Division, for example, viewed the softening of boundaries between modules as being highly conducive to an integrated programme especially between mathematics and science. The staff also had a positive attitude towards changes related to higher education and to schools because they regarded the changes as being politically and socially relevant. They saw more opportunities in the curriculum changes for transformation and contextualization of courses in the form of modules compared to the previous traditional system. But most of the staff at Institution B sought survival in this changing context, not necessarily responding to the needs to change.

Institution C

Institution C is a former well-resourced and privileged White college of education which is peri-urban in its location. It historically catered for White students. Its student population has recently become diverse, with about half the students White. The same applies to the staff. As a college, Institution C was primarily concerned with initial teacher education, especially through a four year Higher Diploma of Education. It had considerable freedom with its programmes, but under the formal control of the provincial Department of Education. With the rationalization of colleges of education in the late 1990's, this former white college of education was merged with a historically white university (referred to as Institution C in this dissertation), so that education studies were available at three campuses. However, the college continued to operate much as before, on its own campus, with its commitments to initial teacher education. The relocation of an NGO for Science and Mathematics Education from another campus to the college campus served as a catalyst for development of research and outreach. Staff were under pressure within the university to complete higher degrees and involve themselves in research and post-graduate education, but when they proposed offering a BEd Honours degree from their campus, the university objected. It was a year and a half later that the university management agreed.

The merger coincided with the modularization process in higher education. The staff worked very hard to convert subjects to modules under the leadership of very competent persons. There was a very powerful work ethic around the development of the templates, though some viewed them as a bureaucratic exercise which resulted in very little change at a lecture room level.

Science education on the college campus is led by four teacher educators C1, C2, C3, and C4. They are all females. C1 is a Coloured, C2 is a White Afrikaner, and C3 and C4 are White and English speaking. At the time of data collection, none of the four had doctoral degrees, but C2 was working on hers.

While still a college, Institution C was responsible for developing the COTEP Norms and Standards for Educators which later were adapted by the NQF as the new NSE (see Chapter Two). The science education staff contributed to this document. The development could be attributed to the college being regarded as a centre of excellence for teaching, and to the leadership of the then Rector, who was later appointed as the National Director of Teacher Education.

6.1.2 Individuals and institutions.

For individuals and institutions, changes were happening in many ways and at many levels. In all three institutions, changes in structures, management and funding coincided with changing staff and student populations and changing curriculum policies. The higher education curriculum policies that affected teacher education were especially the NQF and modularization of courses, and the Norms and Standards for Educators, but these were happening amidst many changes.

In one sense, responsibilities for curriculum and decision-making were devolved from government to and within universities, but in another sense, central control was stronger than ever, through guidelines, accreditation processes, funding arrangements and accountability requirements. It was a situation in which ideological commitments, critiques, workloads, administrative processes and personalities could easily erupt in resistance and dysfunction – for individuals, departments, and/or the whole institution.

My main interest in this research is change as it was experienced and observed by individual science teacher educators. From this perspective, institutions and institutional change are contexts in which individual change takes place. This is not to deny the ways in which individuals participated in and shaped institutional change. A1 expressed his view of the relationship between individuals (interests, freedoms, career advancement, ownership of modules) and organizational development:

Personally I always say an individual has to take the initiative. There are things which you can do, there are other things you cannot do. I wouldn't say institutions are responsible for people's career development. You have to take the initiative and say, "Hey, I like to be developed in this field."

C4 saw herself differently:

Some students like to be innovative, they like to be more creative. Others just want to be told what to do and want to be told how to do it and they will do it. ..I think, most probably, I could easily fit into a comfort zone and do what I was told to.

Regardless of such differences, all of the science teacher educators in this study demonstrated commitments to institutional development, personal development and the development of their prospective students, and were active in all these domains.

6.1.3 Modularization

The curricula at South African Universities were restructured to conform with the NQF, as a requirement for continued accreditation. As explained in Chapter 2, the general goals were to reduce the separation of education and training, to increase attention to competences, and to enable portability and partial credits through modularization. Within this framework, responsibilities for curricula and assessment were devolved to institutions. As part of specifying content, class time, credit points and standards for the modules, science teacher educators had to:

- specify outcomes for the modules (consistent with the NQF);
- propose a continuous assessment strategy;

- integrate learner-centredness with teacher-centredness.

As part of the NQF goal of uniform standards across the nation, the existing Bachelor of Pedagogics became a Bachelor of Education, and the existing Bachelor of Education became a Bachelor of Education Honours degree. The Masters and Doctoral programmes similarly were revised to conform with NQF templates and submitted for accreditation.

The modularization processes were similar in the three institutions, largely as a result of guidelines and suggestions from SAQA. Each university (Institutions A, B and C) assigned the tasks of curriculum revision and modularization of courses to lecturers. However, institutions monitored the process differently. The School of Educational Studies of Institution A appointed a curriculum officer to supervise the process; the Faculty of Education at Institution B formed a committee that operated under an institution-wide Restructuring Committee; Institution C, as a former College of Education recently merged with a university, was supervised by the provincial Department of Education. Institution B and to a lesser extent C adopted team approaches to modules, whereas Institution A followed a more individual approach, with individual lecturers revamping the courses they taught.

In undergraduate courses, the institutions differed in the extent to which they integrated professional and academic aspects of education related to the teaching of science. For example, Institution A offered modules in the form of Science Education 1, 2 and 3, which were aligned in content and purpose with the four themes of the Natural Sciences Learning Area of C2005. The Science Education 1 module focused on energy and change. Environmental education, the life sciences and the earth and beyond became the emphasis in Science Education 2. The Science Education 3 included aspects related to matter and materials. The content was also linked to the teaching and learning of science in schools. Institution B designed its modules to be either pure science oriented (Physical Science, General Science, and Biology), or education oriented (Biology Teaching Methods, Physical Science Teaching Methods and Natural Science Teaching Methods). The same approach prevailed at Institution C at the undergraduate level. Student science teachers at Institution B were exposed to a special module on assessment and another on the Norms and Standards for educators,

which they took along with student teachers from other disciplines. At all three institutions, science teacher educators had responsibility to design their teaching programmes, on condition that these conformed to the accredited descriptions.

Science teacher educators at the three institutions were therefore subject to institutional pressures to conform to the SAQA regulations pertaining to modularization. B1 explains the purpose of the restructuring committee at Institution B that endorsed the institutional pressure for change:

Well, yes, there was pressure. We even had a committee which was called a Restructuring Committee, that was driving the whole process of restructuring. So those were the people who were actually studying the document and unpacking whatever was there in the document. B3 was in the committee and there were others. There was a group of people who were driving the process.

A2 was also critical of the implementation of the modularization process at his institution. He viewed it as being a:

...re-packaging of content. To me it's very much like taking the content and piecing it into small segments with less regard for outcomes. I am talking about University-wide modules. It's re-packaging and making the curriculum into small manageable units. There is very little influence of C2005 at that level.

A2's view is pertinent since the process of "repackaging of content" contradicts the purposes of the reform in terms of shifts to learner-centredness and outcomes. It also has implications for student science teachers, for whom modeling of curriculum approaches might be expected to help them with such approaches in schools. There are different ways of viewing this, which are explored more fully later. On the one hand, lecturers may choose to merely 'repackage', as a way of continuing to do what they have done in the past. On the other hand, changing the packaging and documentation might be a first step in a longer process of personal and curriculum development. Further, although documents can be changed more easily than

behaviours, individuals are accountable for the documents they write and work towards expressing them in their lecture rooms. Thus B4 argued:

I think we are on the right track. Drastic changes have taken place. The change of the old programme that we are offering to the new program and the manner in which the new programmes are now offered, although there are those who just started with the new programmes which were modularised and integrated. We started this year and I think we are in the right direction. Although there has to be some sort of mechanism laid that will monitor whether we are moving actually in the right direction in producing the quality type of teachers that we need. Fine, on paper things have changed, then there is no mechanism of monitoring what actually happens in the lecture hall, and .. very likely, what's in the lecture hall is still the very old thing.

6.1.4 The Norms and Standards for Educators (NSE)

Science teacher educators responded to the NSE in different ways. There were also institutional differences in the process of interpretation and implementation of the directives inherent in the document. Some saw it as the responsibility of other modules and disciplines than science (for example, Institution B created a special module addressing it; C3 indicated that student teachers at Institution C were expected to be exposed to the document in an Education module.). Some chose to have different aspects of it addressed in different modules. For example, Institution A has a module on Action Research. Institutions B and C expect Education lecturers to take major responsibility for introducing it to students. As C3 noted:

... C1 has always done it (the NSE). So I don't need to do this. My students go to her sometime during the course anyway. So we try to not duplicate things.

In any case, the three institutions were committed to making staff familiar with the NSE. The curriculum officer at Institution A made copies of the document available in the Resource Centre and held several staff meetings to discuss it. He also ran workshops to help staff incorporate the NSE in their modular offerings. At Institution

B, the Restructuring Committee organized workshops to unpack the outcomes, roles and competencies, and encouraged staff to integrate them into module designs. Institution C similarly organized workshops related to the document. Institution C made clear the threat of SAQA accreditation being refused if the institution did not comply with the Norms and Standards for Educators.

At the level of individual lecturers, A1 saw the NSE as too ambitious and rejected it. On the other hand, B1 felt that it wasn't especially 'new':

Well, I wouldn't say they are new. I would say now it is spelled out in a more elaborate way. But I wouldn't say really they are new. I think we have been doing that all the time. It's just that they are now written down, spelt out. It is about communication, teaching students about reflection.

B3, like C1, C2 and C3, felt the NSE was new, but not a threat, because he was familiar with it:

.. I know it can be a threat to many people, but for me I was part of the team that even came up with the programmes that we are offering now, which have been approved by the Department. And I also did a module at the University of Natal, Durban based on an analysis of the Norms and Standards for Educators.

B2 staggered the release of the document to his student science teachers because he needed time to understand the roles and competencies himself prior to developing these among them. He referred to the process as being a "learning curve." B1 expressed the need for engagement among staff to conceptualize the prescriptions of the NSE:

The purpose of the unpacking exercise was to negotiate meaning among the lecturers who teach the different modules.

In part, the idea that the NSE is not new arises because the NSE is implicit in C2005 and other policies concerning school governance and management. For example,

Malcolm (C. Malcolm, personal communication, June 12, 2004) observed that, in lists of policies related to devolution of curriculum and management to schools, the NSE was seldom included.

In my observation of classes, I looked for roles that were being modelled and/or talked about. For example, in Institution A, A1, A2, and A3 clearly addressed practical competence, and the roles of an educator as mediator of learning, subject specialist, and (to a lesser extent) designer of learning programmes and materials. There was also evidence of these roles in their curriculum documents. However, these observed roles are likely common to any science teacher education programme (albeit with variations according to the meanings of mediator, specialist and curriculum). The remaining roles and competencies may be new in the South African context of teacher education. As well, they are not confined to classroom practice (eg Manager, Citizen and Pastoral Carer), and they may be subtle in their expression.

Following the idea that the NSE is implicit in C2005, I looked for evidence of C2005 in classrooms and curriculum documents. As with the NSE, the data are hard to interpret, because reference to C2005 may be explicit or implicit, and may take many forms. For example, C2005 was more likely to be referred to directly in Education subjects than in science subjects. A1's course pack provided evidence that he used the Natural Sciences Learning Area and its outcomes in developing his course. A2 in his course pack and examination paper, as explained earlier, had the main ingredients of C2005. A3's course pack on the Nature of Science did not refer to C2005 or the NSE, though a major justification of the module was the C2005 requirement for learning about the nature of science. B4's curriculum documents were clearly linked to C2005, but made no direct reference to the NSE, except in a module called Assessment in Education.

Thus, whether or not lecturers considered the NSE 'new', they gave little attention to it other than the traditional roles of educator as mediator of learning, subject specialist, designer of lesson plans, and assessor of learning. And while Institutions A, B and C all ensured the NSE was known and discussed, they did not exert the same pressures for implementation as they had for the modularization process.

6.1.5 Autonomy

South African universities experienced more academic freedom than colleges of education during the Apartheid era. The latter, especially the historically Black colleges of education, were highly controlled by Pretoria, offering an education that was widely regarded as being in-between secondary and tertiary (Salmon and Woods, 1991). By contrast, universities were viewed as producers of knowledge and hence requiring the autonomy to develop their own curriculum for. This conforms with de Feiter's (2002: 111–64) view that *universities are well-placed to tap the international knowledge base and be informed about new developments, both in content as well as in education and pedagogy*. Standards were maintained through external examination of examination scripts, projects and dissertations by other universities locally, nationally or internationally.

Over the last decade in South Africa, as in many countries, institutional autonomy has decreased, with higher education institutions more strongly integrated into national plans and frameworks, including funding and accountability frameworks. Accordingly, university managements in South Africa were instructed by central government to set into motion rolling plans to meet defined national and institutional outcomes and be economically viable. Departments that did not sustain through-put of students, or produce published research papers were at risk of closure. In teacher education, as noted earlier, the controlling curriculum policies were especially the NQF, the NSE and, via schools, C2005. The mix of central government control, devolution and accountability resulted in pressures on and in institutions that were felt at all levels, right down to individuals.

Science teacher educators differed in their views of autonomy they felt they had and wished to have. They all felt they had 'autonomy' but they were using the term differently. A3 stated that:

Yes, I think we always had a fair amount of autonomy with planning and preparation of materials.

B2 and his colleagues were given the flexibility to experiment with the curriculum even before the introduction of C2005, but on condition that the curriculum offered complied with the University Senates approval:

We could include anything as long as we defined a course and the content and it was approved by the Senate. It was allowed, but it came from us.

He noted that institutional autonomy existed only to a certain extent, because C2005 and the NQF involved prescriptions and institutional pressures to ensure conformity. Even so, as B4 explained, there was flexibility within the SAQA templates:

No, it is much more flexible. That is why I am even able to put in C2005 this way, even though it is not there in the syllabus.

Science teacher educators from Institutions A and C similarly claimed that in as much as there were imposed pressures and regulations, the science teacher educators had the autonomy to implement the changes on the basis of their expertise and with the support of workshops.

Autonomy is a word that, like devolution, decentralization, participation, right and responsibility, has many meanings, but is generally presumed to be a 'good thing'. While none of the teacher educators embarked on analysis of the concept, C2 and C4 hinted at alternatives. C2 observed that, just as some students like freedom and others don't, some staff prefer to be told what to do:

Some students like to be innovative, they like to be more creative. Others just want to be told what to do and want to be told how to do it and they will do it. They don't want to be given the freedom to actually make choices because they are uncomfortable with it....I think most probably, I could easily fit into a comfort zone and do what I was told to. But I need to work on it and most probably as I grew older I just shifted more into it. I think it is my nature and inclination to be quite happy to do as I was told to do.

C4 pointed to teamwork, trust and responsibility:

I think it is more of a sense of the department we have been in here. It has always been a very supportive department and whoever has been in charge always worked in a democratic fashion; trusted people and that we were professional and that we could get on and do what had to be done. So in that sense there has been no pressure to change in the way we were practising and actually teaching. In terms of curriculum, obviously there was institutional pressure because we had to do as we were told to produce the course outlines. We were always put a little bit under pressure.

The appropriate mixes of autonomy and responsibility, individual and group, pressure and support, trust and monitoring are far from simple. Under pressure from SAQA and the institutions the science teacher educators conformed to the SAQA templates for the construction of modules. But their espoused theories (in their written documents and/or during interviews) did not necessarily translate into practice (theory in use). For example, some science teacher educators claimed learner-centredness in their teaching approaches, yet demonstrated a traditional stance in their lecture rooms. So too, all of the science teacher educators claimed knowledge of the NSE, and either that they had ‘done it all along’ or were working on it, but a systematic approach to the NSE – within a module or across modules – was not common. Autonomy is not a simple idea.

6.1.6 Leverage and Resistance to Change

The institutional pressures on staff to ensure the implementation of policy can be viewed as a direct response to leverage by the State. The threats of non-accreditation and reduced funding could not be ignored by any institution since its actual survival might be at stake. However, whether such leverage is resisted, and how, depends on a number of factors, including perceptions of the desirability of the changes, the possibility of resistance being successful, the extent and success of negotiations, and so on.

Following Foucault (1973), I draw on conceptions of power, and the roles of professionalism and ideology as levers in the process of institutional and individual change. In particular:

- Following the liberation of 1994, wholesale transformation of South African life and institutions was expected: this was what the struggle had been about. Further, processes of participation – for the government ‘in waiting’ before 1994 and for the new government after 1994 – were deeper and wider than they had ever been. Thus there was general goodwill towards government and the changes it was suggesting, and general acceptance that changes had to be made quickly.
- Ideologically, while there were deep debates about neo-conservative economic strategies versus social-democratic ones, and whether economic development should precede or follow social development, the needs to restructure higher education so as to improve access, output and equity were not in question.
- Professionally, two streams of thought were relevant, both derived from the international literature and academic communities. One was the wide acceptance of learner-centred, outcomes-based, competency-based approaches to education, whether oriented to technical knowledge and skills or critical inquiry. The other was the more deeply contested but nevertheless wide acceptance of ‘new public management’, with its mix of central control, devolution and accountability, and its orientations to ‘participation’, ‘results’ and ‘measurable outcomes’ (Christie, 1998; Chisholm, 2000).

The accounts below from individual science teacher educators illustrate the ways in which these various levers operated, often reinforcing one another. Since leverage often generates resistance, I will consider also the extent to which the science teacher educators resisted the system (i.e., government and university management). I include the individual responses of science teacher educators in this section on ‘institutional factors’ because, in many ways, the leading ideologies and professionalism were ‘institutionalised’ insofar as they were widely held, even embedded, within the higher education community, and strongly influenced individuals. I deliberately exclude A1, B1 and C1’s beliefs here, because their stories are presented in Chapter Seven.

A2 acknowledged that he was under institutional pressure to change, but also that workshops had enabled him to see how the changes complied with policy and social transformation. He changed at a personal level to be in synch with institutional change. He submitted to administrative demands because his personal belief system complied with the envisaged changes:

Yes, I would have changed because somehow in my own belief system I realized that I am also a victim of the traditional way of teaching. And if you look at democratic change in South Africa you have actually transitioned the way we interact with our students, for example. So there was going to be some form of change.

Similarly, B3 believed the new curriculum policy was relevant to the South African context and was accepted by the institution overall, and he accepted it, even though its meaning and ramifications were not clear:

Ok, we have these new programmes in place. I am not sure and I don't think we or any one of us, has actually been able to implement them as they are supposed to be implemented. So we have been trying to get to understand what is actually expected of us because the change as you may be aware it didn't affect only the Faculty. The change that came into effect is the change that was university change relevant to our country. So you will find there are policies that are from the University. Our policies are in line with those which are university-wide. So we are trying to see how we fit into those draft policies of the University.

C2 had previously worked in a college where about half of the staff favoured curriculum approaches like C2005, while the rest resisted fervently:

There were literally two factions. Can I give you an example: for instance .. before Linda Chisholm actually started out with the review, comments were asked for - I think it came from the department- when Colleges were asked to comment on C2005 and they were asked to comment on Kader Asmal's (the Minister of Education) speech. And people wrote the most horrific things.

They started by saying it was a communist plot. My comment was that you are writing something which reflects badly on the institution. We are fighting to stay open as an educational institution. With this kind of attitude, who is going to allow it to stay open because we are saying that we don't support change at all, we don't support government policy. And it was sent off like that in the end. It was a request from the Director of Education in terms of comments from colleges on education for Kader Asmal's in terms of the review process. And then you feel very upset about that because people are speaking against policy and you as a person don't agree with that.

Where the science teacher educators did express resistance was in the form of personal doubts emanating from the extra workload. B3 maintained that:

It's not because deadlines are intimidating, but if you had to work extra hard, and if you are to work extra hours, I don't think you feel intimidated but you feel that, Ok, you have to do something that is extra. In fact the role of the lecturer normally is just to teach. So if you are expected now to come up with designing modules and programmes, you feel, that Ok, its still part of what you are supposed to do, but I have been working in a system when everything has been in place and now all of a sudden you are expected to dismantle the old system and come up with something new, you feel that you are doing something extra that you were not doing over all these years. So the complaint was probably about that from the staff. It wasn't about what they were supposed to do whilst these programmes were up and running.

So, while leverage related to the systemic reform process operated in different ways, resistance to change was minimal and did not bear significance to the change process.

6.2 Theme Two: Schools as Pressures for Institutional and Individual change

The central purpose of teacher education in Institutions A, B and C is to prepare teachers for South African schools, and hence teacher education programmes are

strongly influenced by school level policies and practices. As indicated in the previous chapter and elaborated in this one, C2005 and the NSE have influenced science teacher educators and their programmes. In this section I will explore the extent to which schools directly or indirectly constituted a pressure for teacher education institutions to change. I begin by exploring how science teacher educators have aligned the teacher education curriculum with the school curriculum, including the extent to which the science teacher educators have engaged with C2005 and the Natural Sciences Learning Area. The extent to which science teacher educators have affirmed science education and science teacher education through C2005 is also scrutinized. In the process, I report on the extent to which science teacher educators have changed individually as a result of the demands imposed up on them through school level curriculum changes.

6.2.1 Pressures from the school as an institution to change

Pressures on science teacher educators to align their programmes with the curriculum policies and structures at school level arise not only from policy documents, but from student teachers and their mentors in the schools. A2 expresses such a need very appropriately:

Even now you would realize that for some of the reforms currently going on in school, you rely on our own students and certain teachers out at schools. .. There has been that kind of leverage between practicing teachers and us. And for certain specifics we are relying, as you know, on the ground. It's like you are on your own in your class unless your students who have been practicing OBE and have actually taught OBE in schools come back and challenge you on certain things.

The reality of school as experienced by student science teachers poses a challenge to science teacher educators to “get their act together” and address issues related to the policy changes. Thus schools, teachers and teacher education students apply leverage to science teacher educators, and science teacher educators respond by aligning their curriculum to that of the school, in content and process. A2 explains how he moved to more learner-centred approaches:

Pretty much the transition has been informed even by the changes in the teaching forces. If you go back, you will find that previously in the traditional curriculum the emphasis was on objectives. Now the emphasis is on outcomes and the outcomes are couched in people terms. So you tend to define everything that you want to do in terms of that which you want the pupils to achieve. So the focus entirely now is on the pupils. So the change has been to giving more opportunities to learners to express and bring into the class what they bring into the teaching and learning situation. So there is less of the teachers' monopoly of the classroom discourse.

A2 recognized that many different pressures were pushing him in the same direction:

I didn't struggle with change per se, it was a welcome change. It was a change which came at the right time. It was a change that came with many other changes. One had to struggle with, for example, coming to grips with specifics that are embodied in the new curriculum. But it was something that did not conflict with what one saw as being ideal.

However, a paradoxical situation arises when student science teachers develop approaches promoted in C2005 during their university courses but find that the teachers they are working with in the schools have not changed and are not prepared to change. A3's observations of such negative pressures in this regard are significant:

... the students felt when they returned from schools that practicing teachers were not prepared to learn from them. They (the mentors) felt learning was a one way process, where the science student teachers would learn from the mentors at school and they (the mentors) were not prepared to engage the other way and learn the new ideas that they (the student science teachers) had about C2005. And, they (the mentors) just used lack of training as an excuse to fall back on traditional methods.

Whether or not schools and mentors have changed to address the new curriculum, they exert leverage on the teacher education institutions.

6.2.2 Changing the mindsets of science student teachers

At this time in South Africa's history, where teachers are less likely than student teachers to have had extended education in the new policies, it is all the more important that student teachers have a robust knowledge of the policies and the skills to implement them. Accepting C2005 as a paradigm shift, it is necessary for student teachers to change their mindset about teaching and the roles of the teacher. B3, for example, believed that there was a need to socialize student science teachers into C2005:

One has to (and I suppose we are doing that quite a lot) emphasize dealing with the mindset because changing from one paradigm to another is very difficult. In the first place as a lecturer myself I have to change, because I was socialised in another paradigm. But now all of a sudden I am expected to socialize student science teachers in a new paradigm. Of course if I have changed it's easy for me to therefore change their mindset, and I suppose the students should agree to do things differently.

B3's recognition that he needs to change his mindset resonates with the claim by Hooijberg, Hunt and Dodge (1997) that change has to occur for practitioners /leaders (who change and empower themselves) and the targets /followers (who learn from the practitioners) for change to be effective.

B4 had reflected deeply on his own position, as part of his engagement with C2005:

Like I say, one began to think much more deeply, about the very act of teaching and learning, and basically if you look at it, our old education system, it was like teaching was not linked to learning, and because someone has to learn, we know it does not happen that way, and I think if I look at C2005 it is basically challenging that old thinking.

He saw it as an advantage that he had known the 'old paradigm' just as the student teachers had, at least because he had become aware of it as a 'mindset' that was hard to change:

Of course, when it comes to the number of theories of teaching and learning, my approach has been that each one of us has our own beliefs about teaching and learning which underpin our very practice in the classroom. That points out to the fact that we have different beliefs about teaching and learning. That's one thing. Then basically we know the kind of students we get from the old system, and obviously when we are talking about teaching, the teaching of science, they have got some sort of an idea based on the teachers who taught them. And I think the first challenge is to let them know exactly what they believe in, because one thing I know about them is, you have not received any training, but if I take you to the science classroom, you can teach. And you can teach because you believe in something and your beliefs were largely influenced by the manner in which you were taught in schools. And now the big challenge we have is to change.

Such change in the thinking does not occur easily according to B3, but takes years:

Well it is difficult for students to just change overnight because we are merely what we see our teachers in schools doing. In short what I am saying is, fine, we are trying to help our students change from their particular beliefs and we are making sure we are changing ourselves, but it will take quite a lot of time for them to really change. But even with me, it may be that change may have come very late in my life. Probably I didn't change while I was a student. I experienced the change maybe when I was here, when I started teaching (lecturing).

In South Africa, as elsewhere, it is common that teachers imitate their own science teachers and professors, and consider that such science teaching is acceptable and normal. In that case, as Fedock et al (1996:7) argue, professors of science and science education are important as models, and effective reform at school level requires reform at all levels.

C2 claimed that that despite lacking training for such a change, she was able to read about the issue and felt that her attempt was reasonably successful. She experienced some resistance from students, especially those who had come through the white system and thought that such a system was very successful, that it worked and that there was no need to change it. Students coming from the so-called Bantu education system were eager for the change, but they were also stuck in the mode of, “*tell us what to do and we will do it, don’t expect us to make changes which we find to be very difficult.*” On the other hand, some of her students were very enthusiastic about the change and liked to be innovative and more creative. Motivation is important:

It wasn’t easy, but it was easier because you wanted to change. I think it must be very difficult for someone who doesn’t feel comfortable with the change and is forced to change. In my case I thought I believed in the changes but it was by no means easy. It was not easy. And I still don’t think I have handled it completely. There has still to be more changes, it’s not complete and some things are easier to change than others, but it was not easy. Its comfortable to be in your groove (comfort zone), but to get out is not easy. It would have been harder if I did not believe in it.

C2 pointed out that some changes related to C2005 were harder to achieve than others:

You see most students found the outcomes that relate to Science as Science (knowledge) easier to cope with because they have come from that background. They have got a background in that. They find the specific outcomes that related to Science and society – we looked at specific outcome number 6; culture and society - they found that more difficult. It was something new to them. When you come from a background that Science was a very objective discipline – how could you deal with some things that are static and that was their perception at that time. They found that more difficult than the ones which dealt with knowledge and principles and concepts.

Changing mindsets through relevant knowledge may not result in student science teachers' changing their behaviours. This is consistent with research findings related to situated cognition. Be that as it may, the paradigm shift needed by science teacher educators and their student science teachers have presented challenges to both groups.

6.3 Theme 3: Individual change for the science teacher educators

In this section I will demonstrate how individual change among science teacher educators grew out of the complexity of institutional, school and personal factors. The institutional changes relate to the NQF and its expectations via SAQA, the teacher education establishment and the school. These and the personal or individual pressures of science teacher educators will be inter-related as determinants of change among the latter in terms of their documents, their implemented programmes and their actual teaching as “lecturers” in science education. At the same time, these pressures in themselves do not effect change: they motivate teacher educators to read, attend workshops, experiment and work together so that change occurs. Hence, the section begins with accounts of the activities in which the various individuals and groups engaged, to effect their own learning.

The data show the interactions between intuitive knowledge (developed through experience and participation) and theoretical knowledge (whether from the research literature, policy documents, professional conversations or personal syntheses). They also show the interactions between individuals and groups, experimentation and reflection.

6.3.1 The science teacher educators' own learning

Most of the science teacher educators said they developed confidence about the changes over time, due to reading, interacting with postgraduate students and other practicing teachers and talking about change, collaborating with colleagues, and attending or conducting workshops. All the science teacher educators indicated that they were almost compelled to find ways of understanding C2005 and its OBE

methodology due to their institution providing them with the autonomy as experts, and the responsibility to change. As indicated earlier, academics did not receive formal training for C2005 in the ways that school teachers did. They depended on reading, each other, workshops they organized for themselves, or workshops the Department of Education conducted for teachers.

Talking to colleagues seemed to be an essential process that complemented their reading. A3 explained:

I think talking to other people is a more useful way of understanding things. But I found that reading about it also gave you some background on what to talk about.

B2 made a similar point:

Well one may read and if you don't understand what you are reading it becomes a problem. But when talking you are able to ask questions and even if you have questions while reading the document won't be able to answer all the questions. I think talking would be the one which would be more beneficial.

B3, on the other hand, was more inclined to reading, perhaps in response to conversations:

Yes. I think that is where you can get most of your information because the information that you get when you are just talking to a colleague; it may not be just sufficient.

C3, in contrast, preferred to talk to people at conferences and workshops:

Yes, I do read. But I hate studying. I've never done a B.Ed for that very reason because it is all theory and I like talking to people.

Collaboration with colleagues in the curriculum redevelopment process was a vital source of learning and support. B4 felt that he was able to manage the 'paradigm shift' mostly by talking to his colleagues. A3 similarly felt that her collaboration with her colleagues was essential to the change process, especially because she was relatively inexperienced:

What helped me to cope with that kind of change was working with my colleagues as a group and planning together and working through problems and ideas together as a group of Science Educators. And I don't think on my own I could have handled that easily. I think that kind of support was very important, especially for me because I am a very junior member and I don't have very much experience in teaching in teacher education.

C2's main source of learning was through collaboration with colleagues. Like A3, she valued the varied expertise and perceptions from different people:

.. I think reading alone would not have helped. You need to read and then engage with people in discussions because there are definitely different perceptions in different people. I found that we often disagreed on what exactly something means. One big bone of contention for everyone was the phase organizer. There are different interpretations as to what a phase organizer should do and also other things in terms of the level of integration between different Learning Areas, there are also differences of opinion.

Attendance at workshops was an integral component of the change process. The workshops were generally run by the Department of Education. They were expert-led input sessions and focused on the Natural Sciences Learning Area of C2005. Some science teacher educators were members of Learning Area Committees established by the Department of Education as part of the development of C2005. Science teacher educators participated in workshops and meetings developed by the Natural Science Learning Area Committee to discuss and clarify aspects and related to the changes. Attendance at workshops was voluntary, but the institutions took steps to inform science teacher educators about workshops and did not hesitate to provide them with time-off to attend.

Workshops held in the Faculty of Education or the Science Education Division addressed some issues related to the change process. B1 stated that one of the functions of the Restructuring Committee established at Institution B was to unpack outcomes related to the NSE and C2005. A2 claimed that meetings in his institution were focused on learning related to the following:

I would say the whole fundamental challenge to traditional fundamentals about teaching, about the teaching and learning environment. The whole mind shift, ideal landscape changes about the way we have done teaching in the class in the past to the expectations of the present new curriculum.

He also stated that:

.....one learnt a lot from, for example, our Tuesday's Science Education Staff meetings, where we shared things like curriculum design, setting outcomes for particular modules. That was the kind of support that we got from previous colleagues who have recently left the institution.

A2 felt that staff meetings tended to address issues from a philosophical level and not at the ground level related to the school context. Yet student science teachers had to be prepared for that school reality:

I think we did not have for example, workshops on OBE or C2005 as a Faculty. Most of the workshops were on designing programs. .. Even now you would realize that, that for some of the reforms currently going on in school, you rely on our own students like certain teachers out at schools. .. And for certain specifics we are relying as you know on the ground. So I would say, actually there hasn't been workshops for academics which entail the kind of training and preparation that is actually given out to teachers out there at schools. And hence this growth, actually emanates, it shows itself up against academics on the theoretical side.

A3 supports the above view:

There was no training of teacher educators. There was no kind of formal preparation and it was pretty much up to the individual to read and to learn on your own, or attend workshops arranged by the Department of Education.

She also claimed that two senior science teacher educators “hogged” these workshops for their own personal gain and credibility and failed to inform others in the Science Education Division about their availability. This has further implications for complexity.

The development of cooperative learning techniques, assessment procedures, and the unpacking of outcomes related to C2005 were the most significant aspects which workshop attendance at the Department of Education secured for C2. She claimed that she had also gained in other ways from the workshops:

Yes, definitely workshops have contributed positively to my learning. That's where I picked up ideas, even if the workshop itself was not all that helpful, interaction with people was useful. That's where I became involved for the first time, got documentation that's what set me on that route. So it was definitely very, very helpful!

Workshops were crucial especially when C2005 was first launched in 1997. C2 attended some of these:

Well initially they were mostly all introductions to OBE and initial training sessions based on the philosophy behind OBE. I did go to the workshops on assessment on OBE. I went to workshops that concentrated specifically on the Natural Sciences; unpacking the Specific Outcomes and exactly what they mean, OBE in Science and so on.

C2 claimed that the workshops helped her to change her practice, while C4 used them to clarify the jargon associated with C2005.

Running workshops for school teachers was also a process that provided opportunities for some science teacher educators to practice their learning. B3 and A1 were among the few science teacher educators who claimed that they conducted workshops on OBE for teachers based at schools. B3 used the expertise of his Masters degree on constructivism to develop a constructivist approach among teachers. He explains the purpose of his workshops:

Well, because we conducted workshops as a team, some may be about assessment, some may be introducing teachers into new teaching and learning methods. In other words introducing teachers into constructivism because constructivism is a theory and it will remain a theory if we don't practicalise it. So how do you go about teaching from a constructivist perspective and such things.

The irony of the situation was that very few workshop leaders were available who had direct experience of OBE or C2005, yet they were leading workshops and prepare school teachers for it. Double-loop learning was required, as workshop leaders 'rose to the occasion'. Conducting workshops were a learning experience for science teacher educators. This could be viewed as a form of leverage from the schools and a sense of responsibility from their institutions.

6.3.2 Indicators of change: C2005 in curriculum documents, lesson planning and teaching

In effecting change, all the science teacher educators claimed that they had incorporated C2005 into their science teacher education curriculum and were generally informed by intuition and theory in the process. This is borne out by my analyses of curriculum materials, which generally incorporate ideas, terminology, outcomes, assessment and other aspects related to C2005.

B4 developed a module on assessment for the Post-Graduate Certificate in Education as prescribed by C2005. His course outline listed the specific outcomes of the Natural Sciences Learning Area which he linked to assessment for OBE. It also covered performance indicators, range statements, and assessment criteria. Other aspects of

assessment were also covered - such as portfolio assessment for OBE, the use of journals and gender issues in assessment. The module represented what may be considered as a good transition to OBE in terms of policy expectations.

During an interview, B4 stated that he used a text that presented two different approaches to assessment, one being traditional and summative while the other was based on a continuous assessment strategy. He gave his student science teachers the task of comparing and critiquing the two strategies:

..So my approach has always been, first, before I can do anything new, continuous assessment and the stuff, I have to come up with the activities that will impact on the mind set in terms of say, let us look at the assessment the way it was studied and let us try and see if that had any advantages or disadvantages. It was very interesting: I have two articles, one written by McDowells who is basically against tests and exams as modes of assessment and that which was written by Eagle, who was for tests and exams. So basically, how I approached the whole thing was to divide them into groups were one group would set the debate, one group would read this article and of course encouraging them to use their own experience because they are a product of test and exams, but then again they can use the articles to inform them in terms of their arguments and stuff like that. But the point I was driving them was to reach the point where they learn: We don't think tests and exams serve their purpose on their own. We certainly need other methods of assessments.

A similar tendency prevailed when B4 attempted to model his teaching to conform to the expectations of C2005 and its OBE methodology. His expectation was that his student science teachers would be able to scrutinize his approach and evaluate and critique it in terms of it representing an OBE methodology. Such an approach was also intended to encourage reflection on teaching approaches the student teachers encountered during their own schooling and during practice teaching.

I think I might say that the approach is not the same in terms of the new programs that we have compared to the old programs. With the new

programs, for which we have got only the BEd (UG) for now, one hadn't really taught them OBE as such, but on my part, what I said to them was that when I am teaching and am facilitating your learning, you only look at the content that I am teaching, but you should also look at the approach. That is what I am trying to emphasize to them, so that when the time arrives that we begin to talk about methodology issues, and talk about C2005 and OBE, then it would be easier for them to say, "A-ha!" This must have been the thing that influenced MrB4 to do things this particular way in the classroom."

I observed B4 teaching a lesson based on analysis of specific outcomes of the Natural Sciences Learning Area. The students analyzed the outcomes of the Natural Science Learning Area in groups. They presented their analyses through group leader presentations.

A2 used a different approach. He felt that he was not a good role model for OBE or for any form of teaching due to his propensity for lecturing. In the session I observed, he used the outcomes of C2005 to draw out teaching methodologies, then asked his students to prepare lessons in groups and present them, with the rest of the class offering comments on the teaching methodologies.

My lecturing is in many ways done in the traditional sense. I give my students the message to do what I don't practise. The emphasis or the message I put across to the students is that they at all times put the learners at the front, although the lecturing, probably by its very nature, is very much located in the traditional curriculum, whereby the lecturer is at the centre.

I am currently involved in the General Science Methods course, and what I have tried to do is kind of give opportunities to students to model what I expect them to do in the classroom by giving them opportunities to facilitate lessons for other students and the rest of the students will be evaluating them in terms of, you know, the new curriculum bases for C2005.

Such an approach addresses directly the challenges that pre-service teacher educators face. As Harris et al (2003: 101) observe, one of the challenges that pre-service

teacher educators face is to enable students to look critically at various models of teaching practice that they have been exposed to. They also argue that students need to compare the ways they were taught with the principles embodied in outcomes-based education. Students need to develop idiosyncratic teaching styles that resonate with who they are as individuals and then to choose teaching methodologies that they perceive to be in the best interest of the learners.

I observed A2 teaching on a second occasion, where he reviewed a test-question the students had completed: “What is the rationale for multicultural approaches in the Natural Sciences Learning Area of C2005?” He invited his student science teachers to interpret the question again, in the light of poor answers in their test scripts. He struggled to get more than 25% of them to contribute, and proceeded to invite participation from “silent” students. He wanted them to acknowledge that all learners were not the same in terms of race, language, culture, learning styles and language abilities, and suggest ways to provide all learners with equal opportunities to learn. His General Science Special Methods examination paper for November 2001 covered the topics consistent with C2005:

- Constructivism
- Outcomes linked to improving South African society
- Cooperative learning techniques
- Outcomes-based approaches to assessment
- Indigenous knowledge systems versus Western Science
- Process skills in science
- Issues of diversity
- Traditional assessment strategies compared with those of an outcomes-based system

A2 viewed cooperative learning as the critical feature of C2005:

It marks this break away from the traditional mode when we emphasized that knowledge cannot be shared by learners where, for example, we tend to evaluate learners and associate them as individuals and not as groups; where for example, we never entertained the idea that a peer can learn from another

peer. And also it's a complete break away from a traditional quiet classroom.

B2, like B4, viewed cooperative learning and constructivism as essential components of teaching science. Institution B had been committed to this prior to the introduction of C2005, when they were faced with teaching large classes:

And added to this, there were imperatives which forced us to use cooperative learning techniques to help us to establish and give more credence to knowledge which students brought into the classroom. And also what catalysed that were the shifts in curriculum policy.

When I observed B2's teaching, he was teaching a class of 200 student science teachers, on the topic of the organic chemistry of lipids – a topic which involves abstract concepts. He used a traditional lecture-dominated approach in this instance. I did not have opportunity to observe his teaching in other situations, or with method-oriented topics. One of the issues here relates to external examining: external examining in the 'science' subjects maintained pressure of content and coverage, and the science teacher educators at Institution B felt this pressure.

6.3.3 When espoused theories contradict theories in action

A3 and B3 offer opposite examples of mismatch between one's theory-in-use and espoused theory. The curriculum materials supplied by A3 covered issues related to the nature of science and the teaching of science, without any reference to C2005. Yet her approach to her teaching was highly student-centred, expressing principles of constructivism and cooperative learning. She developed skills of prediction through observation of chemical reactions, in which students worked in groups, presented and discussed their findings, while she facilitated the learning as the lecturer in charge. Alternatively, B3 taught his session in a highly traditional way. His lecturing was excellent. He demonstrated an experiment on static electricity and discussed scientific principles related to the experiment. His curriculum materials, such as a course pack for the Post Graduate Certificate in Education, reflected a totally different ethos, emphasizing learner-centred approaches and the principles of C2005. Incorporated into the course packs were the following:

- developing skills among student science teachers to enable them to teach effectively according to the skills of C2005;
- lesson design in OBE;
- developing foundational and reflexive competencies in the Natural Sciences Learning Area;
- relating content to competencies;
- reference to performance indicators;
- reference to constructivism and science, assessment criteria, and range statements.

His view of continuous assessment was also similar to principles of assessment embraced by C2005:

You will find that even the whole issue of continuous assessment has to be unpacked because sometimes some students may think that continuous assessment may mean testing regularly and having, maybe having students writing up to five tests, but Continuous Assessment is about using different tools of assessment. So we have been trying to actually get to understand what is actually expected of us.

A1's practice as a lecturer is presented in the next chapter. Like B3, A1 espoused the rhetoric of C2005, but did not teach that way in the sessions I observed. C3 and C4, as presented in the next section, demonstrated in their teaching a number of aspects of C2005, though they did not claim to have internalised its principles. This serves as a reminder of complexity. As Baba says: "Hands that help are holier than lips that pray".

6.3.4 Science teacher educators coping with change as former college lecturers

C2, C3 and C4 were lecturers in a historically white college of education until they and their Institution merged with a historically white university. C1's story is told in the next chapter. Special attention is given here to Institution C due to its legacy as a

college under the control of the Department of Education. Also, it has a white past and a multi-racial present.

C2 said she grappled with change and coming to grips with the philosophy and methods of C2005, which she has adopted wholeheartedly. From my observations of her teaching, her espoused theories conform to her theories-in-use. She expresses the principles of C2005 appropriately and well. Her examination paper in science education for the biological sciences assessed the following:

- an assessment plan for OBE,
- the Natural Sciences Learning Area,
- the demonstration of outcomes,
- problem solving

C2 pointed to the problems of having an examination-led assessment coupled with continuous assessment:

When I got here it [the assessment system] was in place. But being continuous assessment there's no exam. So they are continuously assessed and they get their mark at the end of the year. But the third year group, for instance, that I teach in the old course, still have one exam which counts 50% of their mark and 50 % DP. Now when you are working towards that written exam, you tend to assess things that will be assessed in the same way that an exam would be assessed, because there is an emphasis on knowledge, whereas in continuous assessment, you assess a range of things, not only knowledge. There isn't that emphasis. I find it more difficult to employ different assessment techniques if I know there is that exam.

She expressed her difficulties with assessing outcomes and how she overcame them:

[The student teachers] have a big problem with that. They specify outcomes and they manage the big step of actually what is to be taught and what the learners have to do to enable them to achieve the outcome, to demonstrate that outcome. There is a lot of learning there and they manage that. But, now to

get them to assess the outcome that they specify is difficult for them, because they develop an assessment and they think this is a wonderful assessment, but it is not assessing the outcome that they state at the beginning of whatever activity. Those are the three steps that I tend to concentrate on. Can you define the outcome? What do you want the learners to actually be able to do? Can you design an activity that will allow the learners to develop the outcome and how can you design an assessment for a very nice skill outcome? And they had given the learner activities to do where they can develop the skills and they give them a written test which assesses knowledge and not the practical skills.

The lesson I observed was based on the interpretation of outcomes and the processes of deriving assessment standards for those outcomes. She made only some use of cooperative learning approaches, although the session offered a lot of scope for such approaches. She justified her choice, arguing that the students at this stage were insecure in respect of C2005.

C3 and C4:

Both C3 and C4 were lecturers in the Physical Sciences – C3 taught Chemistry while C4 taught Physics. C4 left the methodology lectures related to Physical Science to C3, who had more experience in schools. C3 said she did not like the jargon in C2005 but felt that she had always taught according to OBE principles. She felt she had adopted the outcomes of C2005 by changing her objectives for science teaching to conform with the outcomes. An analysis of her curriculum documents for Chemistry showed evidence of science concept development (specific outcome 1) and process skills (specific outcome 2), but there was no evidence of the remaining specific outcomes 3 to 9. This can be explained in part in that C2005 applies only up to Grade 9, with the 'old curriculum' still operating in Grades 10-12 where Physical Science is a subject. Even so, analysis of a Physical Science examination paper (November 2001) moderated by C3 and set by C4 revealed an appendix that displayed an OBE reference sheet featuring the four themes with the specific outcomes for the Natural Sciences Learning Area and critical outcomes of C2005. Student science teachers were not compelled to refer to the OBE reference sheet when answering their questions: students could choose to use either an objectives approach or the OBE reference

sheet. This was the only evidence of “integration” of OBE/C2005 in their curriculum documents.

Both C3 and C4 implemented similar teaching patterns when teaching science in the laboratory. Work sheets tended to approximate a recipe approach to guided investigations, but C3 and C4 established a good balance of lecturer and student input through a lively interactive dialogues. C3 used improvised equipment in the class I observed, despite the existence of standard science equipment in her laboratory, because she expected many of her student science teachers to work in schools that were under-resourced. She also attempted peer and self assessment approaches in an attempt to role-model non-traditional assessment strategies:

Self assessment, peer assessment, yes. Last year we did a lot of peer assessment and it works. I even did peer assessment at the school where I am teaching now. I have grade nine's. I have only started with the school this year. And peer assessment is good. I did not think it will work with grade nine's. There are 24 of them in the group, but they are very good at assessing each other.

In contrast, C4's assessment methods were more traditional, combining continuous assessment with testing. She admitted to have focused on knowledge development:

There are certain things we started doing, like having examinations at the end of the year, that's all prescribed in terms of course marks versus exam marks. So there are certain imperatives that we go to and come and work within. We have always had compulsory continuous assessment. We were never able to just write an exam at the end of the year. And I have always set my exams and tests in a way that challenges them to think and ask different kinds of questions. Not assessing like group work skills and things like that.

While C3 and C4 (and A3) did not very directly acknowledge the role of C2005 in their programmes, their learner-centred strategies and concerns for outcomes resonated with the new curriculum. In part, this might be explained in that they attributed such approaches to the research literature, rather than C2005. It also

exonerates C3's claim that she had always emphasized outcomes-based curriculum in terms of knowledge, values and skills, and apply constructivist learning theories.

Thus far I have I have attempted to present institutional pressures emanating from the NQF, the teacher education institution, the science education department, and schools. These pressures have in some way influenced the science teacher educators to change personally and in the process to make corresponding changes to their science teacher education curriculum. Some science teacher educators adapted to the expected changes by either being high in the rhetoric of change and low in its intended practice (A1, B3, B2) or by matching the rhetoric with the practice (A2, C2, B1 and B4. Others continued with their work as usual without embracing the rhetoric of change and yet were very competent in learner-centred approaches (A3, B1, C3, and C4) as prescribed by C2005. This latter group also displayed evidence of concern for "high knowledge and high skills" as recommended by the Chisholm review of C2005 (Chisholm, 2000) and the expectations of higher education. The differences in approaches presented by the three groups shows that change is indeed a complex process.

6.4 Individual responses to social transformation and redress

In this section, I will examine the influence of political and social redress intentions of the NQF on science teacher educator change. I wish to establish the extent to which the science teacher educators were motivated by issues of redress in the South African context. The questions I will address are: How did they change personally in response to the redress intentions of policy? Did they embrace the rhetoric of political and social redress and change accordingly or did they ignore it? In considering the data, I have in the back of my mind Habermas's (1976) classification of paradigms, the technician (positivist), interpretivist (hermeneutic), and socially critical, but aware at the same time that any and all of these can contribute to social transformation.

Internationally the literature has shown that nowhere in the world has education alone been capable of changing society dramatically (Carbone, 1990; Pendlebury, 1998;

Chisholm, 2000) while there are correlations between economic development and participation in education, it is not at all clear which ways the cause and effect run. Education may contribute in some ways to a good citizenry, but education requires the co-operation of other stakeholders and an economy able to provide resources. In South Africa, a large majority of schools and their communities, especially in rural areas, do not have the resources to perform the miracle required. As A1 offered, educational change has to be huge if it is to drive the hoped for social transformation.

Redress of disadvantage is a critical part of social transformation in South Africa: disadvantage that, under Apartheid, existed for non-Whites in all aspects of life, from basic freedoms and needs through infrastructure, services, income, health and education. Science teacher educators see redress in education from different perspectives. A2, for example, viewed it in terms of critical pedagogy, i.e., critique and action to enhance emancipatory goals. The data shows that he acted accordingly in his science education programme. C3 and C4 stressed technical knowledge and skills as means to further education, employment and national development. But of course these options are not either-or choices.

In what follows, analysis of science teacher educators' ideas and beliefs is presented under headings:

- Relevance of C2005 to society in terms of the critical outcomes
- Confining social development to the classroom
- Linking C2005 to society
- Social change
- The role of the critical outcomes

6.4.1 Relevance of C2005 to society:

The science teacher educators held different views about the extent to which C2005 bore relevance to an improved South African society. B3 observed that all curricula are designed with the intention of building a better society:

I think change is linked to what society demands of us as a Higher Education Institution: to provide programmes that are actually in line with the demands

of society. So I will not call it the pressures from the society, but the need to be relevant with what the society actually needs that necessitated that these changes be done.

While he embraced the changes, his teaching was traditional and showed few signs of social critique or learner-centredness. His documents were generally in line with the policy, but nevertheless oriented towards a knowledge basis of western science (specific outcome 2 in the Natural Sciences Learning Area). There was no reference to indigenous knowledge systems and their relation to science, or the interactions of science and society.

A2 was positive that C2005 would assist social transformation, but was of the opinion that a lack of resources would long deny formerly oppressed persons a stake in the economy. It was possible, he thought, that C2005 would further advantage groups who were already advantages:

So in fact I don't see a big impact being caused by this whole C2005. It will accelerate certain sectors in society. We may be acting on curriculum development, but the fact is that this won't be tactful to solve the problem as it would be expected to happen if everyone, i.e., all stakeholders, were on board.

A2's teaching and lesson planning were generally consistent with what he wrote in his curriculum documents and with policy.

B3 expressed a significant concern:

Off course, I have my concerns about the fact that we have tried to put together a lot of disciplines into Natural Science as a Learning Area and the same thing applies to other Learning Areas. I am just concerned that in that maybe it's not going to develop. At the end of the day I am not sure. I don't see us coming up with a person who is very much socialised into a particular discipline because in this new curriculum, what is clear is we are brain-tuned to this programme.

His concern was shared by other science teacher educators: the commitment of C2005 to integration across disciplines was felt not to be conducive to producing science specialists or deep knowledge of science. B3's reference to people being "brain-tuned" to C2005 is a suggestion that educators (and the community) might have been too quick in accepting the new policies. Indeed, the Chisholm Review of C2005 (Department of Education, 2000) also recommended a step back from 'horizontal integration' in favour of 'vertical integration' and planned progression in the development of knowledge and skills.

Jansen (1998) and other critics of the new curriculum, like B3, expressed concerns that the government decision to adopt OBE as a educational approach was a "sudden" decision which lacked consultation with relevant stakeholders and with teachers on a broader scale in South Africa. The policy was "steam-rolled" out of anxiety to offer a curriculum which was different to the apartheid curriculum. The links between the rhetoric of 'transformational OBE' and the rhetoric of the liberation struggle were used as means to convince the public and others that it was the answer to social change. In a sense, as B3 suggested, science teacher educators had not been critical enough, or not vocal enough, in their response to the new policy.

6.4.2 Views about linking C2005 to society:

In 2000, following extensive consultation, the Chisholm review of C2005 recommended that the number of outcomes be reduced, greater attention be given to progression and clear standards, and the structure and terminology be greatly simplified. The effect was to make the policy more similar in structure to policies such as the UK National Curriculum, with grids of outcomes and standards. B3 and C2 held conflicting views on whether the revised curriculum was an improvement, especially in respect of the relationships between science and society. B3 preferred the revised curriculum because:

I don't know what impact in the long run will that (integration) have on the creation of knowledge that is discipline related. I am worried about such things, just like I was worried about the development of concepts in C2005, the old, not the reviewed one because there we were focusing more on

integration. It seemed to me it was focusing more on integration, forgetting the conceptual development because I was worried about that aspect in the long run. But I think the reviewed one is better.

B3 is also referring to the reduction of the outcomes of C2005 so that specific outcomes 1 and 2 (science processes and science knowledge) carried forward while the remaining six outcomes were grouped under one outcome referring to science in society.

C2 saw this as a loss:

We looked at developing sections of learning programmes in terms of for instance how would you deal with specifically the one on Science and Society/Culture and Society. How Science is practiced in different cultures. We have a little bit of a conflict there. Some of the students and colleagues saw that outcome as pertaining to what every learners bring to the classroom as acceptable. And I did not see it as that. I saw it as exploring the ways in which different cultures use Science. And we specifically looked at things such as medicine, using plants in different (cultures), we looked at things like fermentation, how different fermentation practices with different plants are used to make alcoholic drinks. We looked at housing, how different cultures make different houses but there was some science behind it in terms of conduction and convection and things like that. And that's how I understood the idea but I know there are people who understand it differently. And many people who did it like that, it made more sense to them. Again, others seem to think that it now deals with looking at myths and legends and things like that. I don't quite agree with that because at what point do you say that now it is a myth and not science and who is to decide it is and it is not? It can be quite contentious. But I think if you dealt with it like that it was a way of making you understand that all cultures practice Science, they may not formalize it and define it, but they practice science and they understand a lot of how the world works without definitions and laws and things like that, but they understand how the world works. I thought that was very important to bring in those

outcomes and I am a little disappointed, I am not quite sure that I see that in the review document as clearly as it was in the original document.

One of the reasons which prompted her to engage her students with the outcome linking science to culture relates to her observation that:

You see most students found the outcomes that relate to science as science easier to cope with because they have come from that background. They have got a background in that. They find the specific outcomes that related to Science and society - we looked at specific outcome number 6; culture and society - they found that more difficult. It was something new to them. When you come from a background that science was a very objective discipline - how could you deal with some things that are static and that was their perception at that time. They found that more difficult than the ones which dealt with knowledge and principles and concepts. They were ok with that.

Other science teacher educators indicated that their student science teachers were challenged by outcomes linking science to society. For example, A2 claimed that:

Even if when opportunities are there and it is clear that the content can be some demonstration of the relationship between Natural Science and Society, there can be opportunities to demonstrate the contested nature of science. Students are not into those ways, which are habits of the mind, those which are traditionally friendly.

6.4.3 Views on the Critical Outcomes and social change

The critical outcomes of the NQF are intended as drivers of all curriculum in South Africa, at all levels through school and post-school. Encompassing competences such as problem solving, creativity, critical evaluation, communication teamwork and personal management, they can be seen as critical in the sense of important, and in the sense of critique. They also have the capacity to drive teaching methods: to learn problem solving, students need to be involved in problem solving. Thus they have the potential to promote social change and curriculum change.

B1 felt that the critical outcomes provided teachers with a clearer focus and guidelines to develop those skills in their learners, but they were not new. She claimed that she had been addressing such skills in the past. A2 felt that retaining the critical outcomes in the revised curriculum was important to social change, and that science teachers needed to ensure that the critical outcomes were addressed. Her colleague A3 believed that faithfully fulfilling all the critical outcomes would empower learners to take up an active roles in society and participate fully in the social, economic and political domains. She was concerned that emphasising only intellectual skills and knowledge would not be sufficient.

6.4.4 Socio-political perspectives of science teacher educators

Some science teacher educators interpreted the social transformation aspects of C2005 as being demonstrable in classrooms and planned their teaching accordingly. B2, viewed the change from a social justice perspective, aimed at breaking the mould of “Bantu Education” from the apartheid era. He explained his strategy for change when dealing with student science teachers:

Well I informed them, how the old system has disadvantaged us and how the new system will advantage all of us, both learners and educators. And that information made them to believe that C2005 is not coming in to disadvantage them, but to put them at an advantage. And also to be able to work in a situation where learners will not be threatened by being learners and educators will not be threatened by being educators. And no one will take advantage of each situation.

At the same time, his traditional approach to emphasizing science knowledge and skills pointed to a belief that technical knowledge was important to transformation.

C2 agreed with the philosophy of C2005 and supported the view that it would promote transformation. When questioned on whether acceptance or resistance to the policy was a race issue, she said:

Yes, and no. Because, yes, those who didn't change were White, but those who did change were also. One of the people at the college that showed most of the resistance was not White. So I don't know if it necessarily is race. Perhaps its your political views more than anything else.

When I questioned her about her view on the role of C2005 in bringing about change in South African society at large, she responded as follows:

Well I think at the political level it was such. Change was necessary and people felt that a radical change was required, that it was a gradual sort of transition that they felt they needed a radical change. In terms of what I feel, any OBE curriculum can do is to develop integral skills and the social development of learners, rather than just giving them the academic knowledge. I think there was a two fold purpose to the curriculum; a political one, and also one which required a different shift in terms of skills development and attitudes and values development.

My observation was that her classes attended to social development in the classroom context, but without especially linking this to society at large. A2 tried to go that extra step:

If there is one feature of our students (from Institution A), I think we have prepared our students for change. We have made them to be unstable with the past and its status quo and we have always prepared them to always try out methods. It is this kind of confidence that I have in them, they will be able to bring up some new developments.

Brookes et al (1993) claimed that it would be science teachers of the reflective type who would best support the change process by introducing new pedagogies. A2 argues that reflective teachers are also pushed more and more into a critical paradigm:

Yes, there are political aspects which change the classroom discourses, I

would say. Now more than ever before you have students who can stand up and challenge you on the subject matter, which makes us become scared, we sometimes see it as a personal attack.

He contends that teachers who read policy non-critically and follow it to the letter fail to see the unwritten intentions of policy:

My feeling is that somehow people who write policies, they have certain gaps. Those are the gaps that must be exploited by the person who is interpreting the policy to actually adapt the policy to their own contextual environment. But it must be clear when you read policy documents, for example, that you must have an understanding of what I will call the unstated intention of the politics underlying the policy document.

It is significant that issues of redress rarely came up in the few lectures I observed and in the curriculum documents supplied. B1 (see Chapter 7), B3 and A2 were the only science teacher educators who made reference to societal issues. B3 posed a question in an examination paper which linked science to society in terms of fuel used by people in the United Kingdom – an issue arguably of little relevance in the South African context. A2 made a reference in his course pack to issues of cultural diversity and during his teaching. This limited direct engagement with societal issues coupled with the limited engagement with the critical outcomes and the six Natural Sciences outcomes that go beyond science knowledge and skills casts some doubt on whether C2005 will have a impact on issues of social and political redress.

6.5 Conclusion

The level one data analysis presented in Chapter 5 hid much of the meaning of how science teacher educators have changed as a result of curriculum policy changes for higher education and schools. This chapter has sought to illustrate that the complexity through presenting and analysing the data according to these three themes of institutional pressures, school pressures and individual motivations and actions. Science teacher educators have been influenced to change through institutional

pressures of the NQF, senior management in their universities, the Faculty of Education and the Science Education Division. They have also influenced the collective through their exercise as “experts” in science teacher education. The role of the public school as an institution influencing science teacher educators to change has also been demonstrated. I have also attempted to show how the science teacher educators have changed in terms of the social and political expectations of policy for science education. In the next chapter, I look more closely at the interactions of personal and contextual factors, by presenting the cases of three of the science teacher educators.

CHAPTER SEVEN

STORIES OF PERSONAL AND INDIVIDUAL CHANGE

The analysis presented in Chapters 5 and 6 concerned change as it occurred across the eleven cases studied, with Chapter 5 looking for generalizations, and Chapter 6 looking more closely at individuals and their contexts. This chapter goes further in looking at individuals, through presenting three particular cases. I have chosen them because they present different stories of change: from each of Institutions A, B and C, and with different personal backgrounds and styles.

- a) A1 is the youngest participant in this study, a Black male for whom the liberation of 1994 coincided more or less with his entry into university study and his subsequent professional life. His story is characterized by recognizing and taking opportunities, and his beliefs in individual effort and achievement. I have called him “The lone achiever”.

- b) B1 is an older Black woman, who took it upon herself to leave South Africa and work in a neighboring state during the latter part of the Apartheid era, where she was exposed to international thinking and opportunities in curriculum development. She returned to South Africa and a position at Institution B just prior to democratic change with a wealth of experiences. She and her group worked closely together, strongly committed to curriculum and changing schooling in South Africa. I have called her “The Adventurer and Collaborator”.

- c) C1 is female with a “Coloured Education” background as a science teacher educator at an historically Coloured college of education before moving to Institution C. Her work is guided by strong commitments to students, teaching and inclusivity. I have chosen her story because it focuses on her concerns for school-related changes and the preparation of science teachers for the range of school and community conditions in which they might find themselves. In this sense, she was not especially driven by the rhetoric of change, but was

thoughtful and faithful in implementing policy. I have called her “The determined teacher, concerned for students”.

Thus the focus in this chapter, much more than in Chapters 5 and 6, is on individuals and the ways in which they worked with colleagues, students, policies and institutions as part of the change process. In retelling the stories, I have sought to stay close to the views on and experiences of change as A1, B1 and C1 saw them, spoke about them, taught in relation to them, and developed curriculum materials they saw as appropriate.

7.1 A1’s Story of Curriculum Change

“The Lone Achiever”

7.1.1 His background

A1 is a young Black African male science teacher educator who took up employment as a lecturer at Institution A soon after graduating with a Bachelor of Education (Honours) degree. He completed Science Education as his major subject and General Science as a Special Method for his first education degree and his leadership qualities became evident when he presented a paper at a student conference titled “The Politics of Knowledge”. His primary and secondary schooling occurred in a province to the north, under the Bantu Education policy, but he was born here.

Prior to being employed as a lecturer, he served as a graduate assistant to an experienced science teacher educator at Institution A. Subsequently, after completing his honours degree, he was employed by the Department of Arts, Culture, Science and Technology (DACST) where he contributed to developments in science and technology education at a national level. He returned to Institution A to continue with his Masters degree, during which time he also worked at Institution A’s Centre for Educational Research, under the guidance of a prominent education policy analyst and researcher. In each of these positions, he was exposed to “cutting edge” research and thinking related to C2005 and science education. In his success in schooling, his entry into university and his career since then, he demonstrated abilities to seize

opportunities, and enjoy the challenges and ideas they faced him with. Part of this was to read widely:

Some of the documents I have read are the policy documents, Understanding OBE that was written by the HSRC, the OBE research which we conducted in the research unit. I subsequently also worked with UNICEF with OBE and UNESCO and OBE in SA. For me to work with those organizations I had to have some clear understanding of OBE policies as these relate to the curriculum changes that have happened in the changes proposed in those policies.

7.1.2 His views on Institution A

A1 felt that he knew well the policy changes related to C2005, adapted readily to them, and that he may not have changed or might have changed differently if C2005 had not been introduced. He developed a course pack (year 2001) for his Natural Science Special Methods students which focused on the Natural Sciences Learning Area and its four themes, outcomes, assessment criteria, range statements and performance indicators. His incorporation of C2005 into his science teacher education curriculum materials was pertinent to the policy. He was aware of the NSE, but not greatly familiar with the document, because he expected the Teaching Practice Committee to attend to it. He believed that some aspects of the NSE were beyond the scope of teachers in most schools. His representation of the NSE in his curriculum materials emphasized the roles of learning area specialist and mediator of learning.

He did not especially feel institutional pressure to change: he felt that School of Education meetings focused more on administration than the implementation of curriculum change and, as a result, not all the lecturers were facilitating change. He viewed procedural and regulatory deadlines imposed in respect of modularization as an indication of Institution A beginning to respond to pressures of curriculum change in higher education, but emphasized that these changes were not linked to schools and improvement of school curriculum. He had respect for the modularization process in respect of its emphasis on outcomes but was concerned that the lack of a standardized approach to modularization served as a limitation:

I would like to see that further crystallised in terms of how do you actually begin to define our core competencies in such a way that that they are convertible within disciplines. In some disciplines there are clear cut and strict procedures, whereas in other disciplines that does not appear to be the case. Unless we standardize things within our organization we stand a chance of being no better than we are doing at the moment.

A1 was sensitive to the problems experienced by Black African student science teachers from Institution A who did not apply for teaching posts in historically White schools, school which now had a racially integrated learner population but with a predominantly White teaching staff. He believed that the student teachers felt intimidated to teach in such schools, schools in which he himself had practised as an intern. He thought it was difficult to break the cycle of student teachers returning to the kinds of school they had experienced (even though he had) because:

..... basically you have to expose your student teachers to all the skills [required in a different school] and also we are a disadvantaged university, and student teachers are from disadvantaged environments.

7.1.3 His fears about change

A1 admitted that he was initially frightened and frustrated by C2005, when he had encountered it during his first year as a practicing science teacher. He decided to try to understand and live through it, struggling because of:

.....the fear of the unknown; you don't know how it will impact and how it will affect you and people around you and the learners themselves. Will the learners learn anything in the process?

He recognised the paradigm shift required:

.....your whole mindset has to change, the way you see and perceive school, your political understanding of schooling/ teaching and learning is going to change. It affects your whole perception.

The paradox of not being schooled in OBE and having to teach according to it, with children who themselves had not been schooled in OBE, frustrated him further:

.....it could be twice as frustrating for the learners because you don't know where you are going. You are different from anybody else that encountered this before, especially the higher grades, learners have been in school for quite some time in the schooling system; whereas if you go teaching grade ones, you have a better chance of implementing OBE because these people have not been exposed to any learning strategies/teaching and learning methodologies. So you are going to the learners, you can establish a new classroom ethos, which they can then buy into and then you can let them proceed, whereas if I go to a grade 8 classroom, they have already spent 10 years in schooling and suddenly here comes this new method. It really is frustrating.

No one had the right answers and, as a result, he had to work hard as an individual:

You have to develop learning materials based on your understanding of the new policy C2005 and Natural Science. How do you use that to develop a new curriculum for yourself in the classroom when it comes to grades 5, 7 and 8, that you need to choose a particular topic in science and develop new curriculum materials?

.....sometimes, you know I get lost, and I ended up not knowing whether I am on the right track or not. Sometimes it is difficult to come up with an idea of how you can introduce this change in the classroom in such a way that it is sustained because it is one thing introducing change. It is something else sustaining it....

He was not happy about the prospect of superficially implementing the policy, and took steps to understand it deeply. As a result, he felt he developed a good idea of policy, but still had difficulty translating it into practice.

At Institution A, he felt that he was not provided with the necessary support to manage the change, that he was largely alone in the process. At the same time, his experience in the Centre for Education Research was profound:

This experience enhanced the way I perceive and bask with delight at the implementation of OBE.

7.1.4 A moral obligation to change

A1 claimed that the driving force for change for him was personal: he wanted to be an updated person, especially in relation to his exposure to research and literature around science education in schools. He declared that if he did not change, he would have failed the student teachers and the schools they went to, and this meant preparing them for C2005:

That's exactly why we are here preparing teachers. If you prepare teachers who do not fit in the system, then we must begin to ask ourselves why we are still here.

7.1.5 Curriculum, teaching and learning

On the basis of these experiences he was able to integrate C2005 in his course packs, tests and examinations. For example, 40% of his Special Method Natural Science examination paper comprised:

1. Interpretation of specific outcomes related to the Natural Sciences Learning Area.
2. The impact of the Natural Sciences Learning Area and C2005 on teacher change.
3. Constructivism and the Natural Sciences Learning Area: teacher and learner roles.

The remaining 60% of the paper were based on pure science questions. Twenty percent of his Science Education 1 paper comprised issues related to C2005.

However, the more radical aspects of C2005 were not included in his course pack: there was no evidence of the course considering indigenous knowledge, or contextualizing science to South Africa, or exploring the philosophy of science. His position, in broad terms, was: "Science is not about apartheid. Science is about understanding".

I observed him teaching a small group of student science teachers a lesson based on the classification of plants. This lesson was conducted in a physical science laboratory that was adjacent to a biological garden and a biology laboratory. The class comprised three Black African males. For this small class, he tabulated on the board the differences between Monocotyledonous and Dicotyledonous plants, coupling it with questioning to elicit the differences from the students. Actual specimens of plants were not included in the lesson; he used sketches of the plants to "*contextualise their reality*". Only one of the three students responded to his questions and no-one posed questions of their own. They were also given the task of providing labels for a leaf, asked to think also about how they would describe the leaf if they were blind. There was no response. A1 spoke for 85% of the time. In the follow-up interview, I asked him about his concept of learner-centredness, and his response was:

Then you know you can't just go to the classroom and say to them, "Today we are doing pressure." You can't. You have to introduce them to some discussion points and you have to take ideas from learners and explore their kinds of thinking and show how they can affect the kind of understanding they may have.

A teacher's role is (I would say educator) is to prepare. I would not like to say teach content. Content to me is context specific. You are able to use knowledge or information that will enable the learner to understand immediately the environment and using that environment to understand the content that you

are using. But also in such a way that would enable them to understand different contexts when one moves from one area of content to another.

Consistent with this, he argued for a balance between learner-centredness and teacher-centredness, and linked his position to constructivist learning:

It should be a balance of the two [learner-centredness and teacher-centredness][because you know there are things you are going to direct, especially introduction to new concepts and new understandings, you've got to provide the grounding. Yet when you make the connection between concepts, then that has to be learner-centred, because they have to make the connections.

It (constructivism) is quite useful, because the truth is, if you want learners to learn, we now understand that they learn by making connections and before the teacher used to make the connections for them. Now if you allow learners to make the connections in a way that it makes for greater understanding...

The laboratory where he taught his biology lesson was adequately equipped to teach physics and chemistry and was adjacent to a biological garden. The biology laboratory was a few doors away. Such a context was adequately resourced for teaching biological science. A1 believed that a resourced context was not an essential prerequisite for the teaching of science as most of his science student teachers ended up teaching science in under-resourced schools:

Science is not about the facilities, it is not about Apartheid. Science is about understanding. I can teach science in a totally disadvantaged school, better than a teacher with all the facilities. Look: if I need to have a glass jar, I just need to get a bottle to do the same function as a glass jar. If I need a Bunsen burner, I can use a primus stove. The principles of science are still there. So to me it is not about the facilities, it is about the processes and principles of science you want to impart. You want to use what the learners' have.

However, in the class I observed, his approach was neither to use laboratory equipment nor the plants outside in the garden, but ‘chalk and talk’. Later, when I interviewed his students, they reported that he had given them opportunities for discussion and cooperative learning strategies during some previous classes, but rarely contextualized his science teaching in the natural environment.

He believed that continuous assessment for C2005 was misunderstood by many teachers, who viewed it as frequent testing. He viewed it differently, as placing the emphasis on individual progress rather than standardized performance:

To me it says, how are you improving against yourself? How has your understanding of scientific concepts improved from prior to the introduction of the content and after the introduction of the content?

He claimed that his assessment procedure has changed since the introduction of C2005 to incorporate such an approach and that he modeled it in his assessment procedures.

7.1.6 Redress and change

I asked A1 whether he believed that C2005 could be an effective strategy to empower people for a better society. He answered “yes and no”: the policy engaged with change at a depth that was sufficient to achieve social redress, but translating the policy into practice in the South African context was problematic. This was partly an individual matter: if individuals did not take initiatives then the institution should not be blamed. At the same time, the phasing in of C2005 (at different levels in successive years) presented problems for student science teachers who had to function in different modes in different grades. The short school-based teaching practice offered to student science teachers was not sufficient for them to work with this reality, let alone act at the same time as change agents for practicing teachers:

Well one of the things was that the teaching in school shocked me. Some of the things I understood and felt could be done in school did not happen. It just did not work.

He argued that a similar situation prevailed at Institution A, where the School of Education did not push changes in curriculum and teaching sufficiently, apart from procedural and regulatory aspects of policy.

Beyond his concerns for implementation, he was not confident that the policy (or any education policy) could greatly change socio-economic and social aspects of South Africa, such as poverty alleviation.

There are things which socio-economic and political aspects of everyday living that the curriculum in anyway may not address. It does not address a number of issues of violence and crime, unemployment and things like that. As much as it may give us a better understanding through discussions, those things affecting South Africans at large are lacking.

Even so, he believed in the educational potential of the policy, and in linking science education to social issues and conditions. He asserted that he had always emphasized science and scientific processes not only as a classroom activity but as a socio-economic and political activity. He cited the example of extending a discussion on genetically modified foods to social, economic, and political implications. In this, he saw the critical outcomes and the specific outcomes of the Natural Sciences Learning Area as being very useful:

Yes, one of the outcomes that you know we begin to see science helping in the development of the critical citizens that can participate and take decisions you know around issues that are affecting them. Or the other one where you begin to see science as contributing to the socio-economic/political development of the country – it has a lot about what you can do in the science class.

But the potential for change would not be realized unless individuals changed:

It [the policy] says that humans have got to realize that they have to change, but how do we actually ensure that the change happens? That depends now on the kind of teachers that we have in the classroom.

And, in any case, to liberate a nation from decades of oppression:

.....the [change in education] has got to be huge for the impact to be felt

7.1.7 Comment on A1's story

A1 illustrates a number of complexities of change, and was able to articulate them: the combination of curriculum, opportunities, personal motivation and effort that are necessary for change to occur; the importance of mentors and reading; the interactions of policies as ideals, policies as guides to action, and curriculum as it occurs in context; the limitations of policy and curriculum in effecting social transformation.

The liberation surrounding the democratic elections and the subsequent policy changes pervade all aspects of A1's life. As a Black African he determined to succeed in schooling under apartheid, and went on to obtain a university education. Through his achievements, and opportunities that opened up in the late 1990's, his career in science education developed quickly. He was the right person at the right place at the right time. His identity shifted a number of times, from school student under Apartheid, to successful university student, to school teacher, university teacher and researcher. It shifted from a disadvantaged person who was restricted, marginalized and under-resourced to an affirmed individual determined to do well and take his place in society as an achiever. Post-apartheid policy changes enhanced such shifts, and this influenced his attitude towards curriculum change and policy in positive ways.

His view on change conforms to some aspects of Advanced Change Theory, in that he believed that change had to take place within people; that institutional, historical and policy changes by themselves were insufficient. True to this belief, he immersed himself in reading and research, to bring himself 'up to date'. However, as he noted himself, translation of such ideas into curriculum design and classroom practice is far from straightforward – for example, in the class I observed, he struggled with his roles as a teacher 'presenting' science to his students, as against working with them to build their understanding, even while there were only three students in his class, and there were plants just outside the classroom that he might have used in his lesson. He

believed that curriculum should enable changes within individuals, but he was uncertain about how to facilitate that himself: even accepting his position that science was about understanding, he might have used more participative and constructivist approaches to teaching.

At the practical levels of curriculum and teaching, he would have liked more guidance from within his institution, but its focus was more on administrative and regulatory issues to do with the changes in higher education (especially modularization) than curriculum changes related to schools and teacher preparation. He acknowledges that he was given freedom and flexibility in planning and implementing curriculum, despite his anticipation of having to follow a prescriptive model, but he did not use this freedom to initiate close work with colleagues. Neither, for example, did he read the NSE document that the institution had made available to him. At the same time, he was emphatic that the School of Educational Studies was not applying enough pressure on staff to support the change process – by which he meant especially the training of science teachers for a changing school context. This he saw as a moral obligation.

In as much as he saw potential in C2005 in supporting change at a socio-economic and political level, he was critical of aspects of C2005. In particular, he believed that its promises were overstated, and that conditions in schools made it difficult if not impossible to achieve. Nevertheless, he believed in the policy, and the importance of relating curriculum to political and social redress. In this, he felt that a holistic and learner-centred approach to science, as in C2005, was appropriate and that the critical and specific outcomes of the Natural Sciences Learning Area were vital. However he was sceptical about the ability of education policy to address everyday socio-economic and political developments in South Africa. For A1, overcoming disadvantage starts primarily from individual effort and determination, and, in science education, depends on developing understanding of scientific concepts and skills in scientific processes.

7.2 B1's Story of Curriculum Change

“The Adventurer and Collaborator”

B1 is a Black female science teacher educator with several university degrees (including a doctorate in education) who has worked in the tertiary sector since 1979. Her schooling and initial employment in South Africa occurred during the Apartheid era. She chose to relocate to a nearby Black African State, where she gained valuable experiences in curriculum development for science education, including exposure to prominent science educators from the UK, Australia and The Netherlands – countries that she visited during this time. She stated that her international experiences in curriculum development were very significant contributions to her perspectives on curriculum and change.

In fact even then [in 1979], [this Black African State] was addressing these issues, long before I went there. In fact when [a prominent science educator from SA] visited us then, she said SA was 10 years behind.

She viewed her experiences in curriculum development after she had left South Africa as a turning point in her career. She returned to South Africa after Nelson Mandela was released in 1992 and joined Institution B.

7.2.1 Her views on Institution B

One of Institution B's first responses to the modularization process was to elect a Restructuring Committee. She regarded this as an institutional pressure for change and also as leadership:

Well, yes, there was pressure... So those were the people who were actually studying the document and unpacking whatever was there in the document. There was a group of people who were driving the process.

Within this framework, the science teacher educators had autonomy to develop a more appropriate curriculum:

Oh, yes, we did enjoy the freedom because for the first time we said we can now develop a curriculum that suits us and a curriculum that we think is a relevant curriculum. But I must say, our curriculum at the moment is not cast in stone. In fact we are still revising it, by 2003 it should be revised.

The roles and competencies advocated by the NSE were integrated during the modularization process, under the supervision of the Restructuring Committee. She believed that the changes prescribed by the NSE were not new at her institution:

Well, I wouldn't say they are new. I would say now it is spelled out in a more elaborate way. But I wouldn't say really they are new. I think we have been doing that all the time. It's just that they are now written down, spelt out. It is about communication, teaching students about reflection.

Resistance within the group was not to change, but to the time constraints and deadlines:

None of them resisted. The climate was not calm. People were under pressure, a lot of pressure. It was document after document. You would get a document, which within a month would be revised and followed by a new document. People were under pressure, and when people are under pressure, there is likely to be some resistance. Like when we had to write the new modules, there was a lot of pressure because you had lectures, you had documents to read, you had to write these things on a template. There were different types of templates. So there was a lot of pressure due to other things also.

7.2.2 Collaboration and change

At conceptual and ideological levels, B1 took the curriculum changes for universities and schools in her stride and engaged with them as instructed by the Restructuring

Committee. Collaboration with her colleagues in science education was part of this, bringing together their experience in different modules. It was a feature of understanding policies, and of designing curriculum materials. The collaborative spirit in relation to the NSE is shown in this excerpt from her interview:

I remember at one point we had to look at it, is it outcomes, yes, and we had to unpack them. We sat down and actually unpacked, particularly those relating to Natural Science and we said, okay, when we do this, how would we be doing this, so that we could all interpret those outcomes?

There were times when it was difficult to meet with colleagues to clarify meanings and obtain differing views, at which times she had to depend more on reading. B1 found workshops to be valuable, but was frustrated that funds were not available through the university to support attendance at, and the implementation of, workshops to the extent the group would have liked.

7.2.3 A moral obligation to fit teachers to the new system

B1 viewed the change process as a means of providing opportunities for her student science teachers to adapt to C2005. She felt a moral obligation to ensure that her charges were adequately equipped for the changes when they were employed at schools:

Oh, yes, we did see a need. The fact that I am saying: we did not want our students to go out and then to find out that they could not fit into the system.

When it was decided to phase out the old B.Paed degree in the face of overlap with the new BEd degree, she and her colleagues were compelled to revise the old syllabus to integrate changes related to C2005. She explains how they achieved this change:

But we had introduced things that are in C2005, because we felt that when our students complete and they go and teach, it shouldn't be really necessary that they should now be in-serviced because we haven't done C2005. So we are

doing things like phase organizers, how do you develop the programme and things like that. But all those things were really outside the [old] syllabus.

7.2.4 Changes related to C2005 and schools

That Institution B preceded C2005 and the NSE in some ways is evidenced from course documents. In a 1998 course outline for science education, B1 instructed student science teachers to develop a mini research report, concerning COTEP expectations of teachers that were later expressed in the NSE. She also wrote a course outline for General Science EGS 315 Unit 1 (undated): “An introduction to life on Earth”. While the course guidelines bore no reference directly to C2005 they addressed some relevant science education issues, and presented outcomes as part of the module. In 1999, question 4(a) of a Primary Science Exam paper (November 1999) concerned the interactions between science and socio-economic development/technology. By 2000, her General Science examination paper (June 2000) was based on pure science questions in traditional ways, but her Method of General Science (MGS314) exam paper (June 2000), has question 2 on the History of Science, question 3(b) on constructivism as a learning theory, question 4 on integrating science with other subjects and question 5 of features of C2005 (phase organizers, specific outcomes and critical outcomes). In fact 75% of this paper is OBE related and 30% covers pure science. B1 attributed the latter to the requirement that the prescribed syllabus is also covered (a Supplementary examination for the same subject gave much greater attention to science knowledge). A science education examination paper set in November 2001 covered pure science and methodological aspects, including discussion of traditional versus OBE assessment practices. Twenty five percent of the paper addressed OBE assessment.

For assessment in her own courses, outcomes-based assessment strategies proved very stressful and challenging for her, especially with her large classes:

It's a huge headache. In fact when I was looking at those portfolios, I think I really almost had a stress. If you had to do things like they are really supposed to be done, you have large classes, there are a lot of people, like just looking at those journals, what I would do was to just page through them and see if

there were any problems, you know, look at those problems and then address them in class. But it was really impossible to do the thing correctly.

Pressures of time and syllabus, and disruptions due to staff strikes and student boycotts required they use traditional lecturing alongside the kinds of approach advocated in C2005.

B1 took seriously the NSE and role-modelling in her teaching:

I think our view is that we should teach the way we are supposed to teach. In other words, I think we do try to model what we expect them to do (in schools).

I observed B1 teaching a science education class of four student science teachers, of which only two were present. She explained that this was their first class after the vacation period and the students were “rusty”. The topic was enzyme activity. She posed a question related to a previous lecture which required the students to indicate which science process skills could be developed when conducting experiments on food tests. When appropriate responses were not forthcoming, she prompted by referring to one such skill and was able to elicit several more as a result. She thereafter briefly followed a lecture cum questioning technique, followed by an activity in which she provided her students with strips of paper, each printed with a specific step for an experiment to observe the effect of the enzyme catalase on hydrogen peroxide. The students’ task was to arrange the strips of paper in the sequence required for the experiment. They then conducted the experiment, followed by a discussion of the process skills involved and a scientific explanation of the results. I interviewed the students after her lesson. They said that they liked B1’s approach to teaching because it challenged their thinking and forced them to participate. They also found her teaching strategies useful as a role-model for their teaching.

B1 believed in improvising science resources that were lacking in many South African schools:

Let me say, in our primary [primary school] focus, we do that all the time. In fact we try, for our primary focus, we try to improvise as much as possible.

Like for instance, I use a lot of equipment made up of Coca Cola bottles. We collect them. We make funnels, we make beakers out of them. We calibrate our own measuring cylinder. Yes, we do that.

7.2.5 C2005 as policy

B1 had reservations about the slow pace of curriculum change in South Africa and also about C2005 and its critiques:

I must say that I have been beginning to accept it because it seemed like its late, but it is there. In fact it is now [with the Review of C2005] that they have sort of simplified it. Because I think what was more difficult about C2005 was all this jargon. And there are people who are saying in C2005, there is no content and to me it was because people just did not understand it. There is nothing in my view which says C2005 has got no content.

She said she was initially quite negative about C2005 because of its terminology. She was accustomed to involvement in curriculum development, but C2005 was different because so much of its terminology was confusing to her as a university science teacher educator. She wondered how practising teachers, who did not even have her curriculum development background, were going to cope with it. She was disappointed at the expectations of the Department of Education for teachers coming from the traditional training most of them had experienced. She claimed that:

But I think what is wrong that the government did was to expect teachers who have not been taught how to develop curriculum, to all of a sudden know how to do it, because that's what they expected. Like they said, you need to develop your own learning programme. But how do you develop your own learning programme if you have never gone through that process?

However she found C2005 appealing for the following reasons:

Yes ,it was appealing to me in the sense that it did emphasize the fact that we should look at students as individuals and different and give them

opportunities to be able to reach the goal. I don't think it's easy. It's very difficult. In fact when you start really implementing OBE, it takes all your time because it means you have remedial classes for those who are struggling. Although we did that, there was no policy actually emphasizing that.

And she valued the move from objectives to outcomes because:

..... we were beginning to look at exactly what is being achieved in the learning, not that we were not doing it before. And I think we were putting more stress on outcomes, just because they were in C2005 and we wanted our students to understand that.

7.2.6 Social and political issues

When I asked her about political reasons for the curriculum changes, she replied:

Political reasons? Well, yes, okay. It was a new government and to them [teacher educators], because there are things sometimes you don't choose. For instance this C2005 came from above. It's not that we had a choice. But then because we knew that our students were going to teach in that system, we had a responsibility to help them to understand C2005. So we had no choice in it.

She believed that the cultural understanding emerging from C2005 might help to produce a better society in South Africa, and although C2005 could empower youngsters to find jobs it would take a long time to break the inequity of employment in the technology sectors. Her immediate concern was to prepare student science teachers for school contexts in order to conform with Government's intentions, and improve the quality of science education in schools.

7.2.7 Comments on B1

To me, B1 is characterized by her commitments to curriculum and curriculum design, and her beliefs in collaboration. From her background in science teacher education,

her knowledge of the science education research literature and her interactions with academics from other countries, she was well acquainted with the kinds of changes advocated in C2005 and the NSE, and was giving attention to some of them before the policy changes were introduced. C2005 and the NSE came as added impetus to change, and she accepted the policies more or less as givens, policies that student teachers would have to implement. It seems that, while the redress nature of the changes was compelling, her knowledge of the research literature and her commitments to her students were centrally important. Thus, the policy and institutional pressures to change were supported by her personal commitments.

Her Institution's response to the policy changes included the Restructuring Committee and, within the Faculty of Education, a Curriculum Committee answerable to the Restructuring Committee. The fact that some her colleagues served on the Curriculum Committee tied the different levels of responsibility to each other. Resistance, to the extent that it existed, arose from workloads and timelines rather than the policies and plans themselves. This effect is consistent with the rationale for current forms of public management, in which national goals, institutional goals and individual goals are brought together through a combination of central control, participation and devolution (Walenkamp, 2001). Thus B1 was emphatic about the freedom she and her colleagues had in curriculum and teaching even as they worked to strict timelines according to 'top down' policies, templates and plans. In part, this was because the ideals and goals of the individual science educators were reasonably in agreement with the goals of the policies and the institution.

B1 believed in collaboration: throughout my interviews with her, she spoke naturally and unconsciously of 'we', and 'us', rather than 'I' and 'me', with the 'we' referring sometimes to colleagues on the staff, and sometimes to teachers and students. The use of collaborative approaches was limited in the apartheid era, but is explicit in new policies in management and education. C2005 with its learner-centred and critical orientations and the NSE in its roles of teachers have been instrumental in engaging science teacher educators in collaborative approaches.

Sergiovanni (1990) defines collegiality in a school context as the existence of high levels of collaboration between teachers as well as between teachers and administrators. According to him, this collaboration is:

.....characterized by mutual respect, shared work values, cooperation, and specific conversations about teaching and learning. It is also characterized by intellectual sharing, collaborative planning, and collegial work.

Southwood (2003:664) claims that:

..... the collaborative approach positions the educator centrally in both his/her own professional development and that of his/her colleagues. It is one which, rather than relying exclusively on external expertise, recognises the expertise within and deals with both in an interactive way.

B1 and the science teacher educators she worked with seem to have achieved this kind of collaboration.

In her course packs and assessment strategies, and in her teaching, B1 offered good examples of modeling C2005 and a number of the roles in the NSE. Her espoused views were generally translated into action. At the same time, she acknowledged her needs to use lecturing when necessary to ensure that she covered the syllabus, and that assessment strategies such as portfolios were unmanageable with large classes. The assessment processes proved to be nerve-racking and time consuming, and this had implications for C2005, which she enjoyed engaging.

Three phases of B1's career can be identified: the first, in South Africa, when she chose to leave; the second, abroad, when she developed expertise and confidence in curriculum, science education and teaching; and the third, back in South Africa, when she threw herself into institutional and curriculum development to accord the new policies. As indicated in the title, "B1, The Adventurous Collaborator", her story is primarily about an adventure in curriculum. It was also an adventure in collaboration.

7.3 C1's Story of Curriculum Change

“The determined teacher, concerned for students”

C1 is a female science teacher educator, classified as a Coloured person in the Apartheid system. She completed a BSc degree and started teaching in a Coloured secondary school, without a teaching diploma. She was then appointed as a science teacher educator in a Coloured College of Education, and completed a teaching diploma, BEd and MEd part-time.

When the college at which she worked was closed as part of a national rationalization of teacher education, she was transferred to Institution C. She currently works with a science staff comprising four females of which the other three are White. She teaches mainly in the biological sciences undergraduate teacher education programme. C1, in my interviews and observations of her, always showed deep concern for her student science teachers and pride in preparing them for schools and science education.

7.3.1 C1's personal change

C1 had worked with curriculum and teaching of the kinds advocated in C2005 prior to the introduction of the policy, especially learner-centredness and multicultural education. This included collaborating with a former colleague on an action research approach to develop co-operative learning strategies. Even so, she viewed the new curriculum as a challenge and undertook her Masters degree partly for this reason. She felt the major influence of C2005 on her was in the field of assessment:

Well I think that the basic philosophy in terms of looking at constructivist teaching and learning and the use of groupings, etc., I have always been using those particular aspects. I think in the way that I have changed is probably to look at the assessment and the light in which assessment takes place in regard to really getting students more involved in being part of the assessment plan. It's broadened my ideas in terms of the use of portfolios. How should they go about assessing? I think that's a big area in which I have changed.

She also enjoyed intensifying her interests in multicultural education, and the relationships between science and culture, as a result of the new policy:

I think the greater change that took place after Curriculum 2005 was really to look at all the aspects in relation to the racial aspects, although I must be honest I did multicultural teaching even before Curriculum 2005 because it really did interest me.

C1 had initially entered the teaching profession without an education qualification. She claimed that she was “saved” from the predicament through her knowledge of Psychology from her first degree:

I think what had helped me a lot was because I did Psychology and that opened me up to the difficulties that people experience and also the importance of the relationship that people have with the teacher and the types of resources and the way you go about doing things with learners and how you need to interest them and also motivate them. It's not just to work with the content matter that you have at hand. And I think that's when I started teaching myself. I started looking at that very closely.

She sought advice from experienced teachers and also read books on pedagogy. She came to view learner-centredness in science teaching as involving an active participation of all learners in practical work and presentations, and saw such participation as depending on relationships with the learners:

I get a feel for the students. I get a feel from the work I am doing and I think that my teaching and learning strategies are such that they are very student-centered. It is not very often that you come in and then you get a lecture. No, sometimes a whole discussion for an hour can be based on just a paragraph from the work that I put up and then I will be discussing that and seeing how we can link different areas of work through that and how it can also be linked to the school setting.

The recognition in C2005 of ‘people’ within science and in relationship to science was important for her:

I think that it has changed a bit in terms of the person in science and not just the objective nature of science as such, but also the social experiences of science. I think that has changed.

C1 regarded constructivism, especially socio-constructivism, as the essential rationale for C2005. She engages her student science teachers with constructivism by discussing theories with them and comparing traditional teaching approaches. She also encourages her students to reflect on their school-based science teaching practice from the perspective of constructivism.

C1 and her student science teachers discussed C2005 and its prospects of producing better-educated teachers in South Africa. The students pointed especially to outcomes of the Natural Sciences Learning Area related to the cultural aspect, cultural bias, etc. Such discussions helped her to develop her sensitivity to issues of equity, especially in respect of gender and race. She believed that the specific outcome related to culture and science should be broadly inclusive of individuals and groups:

[These outcomes]broadened my perspective in the light of how I should be going and also taking into account that it should not be one-sided – because in many instances when you look at Curriculum 2005, it’s all for essentially the upliftment of the so-called black underprivileged people, and yet that’s not what one should be looking at across the country.

7.3.2 Curriculum and teaching

I observed C1 teaching a class of thirteen student science teachers – two were Coloured males, three were Indian males, two were Black African males and the remaining six were Black African females. It met in a fully resourced biology laboratory. Her lesson was based on the endocrine system and feedback control. She commenced her lesson with two focus questions concerning feedback, and associated diagrams on the overhead projector screen. She asked the students to discuss the

questions in groups and gave them 10 minutes to accomplish this task. During their presentations, one student explained a negative feedback system using her fingers to demonstrate. In building on their answers, C1 drew a flow diagram to show links in the homeostasis process, and referred to a table of hormones. She then gave the students two problem-solving tasks, in which they engaged in healthy discussion while engaging with text. A lively and interesting discussion followed.

C1 attended workshops to help her to come to grips with the interpretation of the specific outcomes of the Natural Sciences Learning Area and the critical/cross-field general outcomes prescribed by C2005. She engaged her student science teachers in the interpretation and interrogation of the outcomes in the following way:

*.....if you look at the specific outcome, process skills, so many people do not understand initially what a process skill is. So we really went through all of them and we tried to see how it is related to the Natural Sciences. So we said OK these are outcomes, this is what we understand by Natural Sciences. How do we tie them together? And more than that, **how** do we then look at activities that we can do in order for the learners to achieve those or to develop those particular aspects.*

As indicated earlier C1 viewed assessment as the most important area in which she has changed as a result of the introduction of C2005. She indicated that she followed policy documents on assessment as prescribed and implemented the requirements as expected:

If you look at our course outlines and the assessment procedures that are in place, we definitely make use of all of that, and even the use of portfolios in assessment is really to the fore.

She felt that her student science teachers were well-prepared for assessment by the time they had reached their third year of training due to the emphasis on assessment by her Institution. She provided them with opportunities to develop or design assessment criteria, establish the weighting of each, and decide whether to use

qualitative or quantitative methods or a combination of both. She used work sheet design as one aspect of assessment. She required students to make up portfolios that included a range of assessment strategies, among which were surveys and displays. She acknowledged that the compilation of portfolios was not fully in keeping with expectations of C2005, because she used it largely to lodge all the assessment tools used.

I interviewed C1's students at the end of the session. One student indicated that they were accustomed to activities, for example, where they designed some aspects of the curriculum and engage in assessment activities. They preferred such activities because of the opportunity to participate instead of being told what to do, and because the activities simulated school-based contexts with learners. The students also claimed that C1 had always referred to OBE practices during her lectures and helped them reflect on the school context of change. They found this most useful for their preparation as teachers.

C1's curriculum documents show emphasis on C2005 and its expectations. The course outline for Biological Science 2A was developed in 2001. It presents the outcomes of the course and is consistent with the guidelines of the SAQA template. The Biological Method 3SCS course outline (undated) refers to the Natural Science Learning Area of C2005 and covers specific outcomes, teaching methodologies and assessment approaches characteristic of C2005. The Professional Studies year planner for Science Studies (2001) in the Bachelor of Primary Education degree covers the following:

1. implications of OBE for the Natural Science Learning Area of C2005;
2. specific Outcomes of the Natural Science Learning Area of C2005;
3. programme organizers;
4. assessment criteria;
5. a paper on OBE and its implications for Science Education prepared by C1;
6. assessment of a group activity related to a learning programme on Astronomy, outcomes, and assessment criteria.

A class test (undated) for this course has 77% of its items related to OBE.

In interview, she claims the following changes to her curriculum and teaching since the introduction of C2005:

- greater sensitivity to culture and race
- more attention to equity, gender and race
- linking outcomes to culture
- engaging Student science Teachers with outcomes
- acknowledging and applying socio-constructivist learning methods
- changing assessment
- acknowledging C2005 as a better curriculum than the traditional one
- overcoming problems related to outcomes

C1 claimed that Institution C had grouped the nine outcomes of the Natural Science Learning Area to three (science knowledge, science processes and science-society) before a similar change was made as a result of the Review of C2005:

We designed our own programs, and if you look at the course outlines for those programs they already had knowledge, skills and attitudes aspects on the cover of them even before the specific outcomes came through.

7.3.3 The Institution, collaboration and change

Within Institution C, she felt there was initially resistance from some colleagues, more in other departments than science, to the introduction of C2005. In science, some colleagues embraced the changes, while others were critical. For the Institution generally:

So yes the changes did take place for many people, and for some people not much of a change - because it doesn't matter to them anyway.

When I asked whether she agreed with a view often attributed to White teachers that OBE was for Black people only, she stated:

Oh, yes. I have come across a lot of that. It depends on how you're doing it, really. No. It's for everybody. It really is for everybody. No I don't see it as that at all.

When I asked whether she felt Whites in South Africa were more likely than Blacks to resist the new curriculum, she replied:

No, I don't think so. Let me tell you now I have been to a school and they say, "No OBE in this school" – and it wasn't a White school.

She felt that she and her colleagues were under institutional pressure to change, citing workshop attendance, requirements of course design and assessment formats, deadline dates and completion of forms as key indicators of that pressure. Staff were frequently encouraged to consult with policy documents, interrogate them and make meaning. Most of the Learning Area Committee meetings for the Natural Sciences were held at her Institution. Three of her colleagues attended the meetings on a regular basis, and were expected to report back to the Science Department. These Learning Area Committee also conducted workshops:

And we were actually work-shopping those documents as they came through all the time and all the lingo in terms of terminology that used to come through because of the Natural Science Learning Area committee meetings that we used to attend.

Working with her colleagues was partly a way of overcoming anxiety, through mutual support and by confronting the challenges. She maintained that she and her colleagues “were always interrogating the documents and looking at trying to make meaning”. Collaboration also included the external moderator of the science education examinations at appropriate times.

The Institution depended on the Science Department to develop additional guidelines to implement the change process in Science. C1 enjoyed the flexibility and autonomy implied:

Flexibility within this Department, I'd say for Science it has always been absolutely fantastic, because when I first arrived, on the first day I came, I was told to design two different courses. I told them that I did not know how to

do it because I had never done these things before. They said, well, you think about the areas you think you would like to work on with these students. I then sat and designed those.

With curriculum design, similarly, support was available, including assistance from the Head of Department. Experimenting with ideas and talking with students were also important: there were times when she could co-create the curriculum by giving her student science teachers particular tasks. For example, she might not provide them with the course outline in the first session:

.....all we did was we just spoke about what they expected within a Natural Science course and how different the Natural Science course would be in terms of teaching and learning strategies and the assessment compared to what they experienced at school. Well, we took those comments and said we need to do something with this particular comment and in the next session we looked at the course outline and we said OK lets look at the comments that were made and let's put them into the course outline, because if we look at the assessment, how should we be assessing and students are free to discuss and voice anything they wish to voice during a section. Secondly there was a lot of presentation that took place. Obviously I was very strong to the fact that there needs to be an output, and the assessment criteria were designed by the group, not just me so that everybody could understand what was expected of them.

Where the NSE was concerned, C1 said that her Institution handed copies of the document to all staff and expected them to incorporate the roles and competencies in course outlines. She considered that most of the proposals in the NSE were not new to her. The Institution ran several workshops on the policy and made clear that accreditation of modules by SAQA would be jeopardized if the NSE were not adhered to. Student science teachers were exposed to the NSE especially during a module in Education.

When I asked her how her Institution as a whole responded to policy developments and whether there had been resistance she responded:

Oh, no, you can ask somebody else. I am not in tune with all of that because I try to keep my own. But maybe you can ask the administrator about that. Maybe he can answer that question. I don't like answering all those questions.

7.3.4 C2005 and social transformation

When I asked C1 whether she was particularly motivated by political and social reasons for change, she replied:

Oh, well, I would say that the social reasons came from looking at the performance of students, and also looking at the great impact that a change in teaching and learning strategies brought about. So for me it was mainly concerned with students and the outputs that were being given.

She felt that improvements in science education could lead to improvements in South Africa:

.....as long as people are aware that it's the knowledge, skills and attitudes which are tightly, tightly interwoven.

... the thing that I am very, very wary of is the mechanistic way in which some things are done, because ultimately we are people with feelings and cares and that type of thing, and the sensitivities are things I feel that are trapped inside us. And it's not just the mechanistic aspect. It's more than that. And too many people are over seeing it as a machinery.

7.3.5 Comment on C1

To me, C1 is characterized by her commitments to students, inclusion and learner-centred education. In this, she sees relationships between students and with her as critical. She encourages participation, and at the same time a focus on learning and outcomes. These commitments extend to learners in schools, and so she works hard with her student teachers to prepare them to teach in the ways she does. Her position is consistent with C2005, and C2005 has both enhanced her understanding and

provided pressure on her and her students to design curriculum and present it in learner-centred, outcomes-based ways. In this, her motivation is not so much political as concern that all students (in her Institution and in schools) learn and gain confidence in themselves. While she was greatly sensitive to equity issues, she believed that redress should not be focused on a single race group but should be for all.

Collaboration, discussion, experimentation and workshops were important in the changes, for the Institution, the Science Department and her. They were pushed along by institutional demands and opportunities. As an institution of teacher education, Institution C attracted the provincial Natural Sciences Learning Area Committee meetings, which three of the Science staff attended, and this involvement was greatly helpful not only in the direct sense of participating in the meetings and workshops, but in affirming the Science Department.

Prior to being appointed as a lecturer at Institution C, C1 had not experienced the kinds of autonomy or the kinds of collaboration available at Institution C. She therefore responded to autonomy and its attendant responsibilities on one hand with fear, and on the other hand as an opportunity. She embarked on further study, reading, workshops, and teamwork with colleagues and students.

C1 has committed herself to developing attributes among her student science teachers that could have a positive impact on the political and social realities of South African society. She committed herself to socio-constructivism and equity in her classes, in ways that are based especially in respect for individuals and their rights to learn. The teaching and learning approaches which she developed with her student science teachers were directly linked to the realities of South Africa. She was emphatic about the development and integration of knowledge, skills and values that have an impact on the lives of learners.

7.4 Conclusion

These three stories show the complexity of change at an individual level, through the interactions of personal characteristics, institutional characteristics, and policies. The three science teacher educators were quite different from each other in their backgrounds, values and workstyles, and so were the institutions, but all were working to the same policies, and the same broad goals. I have presented the three cases in ways that highlight the individuals: A1 the lone achiever, B1 the adventurous collaborator, and C1 the determined teacher, concerned for students. In their different ways, all of them changed as a result of involvement with the policies, their own efforts in learning, and the institutional arrangements that were made. So, in different ways, did their curricula and their institutions.

The next chapter, the final one, draws on the different perspectives and analyses of Chapters 5, 6 and 7, bringing them together to support and finalize my thesis on complexity and curriculum change.

CHAPTER EIGHT

LINKING THE DATA ANALYSIS TO THE MAIN THESIS

On the basis of the data analysis presented in Chapters 5, 6 and 7, I present three claims that constitute the main argument of my thesis, viz., that

Science teacher educators responded to policy imperatives and institutional pressures for revision of teacher education programmes in accordance with the NQF guidelines for modularization and the NSE. In the main, the resulting changes were routine for the science teacher educators, focussed on the procedural and regulatory aspects of the policies, rather than deep changes in practice. However, the science teacher educators changed greatly in response to the 'paradigm shift' of school level changes in curriculum (C2005) and teachers' roles (NSE). In this, they were largely self-directed, without particular pressures within their institutions, or particular support from management or government. Their efforts were motivated and sustained mainly by their professionalism, as individuals and as a group, and their sense of accountability to schools, student-teachers and the profession.

While the science teacher educators were directly accountable to their institutions and institutional processes in respect of procedural and regulatory aspects of modularisation, their enthusiasm for and commitment to changes in school-level curriculum were much greater, and demanded much deeper change. This professional imperative was not bureaucratically controlled nor particularly supported in the institutions, beyond expectations of professionalism and considerable autonomy. Professionalism and change can flourish in the absence of institutional pressures for compliance, and even institutional support structures.

Some change theories and models of teacher change and organizational development that arise in relation to schools seem not to apply to science teacher educators and tertiary institutions. I refer in particular to theories of planned, whole school and even system level change and large scale reform models. The theory of change that is relevant to the major changes in curriculum and teacher educators in my study is based more on the initiatives and motivations of science teacher educators than on institutional arrangements.

In the sections that follow, I will review the data analyses from the previous chapters with the intention of supporting these claims, first descriptively and then with a view to change theory.

8.1 Reviewing the Data

From chapters 5-7, the following findings emerge:

Evidence that there was a separation of two kinds of policy emerged in Chapters 5 to 7, viz., the NQF/NSE (which was more bureaucratically driven) and C2005/NSE (which was more professionally driven). The first was treated routinely and somewhat perfunctorily; the second was treated deeply, in thought and time. The NQF/NSE was seen by the science teacher educators to be less demanding, in that they spent less time and effort on it and more time in response to C2005.

8.1.1 Regulated Change

Science teacher educators responded easily to pressures from the Department of Education and their institutions to modularize courses and express the NSE (even though both policies invited deeper responses of curriculum review and changed practices). Institutions B and C made determined efforts to manage and effect the changes. Institution A accommodated the demands between teaching and research responsibilities. The process conformed with rational change theory, in that the changes were explained, guiding documents and templates were made available, committees or officers were appointed to oversee the process, institutional pressures and deadlines were applied. Institutions A and C had already taken steps to

modularize their academic programmes (in the structural sense) prior to the NQF demand. Institution B had more work to do in converting year-long courses to semesterized modules since it commenced its modularization process upon official request. However, in all cases, the development of templates reflecting outcomes, changed teaching and assessment strategies as required by SAQA were fulfilled in a very short space of time, consistent with set deadlines. Institutional pressures were accompanied by threats of non-accreditation of modules by SAQA if the templates were not submitted.

The science teacher educators often felt frustrated by the deadlines and added responsibilities and complained about them. They completed the work, but there were weaknesses in implementation, as exemplified by Chapters Five, Six and Seven. The resulting curriculum documents indicated that the science teacher educators had changed, but in their classrooms and assessment practices, the changes for some were less than promised in their documents. Further, the interviews indicate that they were motivated to change much more by C2005 than by the modularization process.

Partly this can be explained by the view that modularization was mostly a structural requirement, and that the Norms and Standards for Educators was not new to them. Both claims are questionable. Some aspects of the policy documents were new and challenging – for example, a shift to broad competencies and outcomes in modularization process, and roles of teachers as curriculum designers and ‘mediators of learning’ in the NSE. None of the science teacher educators addressed these new developments formally in their curriculum documents and teaching programmes. However, whether they took the NSE seriously or not may be irrelevant, given that they took C2005 very seriously. This relates to the view of Malcolm (C. Malcolm, personal communication, 7 October, 2004) that, ‘it is the concept of curriculum devolution that is critical, not the Norms and Standards *per se* because they merely describe the expanded roles of teachers in a devolved system’. The responsibility of the teacher education institutions was to ensure that student teachers developed and expressed the roles and associated competencies during practice teaching at schools and not necessarily at the teacher education campus. And these responsibilities, within

the teacher education programme, were taken up in other modules than the science education ones.

While it appears that the science teacher educators had not changed much in response to the bureaucratically driven processes of modularization, pressures for similar changes in curriculum and teaching were present in C2005 – also outcomes-driven and learner-centred, and also calling for broader approaches to assessment and competence. Thus the structural changes and revised documents arising from the modularization process provided a starting point for deeper changes that were driven instead by C2005.

8.1.2 Professionally Driven Change

The science teacher educators changed more, and with greater zest, to the introduction of C2005 than the bureaucratic expectations of the institution through the NQF. The changes were accomplished over years, not weeks (the data were collected over the period 2001 and 2002 – four years after the introduction of C2005, more or less the same period in which the higher education policies were changed and implemented).

The interviews suggested a number of explanations for the science teacher educators' commitments to change consistent with C2005. One related to higher expectations of practising teachers and student teachers at public schools that science teacher educators visited during practical internship. Teachers looked upon the science teacher educators as leaders in curriculum and curriculum change, and felt they could find advice, and even workshop leadership from the science teacher educators. Another arose from the responsibility the science teacher educators and their institutions felt to prepare student science teachers for the reality of the new curriculum. Student science teachers demanded that they be prepared for an outcomes-based approach to education. Thirdly, to the science teacher educators, the timing of the new policy of C2005 was right: they saw the policy as more or less consonant with international literature on science education, and were in general agreement with the new Government's policy intentions of political and social upliftment through the new curriculum. Science teacher educators felt obliged to respond to the spirit of transformation that was abreast in South Africa. It encouraged

people generally to give the new Government a chance and to try the new policies rather than reject them. The science teacher educators saw the government's political and social redress intentions more clearly in C2005 than the modularisation process. Thus their motivation was a mixture of ideological commitment, professional commitment, responsibilities to schools and students, and general support for reform and redress.

In the absence of institutional and systemic arrangements (perhaps because of them), the science teacher educators read policy documents and research literature and collaborated with colleagues in and beyond their institutions. The interviews indicate that the primary purpose of collaboration was to engage with all aspects of change related to C2005. For example, the science teacher educators attended workshops to unpack and interpret the specific outcomes of the Natural Sciences Learning Area of C2005, and the critical outcomes. They attempted to come to grips with the technical aspects related to the new and confusing terminology of C2005 and its associated assessment strategies. They were also trying to work as fast as they could to express ideas they already had from the literature, take hold of opportunities provided by the new curriculum and share and develop expertise with others through their collaborative spirit.

The science teacher educators were proactive and used workshops, conferences, discussion groups, teams, conversations and the literature to co-construct their interpretation of C2005 and its implications for teacher education. They turned to the Department of Education (which was not their employer) to resolve issues and offered support by joining committees and leading workshops. They experimented with teaching methods, curriculum and assessment, mostly with a view to role-model C2005 approaches with their student teachers.

The engagement with C2005 was not university wide, but was confined to a Faculty level. In the case of science education, this confinement tended to be within the science education staff (even though all departments in the Faculty were concerned with C2005 and its implementation). Activities were largely individual at Institution A, but involved formal and informal teams at Institutions B and C. Within the general framework of C2005, science teacher educators responded differently to different

aspects – outcomes, teaching methods, assessment – and interpreted those aspects somewhat differently, taking what they wanted and down-playing the rest. The differences and similarities of their responses are captured in Chapters Five, Six and Seven. Overall, the science teacher educators really wanted to have an effect on schools by preparing student science teachers to engage C2005 and the Natural Sciences Learning Area through the development of outcomes, teaching methods, and assessment strategies.

It is interesting that the science teacher educators did not go to this extent of inquiry, experimentation, collaboration and change in response to the NQF and NSE, even though changes similar to those in C2005 were contained in the modularization process as part of the reform of higher education. The science teacher educators also generally disregarded the NSE, or left it to Education courses, even as they helped their student science teachers with many of the roles and competences that are described in the NSE.

Jansen (1998) in his critique of C2005 suggested that, if C2005 added any value at all to the South African education system, it forced many people in South Africa to engage with curriculum issues more or less for the first time. Science teacher educators and their colleagues from other teacher education disciplines certainly made concerted efforts to engage curriculum issues and inform their practice accordingly.

The data showed no evidence of ‘implementation failure’ in the sense of rejection or subversion of C2005 in science teacher education at the three institutions. Irrespective of the pace and depth of individual change, the science teacher educators’ actions were not counter productive to policy expectations. They were making the changes and knew that they could and would do more over time. Indeed, the contrary argument can be made, that the science teacher educators should have been more critical of C2005 – not only at the technical level of terminology and details, but at philosophical, educational and socio-political levels.

In the next section I will explain these descriptive claims from a theoretical perspective using change theories, models of change and relevant observations.

8.2 An Explanation of the Changes

The NQF's higher education change policy related to modularization and the NSE appeared to be less effective in promoting change than its curriculum change policy for schools. Its strategy for change at a higher education level was based on a technical change first (especially modularization) through templates that had to be submitted for registration with SAQA. Although this process conformed with rational change theory, the NQF had no procedure in place to monitor the associated conceptual and practical implementation of change at a university lecture room level. This resulted in the science teacher educators developing their templates to document anticipated changes so that these suited the bureaucratic demand without responding to the NQF as such in changing their teaching and assessment strategies. (This raises two interesting questions: whether Education Faculties would have made significant curriculum changes in the absence of C2005, and whether other Faculties in higher education have made deeper changes in response to the modularization process.)

The changes marked by C2005 were much more compelling and much more demanding for the science teacher educators than the changes in higher education. They understood C2005 as a large scale reform designed to reach all the primary schools and junior secondary schools nationally in South Africa. Perhaps it was the ambitious nature of C2005 that made the demands of it acceptable.

8.2.1 Accountability as a driving force for change

Science teacher educators as university lecturers, are accountable to a number of different groups, authorities and ideals at the same time. There is formal accountability (within the institutional management system), professional accountability (to do their job well), moral accountability (to the institution and schools, learners, society, etc.), and personal loyalties (to groups, ideals, self-concept, etc.). The idea of accountability, interpreted broadly (so that perhaps responsibility is a better term), provides a framework for examining the science teacher educators' motivations and actions. According to Piscatelli and Craciun (2002), humans will

direct themselves if they are committed to the goals of the organization. If a job is satisfying, the result will be commitment to the organization. Under proper conditions, humans seek responsibility and so sense accountability. The science teacher educators in my study used their professional responsibility to address the issues related to C2005 for reasons expressed above and to follow.

Professionalism, almost by definition, is an expectation that all science teacher educators are expected to fulfill. It is assumed as part of their appointment and defined in their job descriptions. Their decisions to serve as science teacher educators (lecturers) were not imposed. They applied for vacant posts under competition from other applicants. As successful appointees, they were keen to express their professionalism with enthusiasm, and this centred on the preparation of student science teachers for effective action in school contexts. The science teacher educators, therefore, while responding to institutional demands for change in terms of modularization of courses and the NSE, were deeply concerned about ensuring that they made attempts to understand curriculum change as it pertained to schools. This was accomplished despite the fact that they were not under direct institutional pressure to conform to school-based changes: it was a moral responsibility in preparing their students for the school and to the professional community to which they belonged.

They changed within the limits of the bureaucratic expectations of the NQF in changing their documents. They could have changed more at a lecture room level, but did not feel driven to do this. In relation to C2005, schools, teachers and the general public however, the science teacher educators felt strong needs to change, and committed themselves to the process. As noted earlier, they offered a number of reasons for this: ideological commitments, ideas abreast in the international literature, the importance they saw for the nation and government in the policies, institutional (unstated) pressures to provide leadership in their field, and moral responsibilities to school teachers and students. These various accountabilities operated together, tending to reinforce one another. By contrast, the NQF's modularisation process and the NSE, though aimed directly at reform of higher education, were interpreted essentially as bureaucratic requirements of repackaging, and did not carry the range and depth of accountabilities involved in C2005.

There were several ways in which accountability was achieved. In the management system, the science teacher educators obeyed the procedural and regulatory aspects of change in terms of the NQF. They made the necessary changes on paper; they integrated the outcomes of modularization and structured their curriculum materials accordingly. Although some did not change their traditional teaching styles, others made serious attempts. All of them took steps at improving their professional accountability (in relation to C2005 more than the modularisation process) by attempting to do their jobs well, providing leadership and support, and reaching towards the vision of education expressed in the policy.

8.2.2 Professionalism and learning

Professionalism played a critical role in how the science teacher educators changed. They perceived themselves as intellectuals, experts and leaders, capable of self-directed learning, and knew that others (outside the institution as well as inside) viewed them that way. For example, the institution respected the professionalism of the science teacher educators and gave them the autonomy to respond to the changes by their own initiatives. Practising teachers at schools and personnel from the DOE had similar expectations of the science teacher educators. Central to their professionalism were commitments to quality education and serving schools and learners – with teacher education being all the more powerful because of its flow on to and impact upon large numbers. This they viewed as a big responsibility. They responded to this mixture of intrinsic and extrinsic pressures that served to guide them in the curriculum change process.

Their professional approach to their work was driven by their moral responsibility to the institution they served, the schools they visited during school-based teaching practice, their student science teachers and the society in transition to democracy. In the process, their professionalism was reinforced – for example, when they responded to student science teachers' and schools' demands, when they participated in learning area committees, restructuring committees, workshop groups at schools, and discussions among their peers. They used these personal loyalties to support their work. Despite the complexity of the changes, negative aspects were overshadowed by

positive personal and professional aspects related to their lives as science teacher educators. The essential management simplicity and lack of constraints and rules in their institutions not only permitted professional freedom, but promoted it.

In the process the science teacher educators developed new identities. They did this in their own ways – some through research and writing, some through collaboration and team-building, some through experimentation in their classrooms. Those who took an individualistic stance engaged with the changes in individual ways, either within the classrooms, or through writing. Those who collaborated with colleagues depended on such relations to be mutually supportive. Those who adopted a technical stance focussed on the procedural and regulatory aspects of change. One sought a job change, but a job that enabled him to continue his commitments to science and science education. In as much as there were external institutional pressures for change, the overall commitment to the curriculum change process appears to have been intrinsically motivated. So, for example, there was very little or no resistance to the change process related to C2005, in spite of the demands.

Their science teacher educators' notions of themselves as independent learners, with responsibilities to learn, were important. For example, they saw re-writing modules as a means of learning. The mode of learning they tended to choose was 'learning through work' – learning in order to present and explain the policy, design curriculum, and teach in ways that modelled the policy of C2005. For this, in constructivist style, they found reading, experimentation, and collaboration to be appropriate strategies. Also, constructivist, systematic, outcomes-oriented approaches appeared to be a natural means of operation.

Collaboration through professional learning communities was a way of life for most of the science teacher educators. It occurred easily in their institutions, due to the autonomy and flexibility that prevailed. Such freedom was respected by most academics. It was usually accompanied with responsibility to be productive, and it generated personal and moral accountability. This is quite unlike the fixed working hours and tighter structures that practising teachers at schools are compelled to fulfil and possibly accounts for the much lesser achievements of most schools in their

implementation of C2005, in spite of more systemic and more systematic change processes.

It is interesting to note that constructivism as a key rationale for C2005 played an important role in the form of situated cognition in enabling the professional learning communities to make sense of some aspects of the change process as these related to the South African context. In their professional learning communities, they attempted to make sense of the change processes related to C2005 (see Chapters 6 and 7). Most of the science teacher educators worked with the Natural Sciences Learning Area Committees of the Department of Education to make sense of C2005. They did not follow a similar procedure to understand modularization or the NSE which was addressed by curriculum officers of the teacher education institution.

Argyris (1976) refers to the principles of classic bureaucracy as 'Model 1', and argues that they prevent organizations from learning. He refers in particular to the principle based on individuals striving to be in unilateral control – a typical bureaucratic measure exemplified by the NQF and its method of implementing modularization. The lack of bureaucratic control related to C2005 from a science teacher education perspective played itself out positively for the science teacher educators. It was in keeping with the guiding principles of Argyris's Model 2, viz., active participation, shared control, free and informed choice and commitment to monitoring decisions. Model 2 principles flourished in the teacher education institutions, in relation to C2005. As a consequence, the professional community's depth of participation and learning enabled significant and relatively quick changes for most of the science teacher educators. This was unlike the standard change expectation of the NQF's modularization process which failed to result in professional growth of the science teacher educators which developed positively through C2005, and failed to capture the science teacher educators' interest as a change goal or strategy..

The pathway of professional development of the science teacher educators was broadly consistent with the stages of the Concerns-Based Adoption Model (CBAM). The strength of CBAM lies in its reminder to pay attention to individuals and their various needs for information, assistance and moral support (Loucks-Horsley, 1996:1). The interesting aspect in this study was that there was no formal process of Adoption or Change: the science teacher educators rose to the challenge of the new curriculum

voluntarily, and framed their own programme of development more or less as they went. Even so, as they worked through the change process, their concerns and the focus of their energy shifted, roughly following the stages of the CBAM: from personal concerns, to knowledge concerns, to attempts at faithful implementation, to critical adaptation. Especially in the early stages, many of them attended workshops and conferences offered by the Department of Education to develop awareness and obtain information about C2005, then sought through reading, collaboration and experimentation to learn the processes and concepts associated with the policy, and become persuaded of the potential of the new curriculum, and eventually to adapt and grapple with issues of learner-centredness, cooperative learning, constructivism and continuous formative assessment in their science education classes.

8.3 Conclusion

The role of the new school curriculum as a major influence on change among the science teacher educators goes beyond the complexity associated with the change process. The influence of personal factors related to a moral response to school change (C2005) resulted in the science teacher educators making changes that were vastly different from their responses to the NQF's bureaucratically driven higher education changes even though the modularization process and NSE might have inspired the same kinds of curriculum change as C2005 did.

This is contradictory to common findings of School Improvement research which point to the difficulties of teacher change, curriculum change and organization change, and the needs for long term systemic approaches – where institutional management, external support, internal support, rewards and punishments work together. In the three universities in my study, such arrangements were loose couplings at best. But feelings of professional and moral responsibility were high for individuals and groups. Personal, social and professional interests were more obvious drivers of change than institutional interests and career interests.

My research has suggested the following:

- Much change theory developed in the context of schools does not apply to Teacher Education, because professionalism and education are primary concerns for science teacher educators: they chose to do their job well.

- Accountability is not only – or even mainly – about the institution and institutional monitoring systems. It is about professionalism and relationships within institutions and outside them. In this case, the responsibility the science teacher educators felt to schools, science teachers and their communities were much more powerful influences than responsibilities they felt to the reforms indicated in modularization and NSE.
- The professional imperative is not bureaucratically controlled. It flourishes in the absence of pressures related to forced compliance.

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APPENDICES

APPENDIX 1

The Critical Outcomes OF C2005 adopted by SAQA:

- Identify and solve problems in which responses display that responsible decisions using critical and creative thinking have been made;
- Work effectively with others as a member of a team, group, organisation, community;
- Organise and manage oneself and one's activities responsibly and effectively;
- Collect, analyse, organise and critically evaluate information;
- Communicate effectively using visual, mathematical and/or language skills in the modes of oral and/or written presentation;
- Use science and technology effectively and critically, showing responsibility towards the environment and health of others;
- Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation

These themes above are intended to serve as organizing principles. The following are the Specific Outcomes for the Natural Sciences Learning Area to be achieved at the end of Grade 9.

1. Use process skills to investigate phenomena related to the Natural Sciences.
2. Demonstrate an understanding of concepts and principles, and acquired knowledge in the Natural Sciences.
3. Apply scientific knowledge and skills to problems in innovative ways.
4. Demonstrate an understanding of how scientific knowledge and skills contribute to the management, development and utilization of natural and other resources.
5. Use scientific knowledge and skills to support responsible decision making.
6. Demonstrate knowledge and understanding of the relationship between science and culture.
7. Demonstrate an understanding of and contested nature of knowledge in the Natural Sciences.
8. Demonstrate knowledge and understanding of ethical issues, bias and inequities related to the Natural Sciences.
9. Demonstrate an understanding of the interaction between the Natural Sciences and socio-economic development.

APPENDIX 2

Roles and Competencies of the Norms and Standards for Educators

Roles

The teacher as:

1. a learning mediator
2. an interpreter and designer of learning programmes and materials
3. a leader, administrator, and manager
4. a scholar, researcher and lifelong learner
5. a community, citizen and a pastoral role player
6. an assessor
7. a learning area specialist

Competencies

The above roles are to be realized through the following applied competencies:

1. practical competence
2. foundational competence
3. reflective competence

APPENDIX 3

Letter seeking official permission for participation in the research

1. Letter to institutions

The Institutional Head.

Dear Sir/Madam,

I am a registered student in a DEd programme offered at the University of Durban-Westville. I hereby seek permission to conduct my research fieldwork at your Institution. Participants from two other universities in your province will also be invited to participate in the study.

My research is a qualitative study which relates to science teacher educator (lecturer) responses to the curriculum change process in South Africa. The main research instruments used in the study are semi-structured interview schedules and observation schedules. An analysis of documents prepared by the participants will also be conducted.

The supervisors of my doctoral research are Professors Cliff Malcolm and Renuka Vithal. Please find attached the following:

The title and critical questions of my research

A work schedule with time frames

My curriculum vitae

Permission will also be obtained from the science teacher educators at your campus to participate in my research. The name of your institution and its participating staff will remain anonymous in the dissertation. Transcripts of interviews will be given to the interviewees to confirm the accuracy of transcription and to delete information which may be of a sensitive nature. The research includes visits to lecture halls to observe participants to observe them teaching.

I am very excited about the possible outcomes of this research as a contribution to the body of knowledge related to science education. I therefore very keenly anticipate a favourable response to my request.

Thanking you,

Yours sincerely,

.....
Alan S Pillay
Lecturer in Science Education
Tel: 0843713672
Email: spillay@pixie.ac.za

APPENDIX 4

Semi-Structured Interview Schedule

An exploration of science teacher educator responses to curriculum change related to C2005.

Research Question

How have science teacher educators in PRESET education responded to curriculum changes proposed for the Natural Sciences Learning Area of Curriculum 2005, the Norms and Standards of Educators, and modularization in the Higher Education curriculum?

Introducing the research to the interviewee:

The nature of the project will be explained to the interviewee. The reason for collecting the data and how it will be used will also be discussed. The interviewee will be made aware of ethical issues related to the research. The research agenda will be clarified and the purpose and need for confidentiality will be indicated so as to enable the interviewee to be in a relaxed state prior to the interview.

SECTION A: DESCRIPTIVE ASPECT OF CHANGES RELATED TO THE SCIENCE TEACHER EDUCATOR'S PRACTICE

The purpose of section A of this interview schedule is to analyse/probe/ascertain the knowledge and actions of Science Teacher Educators. The main question will be posed as a lead question, while the sub-questions will be used to guide the interviewer.

QUESTION ONE : Personal practice versus institutional pressures/flexibility	Reason for posing question
<p>1. Have you changed?</p> <p>Have you changed your science teacher education curriculum and your practice to incorporate policy changes proposed by C2005 since its introduction in 1996?</p> <p>If "Yes", explain why you changed:</p> <ul style="list-style-type: none">-institutional pressures-personal reasons-political reasons	<p>An opening question serving as a lead question determining whether the interview should continue.</p> <p>To establish whether the reasons are of a psycho-social or</p>

<p>What pressure has institutional change been for you?</p> <p>1. To what extent did institutional pressures compel you to implement a science teacher education curriculum prior to the curriculum change process of C2005/modularization/NSE and after its introduction?</p> <p style="padding-left: 40px;">a) Prior to: b) After:</p> <p>Comment on the role of committees, deadlines, teamwork, etc. in this process.</p> <p>2. To what extent did your institution allow you to experiment with the science teacher education curriculum prior to the curriculum change process of C2005/modularization/NSE and after its introduction?</p>	<p>1. To determine the extent to which institutional pressures have influenced the change process.</p> <p>2. To also determine whether the institution was autonomous in allowing the science teacher educator to experiment with changes prior to policy change.</p>
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QUESTION FOUR : Personal practice versus institutional pressures/flexibility	Reason for posing the question
<p>How have you facilitated change for your students?</p> <p>1. Student science teachers often tend to teach science in a traditional way due to their experiences in traditional contexts of their personal schooling. How have you facilitated change in your student science teachers such that they would not always resort to traditional approaches to teaching? Did you workshop their past pedagogical experiences with them? How did you go about doing this?</p> <p>2. Why are there many rationales for C2005?</p> <p>There are many rationales for C2005, e.g.,</p> <p>Education and Training Democratization/Equity/Devolution/Accountability Effective Learning (learner-centredness, etc.) New outcomes, etc.</p> <p>What do you see as reasons (your choice of rationale).</p> <p>What does devolution mean in terms of accountability.</p>	<p>1. To determine what constitutes the individual, especially where he is coming from.</p> <p>2. To establish power relationships and change: a) Vertical b) Horizontal</p> <p>3. Is he she humane?</p>

QUESTION FIVE : Personal practice versus institutional pressures/flexibility	Reason for posing the question
<p>What have you done in lectures and workshops?</p> <p>What are some of the experiences in lectures and workshops to which you have exposed your student science teachers to enable them to respond to the new challenges and issues of C2005/modularization/NSE?</p> <p>Did these relate to any of the following rationales for OBE:</p> <p>a) cooperative learning techniques?</p> <p>b) constructivism?</p> <p>c) Assessment?</p> <p>d) interpretation of outcomes?</p>	<p>1. To determine the extent to which the science teacher educator was under institutional pressure to offer aspects of the curriculum.</p> <p>2. Looking for relationships regarding the structure, occurrence, and distribution of</p>

<p>e) achievement of outcomes?</p> <p>f) EE as a phase organizer?</p> <p>g) Interpretation of the Natural Sciences as a Learning area?</p> <p>h) Teaching for OBE?</p>	<p>events over time.</p>
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QUESTION SIX : Personal practice versus institutional pressures/flexibility	Reason for posing the question
<p>How has the incorporation of C2005 been challenging for you?</p> <p>What are some of the problems which you as a science teacher educator experienced in incorporating C2005 into your science teacher educator curriculum?</p> <p>a) Did you see it as a threat or a challenge to your usual method of teaching and preparing science student teachers? Explain why. How did you work through the threat?</p> <p>b) Did you feel that you did not have the necessary skills to implement the change? If “yes”, what did you do to overcome this problem, and how did you react?</p> <p>c) Did you experience difficulty managing the change? What were some of the difficulties? How did you finally manage the change? Did you superficially implement it?</p> <p>d) Did you not receive any institutional support to manage the change? If “yes”, what was the nature of the support? Did you approach your colleagues to support you? What was their response?</p>	<p>1. To locate the individual within the continuum of change. (rigid/structured vs flexible) (mindlessness vs mindfulness)</p> <p>Bureaucrats usually have difficulty in managing change. Dissonance Theory</p>

QUESTION SEVEN :	Reason for posing the question
<p>What does learner-centredness mean?</p> <p>Curriculum 2005 also proposes a learner-centred approach to teaching and learning. Learner-centredness has many meanings. What did you emphasize?</p> <p>(e.g. cooperative learning, etc. explain how you went about it.)</p>	<p>To determine what kind of curriculum was developed.</p>

QUESTION EIGHT : Learner-Centredness	Reason for posing the question
<p>How did you focus on learner-centredness in your class?</p> <p>Curriculum 2005 proposes a learner-centred (constructivist) approach to teaching and learning. How have you prepared your student science teachers to respond to such a proposal for school-based science education?</p> <p>a) Have you talked about the meaning of and research related to learner-centredness (constructivism) in your science teacher education curriculum:</p> <ol style="list-style-type: none"> 1. prior to the introduction of C2005? 2. since the introduction of C2005? 3. not used it at all? <p>b) Have you talked about learner-centredness and constructivism with your student science teachers to teach science meaningfully? What was discussed?</p> <p>c) What do you see as the value of constructivism as a learning theory in teaching science in C2005?</p>	<ol style="list-style-type: none"> 1. Use of principled knowledge as a basis for change. 2. Espoused theory vs theory in use. 3. To gauge what kind of curriculum he/she has developed. 4. How does he/she relate to a learner-centred curriculum.

QUESTION NINE : Outcomes and C2005	Reason for posing question
<p>How have outcomes changed your science curriculum?</p> <p>1 C2005 lists specific and critical outcomes.</p> <p>a) In what ways do you feel these outcomes have changed (or not) the definition of "science" in the curriculum?</p> <p>b) In what ways do you think they drive teaching and learning methods?</p> <p>c) How do they change the demands of assessment?</p>	<p>1. Another way of establishing whether the science teacher educator has grappled with the change concept.</p> <p>2. Has C2005 enabled the science teacher educator to move away from the traditional structured nature of science?</p>

QUESTION TEN : Curriculum Development for school-based teaching practice for change	Reason for posing the question
<p>Have you prepared your science teacher educators as curriculum developers for diversity?</p> <p>Given that:</p> <p>a) teachers have to be curriculum designers</p> <p>b) you don't know in which school they may teach after completing PRESET, and</p> <p>c) you are not aware of the nature of the diversity which they may encounter</p> <p>What guidance did you give them for their roles in addressing diversity in classrooms? (How does one draw on diversity for curriculum development?)</p>	<p>1. To determine the flexibility of the science teacher educator to accommodate change.</p> <p>2. To establish whether the science teacher educator views curriculum as a product or a contextualised social process.</p>

<p>QUESTION ELEVEN : Curriculum Development for school-based teaching practice for change</p>	<p>Reason for posing the question</p>
<p>What materials have you developed for your student science teachers?</p> <p>Describe some of the new curriculum materials (lesson plans, course packs, reflective diaries, etc.) which you have developed or encouraged student science teachers to develop as a response to curriculum change related to C2005).</p> <p>Give some examples of what you have done.</p>	<p>These will be used to test the “Theory of Action” of the teacher educator – espoused theory vs theory in use when I conduct a document analysis of curriculum materials supplied.</p>

<p>QUESTION TWELVE : Responses to change related to the school context</p>	<p>Reason for posing the question</p>
<p>How do students see the school context?</p> <p>During your interaction with your student science teachers, what were some of the challenges they have encountered and brought to your attention in their response to the curriculum change process of C2005. How did you support them?</p> <p>a) The student science teachers' background</p> <p>b) Resources for the Natural Sciences Learning Area:</p> <ul style="list-style-type: none"> • Lab facilities • Equipment for teaching science • Language issues/barriers • Cooperative learning <p>c) Interpretation and implementation/ achievement of specific outcomes of the Nat Sc LA :</p> <ul style="list-style-type: none"> • What support or input did you provide or how did you equip them to interpret/achieve some of these outcomes? <p>d) Did you encounter any outcomes which the student science teachers found to be demanding/challenging to achieve? Name these and explain how you assisted the student.</p> <p>e) Which aspects of school change did you regard as threats during your SBTP visits? (school management?)</p>	<p>1.To establish whether the science teacher education curriculum matches the new school curriculum. (was it in synch with it?)</p> <p>To determine the response of the science teacher educator to problems encountered by student science teachers at the school level of the Nat Sc LA.</p> <p>To establish threats/challenges to change.</p>

QUESTION THIRTEEN : Assessment	Reason for posing the question
<p>Assessment in OBE has proved to be a headache.</p> <p>How did you help your student science teachers to cope with this.</p> <ol style="list-style-type: none"> Did you leave them to learn assessment techniques from the school context during SBTP? What assessment procedures did you develop with your student science teachers? How do you assess as part of your own teaching? How has your assessment procedure changed? 	<p>To assess the level of change in the assessment procedure.</p> <p>Dissonance theory.</p>

QUESTION FOURTEEN : Capacity building/support for OBE	Reason for posing the question
<p>HAVE YOU CONDUCTED OUTREACH PROGRAMMES?</p> <p>Have you conducted outreach workshops for teachers (INSET) in the Natural Sciences Learning Area for OBE ?</p> <ol style="list-style-type: none"> How many did you conduct? Purpose? Were you under institutional pressure to conduct these workshops? Was it volitional? Did practising teachers request it? Was it for your student science teachers? What did you do at the workshops? Did you find the workshops useful for yourself? What did you learn from your involvement? Do you have any workshop materials for me to study? 	<p>To determine the extent to which the science teacher educator was willing to accept the change process by actually conducting workshops.</p>

QUESTION FIFTEEN : Capacity building/support for OBE	Reason for posing the question
<p>Where do inputs come from for your own learning?</p> <p>1. If you have attended workshops in the Natural Sciences Learning Area for OBE, how have you been influenced by these workshops for the improvement of your practice?</p> <p>a) What was the purpose of these workshops? b) Did you attend under institutional pressure? c) Was attendance voluntary? d) Did the workshops enable you to change your practice? e) What do you see as the most important learning for you from these workshops?</p> <p>2. What inputs have come from other than workshops? e.g., reading, talking with teachers/colleagues, etc. Which of these have been especially important for you?</p>	<p>To determine the extent to which the teacher educator was determined to engage with change.</p>

QUESTION SIXTEEN : Capacity building/support for OBE	Reason for posing the question
<p>How has the Norms and Standards for Educators /modularization served as a guide to enabling you to conceptualise C2005 and planning programmes?</p> <p>To guide teacher educators for C2005, the Government has released the Norms and Standards which emphasizes roles such as "teacher as curriculum designer and teacher as learner".</p> <p>a) Have you used the Norms and Standards as a guide to your Own programme planning? b) How have you used it? c) How helpful was the document? d) Did you attend workshops on it? e) Are you under institutional pressure to administer/implement it? f) Do you see it as a threat/challenge? g) Have you work-shopped the Norms and Standards document with your science student teachers? h) In what ways have the Norms and Standards influenced your thinking about your programmes?</p>	<p>This is a key policy document especially for the science teacher educators and teachers generally. If excluded from the science teacher educator curriculum, will indicate a superficial treatment of change.</p>

SECTION B: PSYCHO-SOCIAL AND POLITICAL RESPONSES OF THE SCIENCE TEACHER EDUCATOR TO CHANGE

The purpose of section B of this interview schedule is to change the mood of the interview by providing the interviewee an opportunity to become more open and reflective. It will also serve the purpose of recapitulation. The main question again will be posed as a lead question, while the sub-questions will be used to guide the interviewer. The latter are ideas I am interested in but will not ask the interviewee directly in the hope that responses to these would, never-the-less, emerge in the reflective account.

<p>QUESTION ONE : Personal views of science teacher educator as a teacher and learner within the institution.</p>	<p>Reason for posing the question</p>
<p>Looking back....How do you describe yourself as a teacher?</p> <p>a) How do you describe yourself as a teacher?</p> <p>b) How do you see yourself as a learner and science teacher educator? Are your actions as related to the above theory driven or driven by common sense? If driven by common sense, are your actions in keeping with your institution's common sense approach to the above? Do you use intuitive knowledge of what a classroom teacher should be or should do?</p> <p>c) Did you experience a child-centred/constructivist approach as a school-based learner and as a school-based science teacher? How do you handle such a problem in preparing your student science teachers for an OBE context?</p> <p>d) Do you see your personal actions as being more important than theory?</p> <p>e) Do you see a clash between your common sense ideas of what a teacher should be compared to the "un-commonsense" of it as it pertains to what policy is driving?</p> <p>f) Do you also see a clash between what the institution is</p>	<p>Collective common sense versus theoretical sense.</p> <p>The policy of C2005 is regarded as un-commonsense because it claims a learner-centredness approach to teaching.</p> <p>Procedural knowledge versus principled knowledge Theory of Action</p> <p>To determine whether a paradigm shift had occurred or not.</p>

driving (institutional common-sense)as opposed to policy?	Social aspects of change
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<p>QUESTION TWO :</p> <p>Personal views of science teacher educator as a teacher and learner within the institution.</p>	Reason for posing the question
<p>IF I ASKED YOU TO IDENTIFY FOUR OR FIVE PRINCIPLES OR BELIEFS THAT ARE CENTRAL TO YOUR WORK AS A TEACHER, WHAT WOULD YOU SUGGEST?</p> <p>What are your values as these relate to your guiding principles?</p>	<p>To determine positive motivational aspects of change</p> <p>To establish whether change has taken place.</p>

<p>QUESTION THREE :</p> <p>Personal views of science teacher educator as a teacher and learner within the institution.</p>	Reason for posing the question
<p>What do you think have been the main factors that have shaped your thinking and your work as a teacher?</p> <p>What were the key experiences about change which you obtained from:</p> <ol style="list-style-type: none"> 1. people 2. readings 3. the student science teachers 4. staff meetings/workshops? 	

<p>QUESTION FOUR: Personal views of science teacher educator as a teacher and learner within the institution.</p>	<p>Reason for posing the question</p>
<p>Thinking back, can you identify particular experiences (e.g., as a school student, as a university student, as a teacher...) that were particularly important in shaping your approach to your work?</p> <p>a) Which key experience served as a turning point in positively motivating you to change? Describe the experience.</p> <p>b) What have you observed about your student science Teachers' actions which have changed their direction?</p>	

QUESTION FIVE : The role of personality in the science teacher educator's response to threats and change.	Reason for posing the question
<p>Was there any resistance to the change process from your colleagues/yourself?</p> <p>1. Briefly describe the degree of resistance you or your colleagues have encountered in responding to the curriculum change process.</p> <p>a) Was there any initial resistance to change? What was the nature of the resistance? Why did it occur?</p> <p>b) Is there still some resistance to change? Explain.</p> <p>c) When confronted by a threat, do you have a tendency to relate to and emphasize only those aspects of change which are easy to handle? If your answer is "yes", provide an example and explain how you find (organize) your way through the threat. How have you changed as a result of this?</p> <p>2. What do you think are the barriers to change at a:</p> <p>a) Social level b) Personal level c) Political level</p> <p>a) How does one's race background contribute to his/her response to curriculum change in the South African context? Do you believe that race is a significant factor for supporting/subverting change?</p> <p>3. For you personally, did you struggle with understanding, expressing, the C2005/OBE approach to curriculum and teaching? Explain why or why not.</p>	<p>Acceptance Resistance Barriers to change</p> <p>Dissonance Theory</p> <p>Personality/ psychological</p> <p>Dissonance theory and comfort zones. Identifying the threat and going beyond it. Relating to the threat socially. Moving from the descriptive to the interpretive.</p>

<p>QUESTION SIX: Views of science teacher educator about personal change.</p>	<p>Reason for posing the question</p>
<p>In what ways have your views of education and yourself as a teacher changed over the last few years?</p> <p>How would you describe yourself as a science teacher/educator five years ago compared to currently?</p> <p>If you have changed, why have you changed? What have been the key factors which have caused the change?</p>	<p>To establish whether change has taken place.</p>

<p>QUESTION SEVEN: Why did you change/not change in response to C2005?</p>	<p>Reason for posing the question</p>
<p>Do you think C2005, in practice, is likely to lead to improvements in South African science education for a better country?</p> <p>1. How did you respond to the critical outcomes of C2005 as these pertained to your political background and the education of the historically disadvantaged people of South Africa?</p> <p>b) Will C2005 be appropriate as a strategy to empower South Africans to drive the economy?</p> <p>c) Will it prepare them for social change?</p> <p>What are your views?</p> <p>If the response is positive, how did this serve to contribute to the science teacher educator's response to change?</p> <p>2. How do you see your student science teachers engagement with C2005 and the Natural Sciences Learning Area specific outcomes contributing to a better South Africa for the future?</p>	<p>If C2005 is a contextualised social process, much depends on its science teacher educators' attitudes to also contribute to success.</p> <p>Attitudes to change</p> <p>To establish a belief system</p> <p>To move from the descriptive to the interpretive aspects of the study.</p>

END OF INTERVIEW

APPENDIX 5

Observation Schedule

Researcher's Name:.....

Province:.....

Institution:.....

Lecture/Practical:.....

Number of Student Science Teachers present:.....

Length of lecture/practical:.....

Time lecture begins:.....

Time lecture ends:.....

11. Which role/competency of the Norms and Standards for Educators is the science teacher educator attempting to address/develop?:

a) Competencies: Practical competence
Foundational competence
Reflexive competence

b) Roles: Learning mediator
Interpreter and designer of learning programmes and materials
Leader, administrator and manager
Scholar, researcher, and lifelong learner
Community, citizenship, and pastoral role
Assessor
Learning area subject discipline phase specialist

12. Which of the rationales for OBE are being achieved:

Cooperative learning techniques
Constructivism
Assessment
Interpretation of outcomes
Achievement of outcomes
EE as a phase organizer
Teaching for OBE

13. Describe the learning environment

14. Describe the organization of the students:

15. Describe the race groups of the students
16. Describe the teaching pattern:
17. Are pertinent issues related to C2005 being addressed?
18. Does the science teacher educator facilitate change for the students in respect of C2005
19. Are contextual issues for diversity being addressed and are there curriculum development issues related to these?
20. Did the science teacher educator use any teaching materials?

A short student science teacher interview based on the teaching:

8. Do you have opportunities to participate during lectures? Describe your participation.
9. Does your lecturer provide you with experiences to enable you to change in respect of OBE and C2005? Describe the experiences.
10. Did you have curriculum development opportunities related to OBE for diversity? Elaborate.
11. Do you prefer a student centred or lecturer-centred mode of delivery?
12. Did your science teacher educator's input during lectures enable you to teach for OBE?
13. Were the Norms and Standards for educators work-shopped with you?
14. Do you accept OBE fully or did you resist it?

APPENDIX 6 (C1)



100% member
↓ OBE

EXAMINERS:

MODERATOR: MR D BROOKES

FOURTH YEAR BPE
TIME: 2 HOURS

NOVEMBER 1999
TOTAL MARKS: 120

PROFESSIONAL STUDIES : SCIENCE IN EDUCATION

SECTION A : PHYSICAL SCIENCE

You may answer either question 1 or question 2, or if you would prefer it, you may answer both questions 1 AND 2. Notice that if you select only one question to answer then you will be expected to respond in considerably more depth.

1. Specific outcomes no 1 and no 2 for the Natural Sciences learning area in Curriculum 2005 lay particular emphasis on the processes of science and the application of the concepts of science. The approach to teaching and learning which is implicit here is one which assumes the importance of the learner's curiosity and desire to develop new knowledge. However, it could be argued that this approach needs to be set within a still wider context of fostering the sense of wonder and creative imagination than is the case in many science education programmes and textbooks.

Discuss this issue, and illustrate your response with examples, with regard to:

EITHER

- (a) 'The story of electricity'

OR

- (b) A topic in physical science which you have studied this year.

2. To most students in the Senior Phase of compulsory schooling, the Periodic Table appears as something almost totally abstracted from personal experience. Discuss some teaching/learning strategies which can be used to 'embed' concepts relating to the Periodic Table, in the understanding and experience of learners.

(Note that the approach to developing an understanding of what the Periodic Table represents would begin well before the Table itself is presented to learners in grade 9.) You may refer to aspects of your choice in discussing the Periodic Table but some might be the concept of an element, the idea of 'families' of elements, and the understanding of 'periodic' repetition.

{60}

SECTION B

1. You are expected to plan and manage a fieldtrip for a group of 50 Grade 7 learners. The Natural Science outcomes to be achieved are the following:

- (i) Use process skills to investigate phenomena related to the Natural Sciences.
- (ii) Demonstrate an understanding of concepts and principles, and acquired knowledge in the Natural Sciences.
- (iii) Apply scientific knowledge and skills to problems in innovative ways.
- ~~(iv)~~ Demonstrate an understanding of how scientific knowledge and skills contribute to the management, development and utilisation of natural and other resources.

- (a) Decide on a venue/resource centre and give 2 reasons for your choice. (6)
- (b) Design 2 (two) activities that the learners can do, for the above outcomes to be achieved. (12)
- [18]**

2. 2.1 You are expected to design a learning programme. In designing the programme you can decide on the following:

- (a) Programme organiser
- (b) Phase organiser
- (c) Natural Science theme/s
- (d) The time period - duration, and the time during the year when the programme will be presented.
- (e) specific outcomes
- (f) assessment criteria
- (g) performance indicators
- (h) teaching and learning activities. (36)

- 2.2 Why did you decide on this learning programme? (6)

[42]

{60}

APPENDIX 7

(B3)

UNIVERSITY EXAMINATIONS – JUNE 2001
MODULE: MEASUREMENT (ESMS 0A) BED I

DURATION:- 2HOURS

MARKS: 100

INTERNAL EXAMINERS:

Instructions:

1. Question 1 Section A is compulsory.
2. Answer any three(3) questions section B.

SECTION A

Section A consist of multiple choice questions. Four possible answers are given for each question. Read each question carefully and pick the best answer. You may only pick one answer for each question. Write your answer in the answer book. Number your questions correctly.

QUESTION 1

- 1.1 The form $1 \text{ inch} = 2,54 \text{ cm}$ is
- (a) an equation
 - (b) an equivalence statement
 - (c) a conversion factor
 - (d) a conversion statement
- 1.2 The magnitude of the displacement of an object is always
- (a) greater than the distance traveled
 - (b) equal to distance traveled
 - (c) less than the distance traveled
 - (d) less than or equal to the distance traveled

- 1.3 The units of m/s apply to
- (a) speed
 - (b) average velocity
 - (c) instantaneous velocity
 - (d) all of the preceding
- 1.4 On an x – versus $-t$ graph, the magnitude of the slope of a straight line is the object's
- (a) displacement
 - (b) distance
 - (c) speed
 - (d) acceleration
- 1.5 If a straight line on an x versus t graph has a negative slope or inclination, this means that the object
- (a) has a negative speed
 - (b) is moving in the $-x$ direction with a constant speed
 - (c) is a acceleration in the $-x$ direction
 - (d) is coming to stop
- 1.6 For straight line motion, a positive(+) acceleration would produce a deceleration for an object
- (a) with $+V$
 - (b) with $-V$
 - (c) with $V_0 = 0$
 - (d) in no instance
- 1.7 If air resistance is neglected, a ball thrown at an angle to the horizontal has
- (a) a constant velocity in the x direction
 - (b) constant acceleration in the $-y$ direction
 - (c) a changing velocity in the $+y$ direction
 - (d) all of the preceding

1.8 An unbalanced force is necessary for an object to be

- (a) at rest
- (b) in motion with a constant velocity
- (c) in acceleration
- (d) all of the preceding

1.9 Inertia

- (a) sets objects in motion
- (b) causes changes in motion
- (c) is the result of a net force
- (d) is directly proportional to the mass of an object.

1.10 A change in velocity

- (a) results from inertia
- (b) requires an unbalanced force
- (c) results from a zero net force
- (d) is the natural state of motion

1.11 The acceleration due to gravity

- (a) is a universal constant
- (b) is a fundamental property
- (c) decrease with increasing altitude
- (d) is different for different objects in free fall

1.12 The force pair of Newton's third law

- (a) can never produce an acceleration
- (b) act on different objects
- (c) cancel each other
- (d) only exist for internal forces

1.13 Two books, one on top of the other, lie on a table. How many force act on the bottom book

- (a) 1
- (b) 2
- (c) 3
- (d) 4

13 x 2 = 26

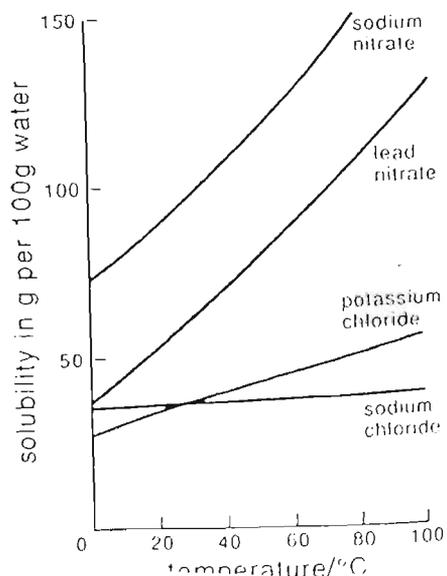
SECTION B

QUESTION 2

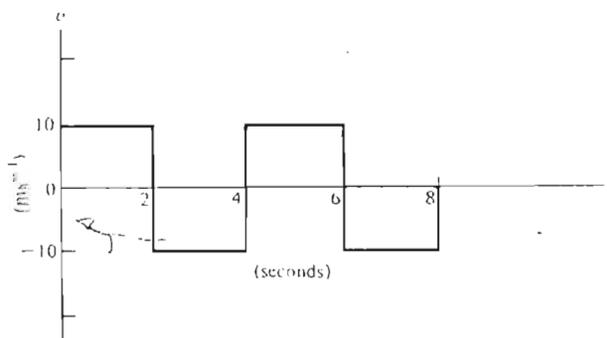
- 2.1 What is the difference between exact figures and significant figures. (4)
- 2.2 How many significant figures are in the following values
- (a) 93, 529 (2)
- (b) 20700 (2)
- 2.3 Convert a velocity of 60 mi h^{-1} (miles per hour) to metres per second (ms^{-1})
 $1 \text{ mi} = 1,609 \text{ km} = 1609 \text{ m}$ (4)
- 2.4 A car travels 30km in 43min on a straight highway. What is its average velocity in kilometres per hour (km h^{-1}) (4)
- 2.5 A ball thrown straight upward has a height x above the ground which is given by the equation $x = (19,6 \text{ ms}^{-1}) t - (4,9 \text{ ms}^{-2}) t^2$ find the average velocity from
- (a) $t = 0$ to $t = 2$ (3)
- (b) $t = 2$ to $t = 4$ (3)
- 2.6 A car initially moving at 20 ms^{-1} brakes with an acceleration of 2 ms^{-2} . How long will it take for the car to stop? (3)
- [25]

QUESTION 3

- 3.1 The following graph shows the solubility of different salts as the temperature rises



- (a) Describe the effect of a rise in temperature on the solubility of each of these substances (4)
- (b) Which substance is
- (i) Most soluble at 60°C ? (1)
- (ii) Least soluble at 60°C (1)
- 3.2 Plot the ~~positive~~ ^{position} - versus - time graph corresponding to the figure below (assume object starts from $x = 0$)



- 3.3 A model rocket is fired straight up from the ground level with a constant acceleration of 50ms^{-2} until the engine runs out of fuel after 4s. Neglecting air resistance find
- (a) the height of the rocket when the engine stops (3)
- (b) the maximum height reached (4)
- (c) the total time duration of the flight (4)
- 3.4 State Newton's first law of motion (3)
- [25]

QUESTION 4

- 4.1 A ball is thrown at 30ms^{-1} at an angle of 20° to the horizontal direction. Find the horizontal and vertical components of its initial velocity (4)

- 4.2 A baseball is hit at 40ms^{-1} at angle of 30° to the horizontal.
- (a) How high will it go? (3)
 - (b) When will it reach that height? (3)
 - (c) What will be its horizontal distance from the batter at that time? (3)
- 4.3 A ballast bag is dropped from a balloon that is 300m above the ground and rising at 13ms^{-1} . For the bag find
- (a) the maximum height reached (4)
 - (b) its position and velocity 55 after being released (4)
 - (c) the time before it hits the ground (4)
- [25]

QUESTION 5

- 5.1 On a horizontal air track, a spring exerts an average force of 2N on a cart of mass 0,4kg
- (a) find the acceleration of the cart (2)
 - (b) if the cart accelerates from rest to $0,3\text{ms}^{-1}$, for how long a time is the force applied? (4)
- 5.2 An elevator of mass 900 kg accelerator upwards at 3ms^{-2} . What is the tension in the cable where it is attached to the elevator? (4)
- 5.3 A constant force acts on a 5kg object and reduces its velocity from 7ms^{-1} to 3ms^{-1} in a time of 3s. Find the force. (4)
- 5.4 A 60kg man hangs from a high cable suspended from a helicopter. Find the tension in the cable if the acceleration is
- (a) 5ms^{-2} upward (3)
 - (b) 5ms^{-2} downwards (3)
- 5.5 An elevator cable that is light in weight compared to the elevator can support a weight of 10 000 N. if the elevator and occupants weigh 800N, what is the maximum possible vertical acceleration of the elevator (5)
- [25]

APPENDIX 8
(A3)

Q2.1
= 10/75
= 13 2/3
(ORF)

JUNE 2002
SCIENCE EDUCATION III - ESE 331S
Internal examiner:
External examiner:

Total marks: 75

Duration: 2 hrs

ANSWER ALL QUESTIONS

QUESTION ONE: 25 MARKS

1.1. Grade 6 learners want to compare the densities of water, paraffin and cooking oil. They tried to accurately measure 10cm³, 20cm³, 30cm³ and 40cm³ of each of the liquids. They then accurately measured the mass of each sample of each liquid. The data obtained is shown in table 1 below:

Table 1

Type of liquid	Volume of liquid (in cm ³)	Mass of liquid (in g)
oil	10,00	10,01
oil	20,00	20,00
oil	30,00	29,99
oil	40,00	40,00
Water	10,00	17,30
Water	20,00	34,59
Water	30,00	52,52
Water	40,00	68,43
Paraffin	10,00	12,25
Paraffin	20,00	24,18
Paraffin	30,00	36,30
Paraffin	40,00	47,98

- 1.1.1. Define the term **Density** as you would to your grade 6 learners. $\frac{m}{v}$ (4) *cm³/g*
- 1.1.2. Calculate the average density of oil. $\frac{10,01}{10} + \frac{20,00}{20} + \frac{29,99}{30} + \frac{40}{40}$ (5)
- 1.1.3. Define the phenomenon "error of parallax" as you would to your grade 6 learners. *eye not level - reading menisc* (4)
- 1.1.4. Rank the three liquids in order of increasing density. (From the least to the most) Explain how you arrived at your answer. (6)

*oil
paraffin
water*

From table: 1

1.1.5. Describe the procedures that you would follow to determine the volume of an irregular shaped golf ball. *displacement method.* (6)

QUESTION TWO: 25 MARKS

2.1 The Critical Outcome number 2 in the Natural Sciences Learning Area states :
 "Learners will work effectively with others as members of a team, group, organisation, community".

Describe five different group work methods that you can use in your primary science class. (10)

2.2. Mercury is a very hazardous chemical and its use has serious health risks. What are the properties of mercury that make it difficult/problematic to work with? (5) *low v high temp, insuli in w*

2.3. Mention two precautions you would take when storing mercury in your school laboratory? (2)

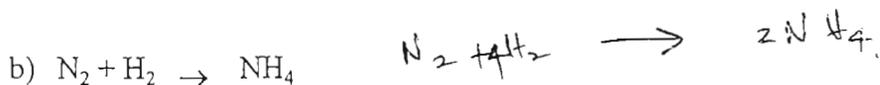
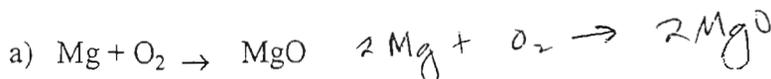
2.4. How would you clean "dirty" mercury that you collect after it has been spilled onto the floor? *- shake in strong container with redox reagent (3) - NaOH - clean with water and then dry*

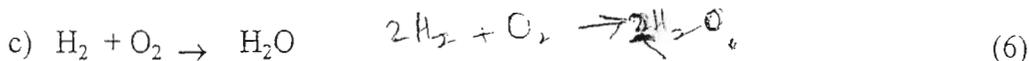
2.5. How would you prepare 200ml of 40% formalin solution. (assume the original solution is 100%). Show all calculations. *40ml formalin + 60ml water (5) = 100ml
 80ml " + 120ml water = 200ml*

QUESTION THREE: 25 MARKS

3.1. One of the dilemmas facing the "science for all" movement is that society demands two things of school science: the provision of specialist personpower and of a scientifically literate citizenry. Briefly discuss this statement with respect to the needs of developed and developing countries. (6)

3.2. Balance the following chemical reaction equations:





3.3. Use your knowledge of the Periodic Table to answer the following questions:

- Define a Group \downarrow
 - Define a Period \leftrightarrow
 - Name a metal which forms a single bond when it combines with another element. *Cu*
 - Name a non-metal which forms a single bond when it combines with another element. *C*
 - Name a non-metal which forms two bonds when it combines with another element. *C*
- (5)

3.4. Study the electric circuit below and answer the questions that follow:

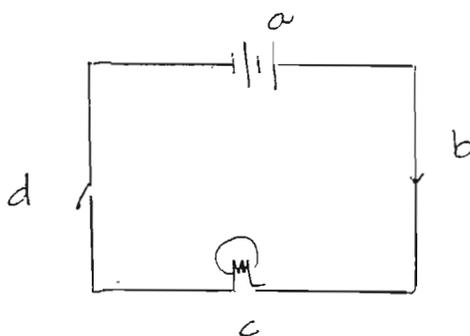


Fig.1

3.4.1. Label the components a,b,c,d in fig.1

*a cells
b wire
c bulb
d switch*

(4)

3.4.2. What would you do to double the brightness of (a) in the above circuit? (1)

double cells.

3.4.3. Which of the above is:

- the user of electricity - *bulb*
- the carrier of electricity - *wire*
- the producer of electricity - *cells*

(3)

