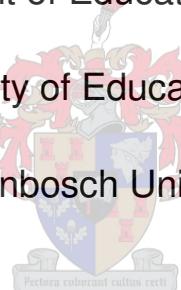


**Towards a conceptual framework for the integration of
critical thinking into a teacher education curriculum:
addressing some of the educational challenges of South
Africa.**

Dissertation in partial fulfilment of the requirements for the degree of
PhD in Philosophy of Education

in the Department of Education Policy Studies

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Stellenbosch University



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December 2019

DECLARATION

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ABSTRACT

There seems to be a general acceptance that the development of critical thinking should be an important aim of higher education. The notion of critical thinking was presented as being particularly pertinent to the transformative goals of the new South African democracy and was included as an essential cross-field requirement in educational policy at both higher education and school level. The purpose of this study is to explore how notions of critical thinking manifest in relation to policy and pedagogy in initial science teacher education.

My research methodology is interpretive hermeneutics and my research method entails a conceptual and deconstructive analysis of notions of critical thinking as they are revealed in the literature, dominant South African educational discourse, South African teacher education policy and physical science school curriculum documents. Each subsequent cycle of the analysis results in an expansion of a conceptual framework on notions of critical thinking in relation to science teacher education. Throughout the dissertation I develop insights through an interrogation of the literature, where I search for and formulate constitutive meanings, that is, shared assumptions and understandings of notions of critical thinking. These constitutive meanings serve as indicators that guide my analysis of education policy pertinent to my study. In addition, I identify conceptual gaps by reflecting on how notions of critical thinking may be relevant to the role of the science teacher. Furthermore, my own personal experience as a teacher educator informs my exploration. The study culminates in the development of an elaborated conceptual framework which contains dimensions of critical thinking that hopefully have the potential to inform how science teacher education programmes can operationalise notions of critical thinking in the subject discipline of Physical Science. These dimensions are perspectives on notions of critical thinking which influence the teacher's conduct, features of critical thinking which are key concepts related to critical thinking, particularly the notion of a reflexive praxis that highlights the teacher's professional judgement, pedagogical aspects which are likely to promote critical thinking in the classroom, and finally, the pedagogical focus which highlights the epistemological and methodological nature of science. Implications of the elaborated conceptual framework for science teacher education programmes are discussed.

Key words: critical thinking, science teacher education, reflexive practice, pedagogy, policy, South African educational discourses, conceptual elaboration

OPSUMMING

Daar is blykbaar algemene aanvaarding dat kritiese denke 'n belangrike rol van hoër onderwys speel. Dit is veral belangrik vir die transformerende doeleindes van die Suid-Afrikaanse demokrasie. Kritiese denke is dus as 'n belangrike kruisveld behoefte in opvoedingsbeleid in beide hoër en basiese onderwys ingesluit.

My navorsingsmetodologie is interpretatiewe hermeneutiek en dit behels 'n konseptuele en dekonstruktiewe ontleding van begrippe van kritiese denke soos dit voorkom in Suid-Afrikaanse opvoedkundige diskouers, die Suid-Afrikaanse onderwysbeleid en die beleidsdokumente vir die fisiese wetenskap kurrikulum. Elke opeenvolgende siklus van hierdie ontleding dra by tot die opbou van 'n konseptuele raamwerk wat uiteindelik idees van kritiese denke in die wetenskaponderwys verteenwoordig. My navorsing behels die ondersoek na konstitutiewe betekenisse van die konsep 'kritiese denke' in die literatuur. Dit wil sê, gedeelde, aanvaarde betekenisse van 'n konsep wat in die literatuur voorkom. In hierdie verhandeling ontwikkel ek deurgaans insigte deur middel van 'n bevraagtekening van die literatuur oor kritiese denke waar ek na konstitutiewe betekenisse soek en dit formuleer. Hierdie konstitutiewe betekenisse dien as rigtingaanduiders vir die analise van die opvoedingsbeleid van my keuse. Ek identifiseer ook konseptuele gapings wat van toepassing op die rol van die wetenskaponderwyser is, maar in die literatuur ontbreek. Verder, belig my persoonlike ervaring as 'n opvoeder in die onderwysopleiding ook die rigting wat my studie inneem. Hierdie studie kulmineer in die ontwikkeling van 'n uitgebreide konseptuele skema of raamwerk met dimensies van kritiese denke wat hopelik tot die hantering van die konsep 'kritiese denke' in die skoolvak, fisiese wetenskap kan bydra. Hierdie dimensies sluit in perspektiewe van die konsep, 'kritiese denke' wat die onderwyser se gedrag kan beïnvloed, sleutelienskappe van kritiese denke veral die idee van 'n refleksieve praktyk wat die onderwyser se profesionele diskressie belig, pedagogiese aspekte wat kritiese denke in die klaskamer bevorder en laastens die pedagogiese fokus wat die epistemologiese en metodologiese aard van wetenskap beklemtoon. Implikasies van die bevindings vir wetenskap onderwys word ook bespreek.

Sleutel woorde: kritiese denke, wetenskaponderwys, refleksieve praktyk, pedagogie, opvoedingsbeleid, Suid Afrikaanse opvoedingsdiskoerse, konseptuele uitbreiding.

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I dedicate this dissertation to the memory of my physical science teacher, Dr Salie Adams.

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ABBREVIATIONS AND ACRONYMS

BAAS	British Association for the Advancement of Science
BEd	Bachelor of Education
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statement
CASE	Cognitive Acceleration through Science Education
CHE	Council on Higher Education
CNE	Christian National Education
CPUT	Cape Peninsula University of Technology
CT	Critical thinking
CTG	Critical Thinking Group
DHET	Department of Higher Education and Training
DoE	Department of Education
EDF	Education Deans' Forum
ELRC	Education Labour Relations Council
ETDP SETA	Education, Training and Development Practices Sector Education and Training Authority
FET	Further Education and Training
GET	General Education and Training
HEQF	Higher Education Qualifications Framework
HEQSF	Higher Education Qualifications Sub-Framework
HESA	Higher Education South Africa
ICT	Information and Communication Technology
IKS	Indigenous Knowledge Systems
MRTEQ	Policy on the Minimum Requirements for Teacher Education Qualifications
NMMU	Nelson Mandela Metropolitan University
NCS	National Curriculum Statement

NOS	Nature of Science
NPF	National Policy Framework
NQF	National Qualifications Framework
OBE	Outcomes-Based Education
PCK	Pedagogical content knowledge
PEDs	Provincial Education Departments
PDS	Professional development schools
PLCs	Professional learning communities
PTSAs	Parent, Teacher and Student Associations
RNCS	Revised National Curriculum Statement9.3
SA	South Africa
SACE	South African Council for Educators
SAQA	South African Qualifications Authority
SI	Scientific Inquiry
STEM	Science, Technology, Engineering, and Mathematics
SU	Stellenbosch University
TUT	Tshwane University of Technology
UFH	University of Fort Hare
UFS	University of the Free State
UK	United Kingdom
USA	United States of America
UWC	University of the Western Cape
WCED	Western Cape Education Department
WITS	University of the Witwatersrand

CHAPTER 1

EMBARKING ON AN EXPLORATION OF NOTIONS OF CRITICAL THINKING IN SCIENCE TEACHER EDUCATION

1.1 Introduction

Critical thinking (CT) is not a new notion, extending from various epochs, such as the eighteenth-century Enlightenment, the Renaissance, and the Aristotelian and Socratic eras as noted by Facione, Sánchez, Facione and Gainen (1995:2). Facione et al. (1995:2) acknowledge the view that critical thinking can be regarded as a liberatory force in education as well as a powerful resource in personal and civic life. Critical thinking became the buzz phrase more than three decades ago, especially in the United States, where there was a concerted attempt to integrate critical thinking into higher education curricula. This movement for integrating notions of critical thinking into higher education started in earnest in the eighties. Academic discourses on how to conceptualise critical thinking as well as the best way to develop critical thinking among students abounded (Ennis, 1987, Siegel, 1980, 1988; Paul, 1992, Chaffee, 1992; Cromwell, 1992). Facione (1990:4) indicated growing agreement with advocates of a liberal education that the heart of education lay in the process of enquiry, learning and thinking, rather than in the accumulation of disjointed skills and content. Universities and state departments thus included critical thinking requirements into their programmes. Paul (1992:4-5) posits that human beings have the propensity for rational and irrational thought, and that both have implications for learning. He argues that critical thinking could be used as a tool for acquiring knowledge in a way that enhances authentic learning, and that through critical thinking, students will not only be able to learn effectively in their discipline but also be better equipped to address the challenges of a complex, modern world.

In South Africa, however, the overt requirement for critical thinking came a decade later, with the onset of the newly formed democracy which served as a stimulus to overhaul education programmes radically. Since the onset of democracy in South Africa (SA) in 1994, the quest to develop an appropriate national educational system has been ongoing. One of the main challenges was to establish a single, unified educational system underpinned by the transformative goals of the new constitution. Concomitant with this was the development of a new outcomes-based school curriculum (DoE, 1997), which has

subsequently undergone a series of changes in the General Education and Training (GET) and Further Education and Training (FET) phases. One aspect that did not change was the requirement for the development of critical thinking which features prominently in the generic critical outcomes presented by the South African Qualifications Authority (SAQA:2000) for all students across the education spectrum. The notion of critical thinking was presented as particularly pertinent to the transformative goals of the new democratic nation. Qualities such as the ability to think critically in order to make informed decisions and to solve problems in social, scientific and economic contexts are highlighted (SAQA, 2000:18-19). These qualities conform with the strategic goal to develop individuals who can contribute to the social and economic development of the new South Africa. Implicit in this requirement is the envisaged need for teachers to change their pedagogy from one which is more didactic and teacher controlled, to one which encourages active learner participation. Despite the rhetoric, there were no specific guidelines which showed teachers how to develop critical thinking in their learners¹.

In this chapter I present the background to, rationale for and focus of my research as well as introduce the methodological choices made for my study, which involves a conceptual and deconstructive analysis of notions of critical thinking. I also provide a fleeting examination of how critical thinking manifests in the prospectuses of selected universities as a prelude to my study at the very beginning of my research journey. Furthermore, various notions of critical thinking from the literature are examined and implications of these notions for teacher pedagogy are addressed. The chapter concludes by providing an overview of the study.

1.2 Background to the proposed research

In 2003, science curriculum advisers of the Western Cape Education Department (WCED) approached lecturers (of whom I was one) at the then Peninsula Technikon² and requested that we work together to assist teachers in using teaching and learning strategies that would develop critical thinking in their own learners. The Critical Thinking Group (CTG) was formed which consisted of Science and Technology lecturers, science curriculum advisors of the WCED, and teachers from schools that had worked with us on a previous project. A decision was made to focus on strategies that would facilitate argumentation as a component of critical thinking in the school science classroom.

¹ I use the term learners for school pupils.

² Peninsula Technikon merged with Cape Technikon in 2005 to form the Cape Peninsula University of Technology.

Considerable work on argumentation in the science classroom had already been done in other countries at that time, such as the UK (Newton, Driver & Osborne, 1999), Spain (Jiménez-Aleixandre, Rodríguez & Duschl, 2000; Jiménez-Aleixandre & Pereiro-Muñoz, 2002) and Israel (Zohar & Nemet, 2002). It was envisaged that the group would be able to learn from the insights gained in these studies. The first three years of the project focused on assisting and introducing in-service science teachers to teaching methods and techniques that would enable them to facilitate argumentation in their own learners. Subsequent years focused on work with pre-service student teachers. A module on critical thinking and argumentation was developed for the method course of the final-year science education students. We have reported on the nature of teachers' argumentation (Scholtz, Braund, Hodges, Koopman & Lubben, 2008), learners' argumentation abilities before teaching (Lubben, Sadeck, Scholtz & Braund, 2010), and the different argumentation outcomes of scientific and socio-scientific contexts for lessons (Braund, Lubben, Scholtz, Sadeck & Hodges, 2007), as well as facilitated reflection on introducing the module on argumentation into a pre-service teacher education programme (Braund, Hewson, Scholtz, Sadeck & Koopman, 2011).

Feedback from pre-service student teachers revealed that they would have liked to have had exposure to the concepts and practice of critical thinking much earlier in their four-year degree programme. Lecturers at a departmental meeting in June 2011 also expressed their concern at the lack of critical thinking displayed by students. If critical thinking were not prioritised as a worthwhile educational endeavour in the teacher education programme, then the likelihood that graduates would consciously address its development in their own learners would be low. One way of addressing this concern is to formally integrate the notion of critical thinking into the four-year Bachelor of Education (BEd) programme. This led to my thinking about the way in which critical thinking is articulated and operationalised in teacher education programmes in South Africa and prompted me to do an initial exploration at the time.

1.3 A preliminary exploration of teacher education programmes in South Africa

Teacher education curricula normally focus on general education courses such as the history, psychology and philosophy of education, content specialisation courses such as science, business or languages, communication courses, and teaching and learning method courses. Student teachers may be required to think critically when confronted with

assignments and assessment tasks in various courses of their programme. Some of the theory courses may focus on critical thinking as a concept, yet the links between these courses and the implications for the development of critical thinking in the other courses in the programme need not necessarily be articulated. If these links are made explicit and sustained throughout the programme, they may enhance the development of critical thinking in students. I contend that the notion of critical thinking is implicit and inferred, and that teacher education programmes that promote critical thinking explicitly can make a contribution towards addressing some of the educational challenges of South Africa.

A preliminary exploration of the 2011 prospectuses of the education programmes at three higher education institutions in the Western Cape was done. These institutions are the Cape Peninsula University of Technology (CPUT), Stellenbosch University (SU) and the University of the Western Cape (UWC). At CPUT there is no reference to critical thinking in the prospectus. At SU, however, mention is made in its vision statement that the education offered at the faculty is designed to develop, among others, '*critical and creative philosophical thinking*'. The SU prospectus, in its introduction, indicates: '*The main duty of educators is to help see that learners receive support of the kind that in the long run enables them to acquire and foster the values, knowledge, skills and opportunities that are of benefit to communities and individuals alike.*' CPUT is less generalised and more focused on specialisation. For instance: '*The aim of the course is to equip students with the knowledge, skills and values needed to effectively mediate learning in the field of further education and training, specializing in Natural Science and Technology Teaching.*' In all three prospectuses, the emphasis is on listing the prerequisites needed for admission as well as listing the subjects that a prospective candidate can choose, without providing much detail as to the approaches employed. In addition to the aforementioned, both UWC and SU provide module descriptors for each course. At SU, topics for the module content are listed. Reference to critical thinking is limited, except in 'Language and Literature in Context 178, in the literature and film studies module, where it is indicated that '*Critical and analytical skills related to a study of selected novels, dramas and films*' will be covered. In the module 'Multireligion and Multicultural 377', the following appears. '*The development of cultural and religious literacy in order to use a critical perspective to identify the diversity of religions, value orientation and cultures in the school environment...*'. On the other hand, at UWC the notion of critical thinking features more prominently in both general and specialist courses. In some of the courses, for example, in Education 4, the student is expected to '*Engage critically with literature in Philosophy and Philosophy of Education*' as well as

'Engage critically with debates around the concept teacher professionalism.' In a specialist subject like 'Method of Teaching Economic and Management Sciences', one of the main outcomes is stated as follows: *'Critically engage with the policies and principles underpinning the teaching at General Education and Training (GET) level.'* Students are expected to *'Critique the seven roles of the educator, and the associated practical, foundational and reflexive competences within each of these seven roles...'* as well as *'Evaluate the Grade 7 to 9 textbooks for their relevancy, socially critical approach and design features.'* Similar expectations are scattered throughout the module descriptors of the other courses.

A further examination of Bachelor of Education prospectuses of a representative sample of universities nationally reveals similar trends. These universities participated in the student engagement survey 2010 (Strydom & Mentz, 2010). They were chosen as broadly representative of the universities in the country and ranged from historically advantaged institutions such as the University of the Witwatersrand (Wits) and the University of the Free State (UFS), historically disadvantaged institutions such as the University of Fort Hare (UFH), merged institutions like the Nelson Mandela Metropolitan University (NMMU)³, to universities of technology such as CPUT and Tshwane University of Technology (TUT). The prospectuses all featured aspects such as admission requirements, pass requirements and lists of the courses offered from first- to fourth-year level. Wits is the exception, as the prospectus, like those of UWC and SU, not only lists the various courses offered but also gives a short description of what is covered in each course. The development of critical thinking features explicitly in the Education Studies and Teaching Experience courses. For example, in Teaching Experience 1: *'The development of appropriate academic skills and critical thinking'*; and in 'Studies in Education 3: *'Critical conceptual and theoretical analyses of issues pertinent to education'*; while in Studies in Education 4: *'Advanced critical investigation of issues in education such as mediation, democracy and citizenship, reflective practice, professionalism; development of critical thinking and analysis relevant to education; development of an autonomous critical and practical perspective.'* Implicit reference to critical thinking is also made in other courses at Wits. For example, this statement in English in Education 2 implies critical engagement with the role of English as a language of learning in diverse South African contexts. *'Further study of language (specifically English), including attention to some of*

³ The name was changed from Nelson Mandela Metropolitan University to Nelson Mandela University in July 2017.

the major debates in linguistics, with particular reference to the role of English in education in the context of South African society.' And yet again in 'Biology in Education 2, the 'teaching of controversial biological issues' implies a critical engagement that has the potential to draw on students' critical thinking abilities. Other socio-scientific aspects drawing on critical thinking abilities are also articulated. For example, in Physical Science in Education 4: '*Critical evaluation of issues involved in environmental chemistry*'. In Geography and Environmental studies at all levels the following appears: '*Critical evaluation of teaching and learning strategies*'. A more recent examination of the 2018 prospectuses for the same universities reveals no new insights.

The way in which critical thinking features in the 'intended curriculum' as expressed in the prospectuses may or may not be operationalised in the 'implemented' curriculum. That is, does the curriculum actually do what it intends? So, in spite of the limited or lack of explicit reference to critical thinking in a public document such as the prospectuses at the universities other than Wits and UWC, it is possible that the requirement for critical thinking may in fact feature in their respective courses. However, perspectives on notions of critical thinking differ, and if the construct is valued as an important inclusion in teacher education programmes, then clarity on the way it is viewed and implications for teacher education programme development are worth exploring.

1.4 Purpose of the research

The purpose of the study is to explore how notions of critical thinking manifest in the literature, South African educational discourses, South African teacher education policy, and physical science school curriculum documents for the Further Education and Training (FET) phase. It is hoped that the insights gained have the potential to inform how science teacher education programmes can operationalise notions of critical thinking in the subject discipline of Physical Science.

1.5 Methodological aspects

My research design is interpretive hermeneutics, which contains two parts, namely, my research methodology, which is interpretivism, and my research method, which involves a conceptual and deconstructive analysis of notions of critical thinking in the literature, South African teacher education policy documents, and school physical science curricula. I employ a layered approach in which I explore notions of critical thinking in education

generally and in science teacher education specifically. With each subsequent layer, in my search for constitutive meanings (Fay, 1975) of notions of critical thinking, I expand the conceptual elaboration as I move towards considerations of science teacher education programmes. Understanding emerges through iterative cycles of comparison and reflection. I give a more detailed description of my research design in Chapter 2.

1.6 Contribution and delineation of this study

Various studies in South African classrooms support the idea that any conscious intervention in developing critical thinking can make a difference (Mashike, 2000; Kaminsky, 2004; Webb & Treagust, 2006). Interventions using particular approaches to develop the critical thinking skills of student teachers in South Africa have been reported on. Kloppers (2009) investigated the impact of Feuerstein's Instrumental Enrichment Programme on the development of the cognitive skills of student teachers and concluded that the programme possesses the latent potential to improve and develop thinking skills. Lombard and Grosser used the Cornell critical thinking test (2004) and later the Watson–Glaser critical thinking test (2008) to determine the critical thinking ability of first-year student teachers. They revealed deficient critical thinking abilities among the participants and suggested that the teaching methodologies used by teachers in South African schools did not focus on developing critical thinking. Work with in-service biology teachers showed that an intervention-enhanced pedagogy promoted higher-order thinking skills (Du Preez, 1998). However, to date little research has been done on how to prepare student teachers to develop critical thinking in their own learners, particularly in African contexts. Studies on learning to teach argumentation have been reported on (Scholtz, Sadeck, Koopman, Hodges, Hewson & Braund, 2008; Braund et al., 2011), but these focus on argumentation as a particular kind of intervention, rather than looking at implications for curriculum development more broadly.

Success in enhancing critical thinking ability in higher education has been highlighted in many studies (Bensley, Crowe, Bernhardt, Buckner & Allman, 2010; Alwehaibi, 2012). Most authors concur that pedagogy and contexts that create an enabling yet challenging environment which presents opportunities for students to participate actively in their own learning would be more likely to succeed.

International studies (Paul, Elder & Bartell, 1997; Cosgrove, 2011, 2013) have examined educators' notions of critical thinking based on the assumption that such notions will

impact on enactment in the classroom, whether at school or university. Initially, I considered this as an option for my study, possibly focusing on those universities that offer teacher education programmes. However, I realised that the findings would be highly site specific. While such a study might reveal practices that could inform programme design, it could verge on the episodic. I needed a more comprehensive data source to guide my exploration. Two types of policy influence teacher education programmes in South Africa. They are teacher education policy and school curricula policy. The former type informs teacher education programme development and the latter type guides teacher pedagogy. This study, therefore, focuses on the way in which critical thinking features in South African teacher education policy and physical science curriculum documents. It explores the potential for promoting pedagogies that will foster critical thinking in the classroom. Insights from the study as well as literature reviews and document analysis could serve as a guide to integrating critical thinking into a science teacher education curriculum.

1.7 Assumptions

Any teacher education programme that expects student teachers to teach in a way that enhances critical thinking should do the following:

- Value critical thinking as an important dimension of education.
- Regard students as thinking human beings who have the capacity to form their own opinions and make their own decisions.
- Have critical thinking as a significant feature of the broader curriculum.
- Endeavour to foster and develop critical thinking in their students through the programmes on offer.
- Support and encourage practices that develop critical thinking in their own students.
- Provide an enabling environment that would foster critical thinking.

1.8 Ethical considerations

The study is essentially a theoretical one which focuses on literature reviews and analysis of documents which are in the public domain; hence the study does not present ethical dilemmas or consequences for individuals or institutions. Ethical clearance to conduct the research was, however, granted by the institution of which I am a member, as there is a self-reflective aspect to my role as a science and technology educator which may reveal ways in which the institution and its staff operate.

1.9 Conceptions of critical thinking

A quick internet search on ‘critical thinking’ yielded over 20 million responses. So, when this requirement for critical thinking is articulated in policy documents and programmes, it is likely that it may be understood in a variety of ways. A perusal of the literature also reveals different conceptualisations of critical thinking. I now proceed to outline various conceptions of critical thinking from the literature as a general introduction to a more pertinent discussion of the implications of notions of critical thinking for science teacher education programmes later in the dissertation.

1.9.1 Critical thinking, democratic citizenship and higher education

As a start I consider the role of higher education in nurturing the development of the student teacher as a democratic citizen, who uses his or her professional judgement to make educational choices. Martha Nussbaum (2002:289–303) counterposes Socrates’ notion of the ‘examined life’ as the best preparation for citizenship versus the notion of acculturation and tradition. She draws on Seneca’s ideas of a ‘cultivated humanity’, which echoes Socrates’ ideas of encouraging students to be in control of their own thinking and to examine critically traditional practices as an approach by higher education to shape future citizens in an age of all manners of diversity and increasing globalisation. Nussbaum warns that our exchanges will be reduced to narrow norms of market exchange if our institutions of higher education do not cultivate a richer network of human interactions.

Nussbaum points out that higher education should produce adults who function as citizens, not just of some local region or group, but as citizens of a ‘complex interlocking world’ (2002:292). The rapid advancement of information technology does make this possible and, in a way, even essential. However, I think that teachers grappling with local issues and conditions may lose sight of their global citizenship. Would an international perspective detach them from the community in which they operate or would it enable them to make the links between the local and the global? In addition, how would an international orientation relate to the appeal that an African perspective should be placed at the core of curriculum development in Africa? The argument is that universities in Africa are still largely Eurocentric and do not prioritise African needs and perspectives. I elaborate on this aspect later in the dissertation.

Nussbaum (2002:289–303) argues that three capacities are crucial for cultivating citizenship that affirms humanity in today’s global world. They are the capacity to examine

oneself and one's own traditions critically; the ability to think as a citizen of the world, sharing a common humanity, rather than as a member of a local group or community; and the imaginative capacity to put oneself into the shoes of an individual very different from oneself. She advocates that courses in literature and the arts would cultivate these three capacities. The implications of promoting these three capacities in teacher education as part of a higher education scenario could be considered. However, even though this may be a starting point, it may not be sufficient to encourage the 'examined life' as espoused by Socrates, because the challenge is to present programmes in ways that highlight the capacities to which Nussbaum refers. The critical thinking component needs to be nurtured and this requires conscious intent, an enabling environment and concomitant pedagogy. This implies a democratic context in which students and staff are able to express themselves and critique the status quo without fear of retributive consequences. Critical dialogue and imaginative conversation, as espoused by Maxine Greene (1995:5), could enable the 'teachers-in-becoming' to evolve their own professional identities in a way that would '*cultivate multiple ways of seeing and multiple dialogues in a world where nothing stays the same*'. (Greene, 1995:16).

Creative ways of doing this can assume their own form and content, depending on the context. However, this implies a greater degree of flexibility in shifting parameters of organisational control, as the faculty operates within the broader institution that has its own organisational norms and academic traditions which may be fairly fixed and prescribed. Navigating around these norms and traditions could be quite a challenge. In turn, the institution is governed by national requirements of higher education policy and rules for accreditation (DHET, 2015).

A cursory examination of South African education policy documents (DoE, 1995, 1997) reveals critical thinking as a component of democratic citizenship and it is presented as a necessary condition for the vision of a democratic nation. However, a closer analysis of selected teacher education policy documents is described in Chapter 5 in which other tendencies are also uncovered. Democracy as a social construct implies particular kinds of relations among people – relationships in which people interact with one another on a basis of equality, despite their differences. Hence, democratic education offers an approach in the classroom in which participants are encouraged to learn through critical deliberation and interact without fear of reprisal. However, the classroom, whether at school or university, is not an isolated entity and functions in a much broader context (school, community, country). Cultivating critical thinking as a component of a democratic

education could contribute to unlocking the potential of the child, despite limiting educational contexts. It might be good to pause for a moment and consider the work of Waghid (2014a:1–28) who acknowledges the contribution of notions of democratic education that emphasise iterative reasoned, reflexive deliberation in unrestricted or non-threatening spaces; argumentation driven by moral and ethical imperatives, an inclusive orientation, compassion and care. Yet he suggests that these liberal conceptions of democratic education might be insufficient to maximise democratic participation in education. His argument is that they may not be disruptive enough to evoke encounters that would promote the unexpected, the improbable or the unheard of. The implication is that it may be ‘business as usual’, while paying lip service to democracy. He draws on Derrida’s notion of friendship where the role of the teacher is to provoke the students to see things anew in search of a new becoming. He regards this as a ‘democratic education in becoming’ which opens up possibilities. The notion of friendship for the student signifies a love that serves as a ‘catalyst’ for learning. These disruptive, provocative encounters can engender ways of becoming that resonate with the possibility of seeing things anew.

1.9.2 Critical thinking and critical pedagogy

The constructs ‘critical thinking’ and ‘critical pedagogy’ are often used interchangeably. Burbules and Berk (1999:45–65) provide a useful comparison between critical thinking and critical pedagogy. According to them, both traditions are motivated to overcome ignorance, to test the distorted against the truth and to ground effective human action in an accurate sense of social reality. Their orientation, however, is somewhat different. As pointed out by Burbules and Berk (1999:45–49), the critical thinking tradition emphasises the individual’s quest for clarity, truth and empirically informed reason and action. The critical pedagogy tradition, on the other hand, emphasises the quest for exposing institutions, ideologies and relations that sustain unequal power relations with the intent of transforming them. For me, here lies the paradox – critical pedagogues need the reasoning skills as espoused by the critical thinking tradition to identify those oppressive systems they seek to challenge, while for critical thinkers, as also noted by Burbules and Berk (1999:45–66), in the process of seeking accuracy and truth, one of the consequences may be to expose and challenge deceptive institutions or systems that maintain states of oppression. In short, they become critical pedagogues if motivated enough to see their convictions through to action.

In education, Paulo Freire (1970, 1996) epitomises the critical pedagogy tradition together with such theorists as Henry Giroux and Peter McLaren. Freire (1970, 1996) rejects the

banking concept of education which maintains the power relations in society, but rather encourages a movement of enquiry towards humanisation and ultimately liberation. Although the contexts of Freire's work may have been different, yet, while conditions prevail that cause people to remain passive, unquestioning receivers of content, his work still remains applicable. Although Freire (1970, 1996) acknowledges that even though people may be the recipients of the banking method of education, they may perceive its consequence and hence engage themselves in the struggle for liberation. For Freire (1970, 1996), critical thinking can be considered a key component of this quest for humanisation. Critical pedagogy is about an approach to teaching and learning which exposes unequal power relations and seeks to give voice to the oppressed and subjugated, while critical thinking focuses on a way of thinking with rationality at its core. Yet the two traditions might not necessarily be mutually exclusive.

I now turn to further conceptualisations of critical thinking in my attempt to establish relevancy to teacher education in general and science teacher education in particular.

1.9.3 Critical thinking and other kinds of thinking

One way of conceptualising critical thinking is to consider how it may be different from other kinds of thinking as suggested by Coney (2015:515–528). By implication, a consideration of what it is and what it is not. I thus turn to Coney (2015:515–528), who provides a useful categorisation of forms of thinking by drawing on ancient Greek classical philosophy, particularly Aristotle. Coney (2015:515–528) identifies three other ways of thinking that would not necessarily be considered critical thinking. They are technical-instrumental, practical, and contemplative thinking. The point is made that it was not until the European Enlightenment that critical thinking was theorised as a discrete form of thinking, even though the debates waging in ancient Greece could be considered a manifestation of critical thinking. Coney (2015:515–528) elaborates on all three and then explains the features of critical thinking in greater depth. According to Coney (2015:515–528), technical-instrumental thinking objectifies the material world and is prevalent in the trades as well as in science and technology, where physical things are transformed to produce things that satisfy human needs and desires. In addition, the point is made that technical-instrumental thinking may also objectify human beings. The terms 'human resource management' or 'human capital' come to my mind and possibly accord with this technical-instrumental notion of thinking, by viewing and treating people as if they were commodities.

Coney (2015:515–528) explains practical thinking as thinking which contributes to the smooth functioning of everyday human social interaction. This kind of thinking involves processes of interpersonal engagement and is mooted as the most pervasive of the four kinds of thinking, which begins in infancy as soon as a person starts to use language and is a conduit for thought. I suppose that the thinking involved in uncritically following rituals, traditions and accepted practices in a society could also be viewed as part of practical thinking.

Contemplative thinking, according to Coney (2015:515–528), is theorising about things which are timeless, such as God, and the universe, contemplation of ideas as well as the identification of timeless patterns in the abstract, numerical and natural worlds. Though contemplative thinking may have applications in the real world, it is still distinct from techno-instrumental thinking as it is driven by a desire to understand or to know something for its own sake.

Coney (2015:515–528) turns to Habermas (1976) for a clarification of critical thinking as different from the aforementioned types of thinking. Here, critical thinking as a distinctive kind of thinking is not as clear-cut as the previous explanations. Rather, it presents the type of circumstances calling for critical thinking. One of the pertinent considerations is the need for critical thinking in a crisis situation, in which appropriate judgements need to be made which will help to resolve the crisis. So, according to Coney (2015:515–528), there is definitely a judgemental aspect to critical thinking.

The types of thinking as identified by Coney (2015:515–528) are quite useful, as they offer a broad perspective of categories, seemingly based on a purpose for thinking. For the four types identified, the purposes may possibly be classified as instrumental, interactional, for understanding or for problem solving. However, when we reflect on implications for classroom practice, these formulations become too vague. What kind of thinking is involved, for instance, in rote learning so prevalent in South African schools? It could possibly fit into the practical category but needs to be examined a little further. Could it be valuable for learning? Possibly, if it serves as a basis for development of insights. Is it critical thinking? Not according to the formulations of critical thinking discussed up to this point.

So, if, according to Coney (2015:515–528), critical thinking involves addressing a crisis or a problem based on sound judgement, then it would still need to draw on some or all of

those reasoning abilities that have been designated as necessary for critical thinking, such as appropriate analysis, evaluation, inference and so forth, around the issue at hand. Where does that leave critical thinking in education? If one accepts the different kinds of thinking presented by Coney (2015:515–528), then most of what the teacher does in the classroom would comprise the first three kinds to a larger or lesser degree. Much of the thinking done by the teacher or the learner for that matter may simply be procedural. When does it become critical? How do we promote this in the learners? How then, will the teacher in the classroom provide such opportunities for their learners in which they draw on these abilities to make sound judgements that would not only enhance their competence in the subject, but also enhance their critical thinking capacities? The literature presents many methods which encourage reflective enquiry to address simulated or authentic scenarios that require judgement on the part of the student, such as case studies, argumentation around controversial issues, problem-based learning, and so on (Hmelo-Silver, 2004; Dawson & Venville, 2010; Herreid & Schiller, 2013). I now turn to more concise ways of describing critical thinking.

1.10 More concise notions of critical thinking

The view that critical thinking is an active process features in the literature on many occasions. Dewey wrote about ‘good thinking’ as ‘*more or less troublesome because it involves overcoming the inertia that inclines one to accept suggestions at their face value*’ (Dewey, 1910:13). I could interpret this as overcoming the laziness of the mind in order to think more actively by possibly questioning assumptions, addressing aspects of accuracy and truth, aligning claims made by others with evidence, or drawing on one’s own experience. Many theorists specify an active engagement with ideas and information, such as the ability to analyse, question, imagine possibilities and make appropriate judgements, among others, as a condition for critical thinking (Bloom, 1956; Ennis, 1987; Facione, 1990; Duron, Limbach & Waugh, 2006; Swartz, Costa, Beyer, Reagan & Kallick, 2010). Bruner (1996:126) points out that learning in itself is not enough, but that what one has learned needs to be put to use, which in itself is an active process: ‘*The leap from mere learning to using what one has learnt in thinking is an essential step in the use of the mind*’ (Bruner, 1996:126).

Some scholars describe the nature of the thinking process, while others list abilities or characteristics of critical thinkers. For example, Ennis (1987) highlights the reflective aspect of critical thinking, whereas Duron et al. (2006) emphasise the ability to evaluate or

judge beliefs, assumptions and information. In Facione's *Delphi Report* (1990), a team of experts identified core critical thinking skills. These are presented as interpretation, analysis, evaluation, inference, explanation, and self-regulation. Paul et al. (1997) include a value dimension to their underlying core meaning of critical thinking that refers to traits such as faith in reason, fair-mindedness, intellectual empathy and intellectual integrity.

On the other hand, Bailin and Siegel (2003:181–193) choose not to define critical thinking as a particular set of procedures or mental operations. Rather, they present their notion of critical thinking as a variety of 'good' thinking. They assert that to characterise thinking as 'critical' is to judge that it meets relevant standards or criteria of acceptability and is thus appropriately thought of as 'good'.

Two important dimensions of critical thinking are discerned in the literature: these are a dispositional dimension and a cognitive ability dimension (Facione et al., 1995). This implies the willingness to think critically, which is different from the skill to engage in critical thinking. This concurs with the observation of Vandermensbrugghe (2004:417–422), who examined trends in critical thinking definitions and concluded that two categories could be discerned. The first category refers to the ability to develop a capacity to reason logically and coherently, while the second category refers to the ability to question and challenge existing knowledge and the social order.

So, while reasoning ability is an important aspect of critical thinking, the inclination to reason rationally is also considered a significant feature of critical thinking. The California Critical Thinking Disposition Inventory (Facione & Facione, 1992) is the first instrument which lays the groundwork for attempting to measure disposition towards critical thinking empirically. The instrument focuses on the following dispositional dimensions: inquisitiveness, open-mindedness, systematicity, analyticity, truth-seeking, critical thinking self-confidence, and maturity. Following Tishman (1994), Facione et al. (1995:21) recommend the 'cultivation of the intellectual character' as one of the goals of the college curriculum, with other attributes such as humaneness, ethics, knowledge, and creativity. Hence, a curriculum that espouses the value of critical thinking would do well to provide some guidelines as to how it can be attained.

My own conception of critical thinking also emphasises these two important aspects: a dispositional aspect and a cognitive ability aspect. Paul (1992:14) refers to these two aspects as intellectual character and intellectual skills. The dispositional aspect would

emphasise a spirit of enquiry that would value such things as truth, accuracy, open-mindedness, and fairness, that is, all the accepted norms of democratic citizenship. The cognitive aspect would emphasise those skills and abilities that would contribute to an enhanced quality of thinking in order to consciously make good judgements and decisions in a variety of contexts, whether within a particular discipline or in life generally. Those cognitive skills, among others, may be the ability to analyse, to ask deep and relevant questions, to interpret, to regulate one's own thinking, and to draw on appropriate evidence, theory and experience using intellectual standards based on sound systematic reasoning. In line with Cromwell (1992:3–24), I believe that critical thinking can include logical approaches to problems or issues as well as creative applications that may at first seem beyond the realm of logic. Hence, critical thinking could also contribute to pushing the boundaries of accepted norms and standards.

1.11 Placing the self

In line with the nature of an interpretive study, the lens of the researcher influences the nature of the exploration and its eventual outcome. My interest in the research is closely aligned with my role as a teacher educator. Hence, it is timely, at this stage of my dissertation, to relate my own journey as a science educator. This looking back has particular intent, that is, to clarify how these conceptual deliberations on the notion of critical thinking may have influenced my educational endeavours in the past, and how this exploration might impact any future educational undertakings going forward.

1.11.1 My own biography

Having straddled all phases of the South African educational system, first as a learner then as a science educator at secondary and tertiary level, before and after the political democracy, I am able to reflect on my own biography in relation to the notion of critical thinking in science education.

As a start, I cast my mind back to how I was taught as a child and what stimulated my interest in science. In primary school in the late sixties and early seventies, science was like any other subject such as history or geography – facts to be memorised. Doing well in tests meant memorising the facts presented by the teacher, writing notes from the blackboard, learning them and giving them back in tests nearly verbatim. This approach was not questioned by parents who were very happy when we obtained good marks. The textbook was the ‘go to’ authority. I do not remember any hands-on activity in the primary

science classroom. Class teachers were generalists and taught all subjects up to Standard⁴ 5. However, for me, language learning was different. Reading aloud and getting to recite poems was a pleasurable activity. Even though we had to memorise the rules of grammar, numerous exercises in applying these rules consolidated our language learning. Reading was an accepted social activity that my friends and cousins indulged in during our spare time. We would exchange books and magazines on a regular basis. No doubt, this reading culture positively influenced our academic performance in subjects such as science. The television was not a feature of our lives in primary school. My exposure to questioning the nature of our separate South African society and the concomitant injustices imposed on the majority of South Africans did not come from school at the time. Such questioning only came later in high school, during the turbulent seventies. Rather, as young children, we were witness to the heated discussions of the adults around us regarding the inequities of our society, during extended family gatherings and intimate domestic settings at home, which we unconsciously absorbed.

High school brought changes. In Standard 6, for the first time, I was exposed to hands-on activity, such as building electrical circuits or doing basic chemical experiments in groups. To a large extent, however, the nature of the assessments comprised term tests and final examinations based on memory recall and procedural aspects of science content knowledge. I selected the science stream, which included Physical Science and Biology, for the senior phase of high school, that is, Standards 8 to 10. Our physical science teacher was conscientious and displayed an enthusiasm for the subject which influenced us positively. He presented science demonstrations and facilitated experiments done by us in groups⁵ for most of the allotted science practical work set out in the syllabus. This was followed up or pre-empted by class teaching in which the science concepts were consolidated. As a consequence, our attainment in tests and examinations was quite high. Failure in his class was an exception. Our biology teacher was serious and stern, but similarly expected application from those she taught. We also participated in hands-on practical work in her class⁶ but not to the same extent as in that of the physical science teacher.

However, we were not exposed to open-ended investigations of our own design at all, which as far as I know was rarely a practice in any school during those times. The inert

⁴ Standards 5 and 6 are comparable to the current grades 7 and 8, while standards 8 and 10 are comparable to the current grades 10 and 12 respectively.

⁵ Ticker-tape experiments, acid and base titrations, inorganic interactions and production of chemicals.

⁶ Food tests, dissections of plants. I cannot recall any animal dissections.

message was that we were learning about and interrogating existing science knowledge. There was no notion of our being able to extend, contribute to or challenge that knowledge. Despite this, the way we were taught set a good basis for some of us to further our careers in the science field.

In 1975, learners could make a choice between doing their subjects on the higher or standard grade. The former grade was cognitively more demanding. The cohort that year, in Standard 8, was compelled to do their subjects on the higher grade as the school management felt that they weren't prepared to be complicit in the 'dumbing down' of their learners.

The biology teacher though, trusted our intellectual abilities sufficiently to leave us to do some aspects of the content we needed for the matriculation examination by ourselves. In addition, to this, I remember a biology test question she set which assessed our ability to apply our understanding of genetics. The challenge was to work out the genotype of an albino lion cub born to two normal-looking parents. As this was not a rehearsed question, it was clearly within the realm of critical thinking as it required us to consider and interrogate our understanding of genetics and make the appropriate justifiable links that would explain the phenomenon.

The transition to university came with its own challenges. As a person of 'colour', I required a permit to study at the University of Cape Town. My choice of 'Microbiology' was my permitted subject⁷ that allowed me entry. I did all the traditional science subjects in that first year in 1978, such as Physics, Chemistry, Botany, Zoology, and Mathematics. My days consisted of lectures in the mornings in large lecture rooms with many students, and science practical work in the afternoons. I did not enjoy the laboratory work. We were required to follow the steps and fill in the accompanying worksheet. Often, for me, the aim was to get it done. I imagine that I refined my techniques in working with the apparatus and developed science process skills such as observations, completing tables and graphs, as well as reaching some conclusions from the observations and data. In general, there was an alignment between the theory that we were exposed to in our lectures and the nature of the science practical classes, which possibly served to consolidate our conceptual understanding. I remember the numerous distillation experiments we did in the first year chemistry class. Ironically, I only understood that the distillation process was

⁷ Universities were designated for the various groups classified 'white, coloured, Indian and African'. The only way a person could study at a 'white' university was if the subject of choice was not offered at the designated university aligned with the person's classification. Subjects like Drama in the humanities and Microbiology in the sciences were popular choices to gain entry.

based on using evaporation points to separate liquids when I taught Standard 6 chemistry, four years later, as I needed to interrogate the process for my learners. This insight made me realise that I had been going through the distillation procedures mindlessly, when at university.

Two things stood out for me in my third year. I chose plant virology as one of my electives. For the first time, we students were expected to read journal articles and do class presentations on their content. This provided us with some insights into the working life and scientific problems and questions pursued by plant virologists. The other vivid memory was the ‘chaos prac’. The lecturer, Professor Von Wechmar, surprised us with what she termed the ‘chaos prac’. All the previous practical classes were of the standard, worksheet-based kind. In the ‘chaos prac’, however, she simply gave us the aim of the experiment, which I cannot recall, and told us to design and execute it ourselves in whichever way we chose within the three hours at our disposal. We students were not used to being given ‘carte blanche’, and the laboratory was indeed chaotic. We were vehemently discussing what steps to take, consulting textbooks, justifying our choices and taking action. Even preparing solutions for plating on our Petri dishes was problematic. Normally we were given explicit instructions to prepare our solutions. This time we needed to make our own decisions on the appropriate solution and its preparation. Needless to say, most of us succeeded in addressing the aim by the end of the three hours and the degree of satisfaction at our own endeavours far exceeded previous attempts at following the steps; a thoroughly challenging yet enjoyable experience. Rancière’s notion (1991, 1–43) of ‘intellectual equality’ comes to mind, where faith in students’ intellectual abilities to apply their own minds in addressing a scientific problem or question is confirmed. It’s a pity that we did not experience more of this throughout our time at the university. A one-year postgraduate diploma in education followed, during which there were no noteworthy occurrences. Content competence was assumed and the focus was on education theories and teaching methods courses. However, our cohort was privileged to visit a gold mine during the June vacation where we worked in groups to develop materials that linked science concepts with mining procedures and processes. Here we were challenged to apply our conceptual understanding of science with real-world processes.

During my high school teaching career, I taught both physical sciences and life sciences at all levels. I had a reputation as a good teacher and my pass rates were excellent. However, I tended to teach the syllabus as specified, and was very much in teacher control mode. Learners would be involved in groups, only during practical classes, which

to a large extent were procedural and worksheet driven. Getting them to design their own experiments was not part of the agenda nor was it a focus of the syllabus, the term used to describe curriculum guidelines. I did however coordinate the participation of interested learners in science competitions, with positive outcomes. This was an extramural activity. Significantly, some of the learners who did well in these competitions were not the academically acknowledged performers. This different format of science involvement appealed to learners who normally did not show an enhanced interest in their normal science classes. The success of science learning in hybrid spaces where learners are not limited by the structured conventions of school science have been reported (Ramnarain & De Beer, 2013).

When doing my BEd at UWC, as an in-service teacher in the late nineties, I was introduced to the notion of accelerated schools. This approach to teaching is based on the premise that every child is regarded as gifted and that the learning environment and interactions in the school should contribute to maximising the child's learning potential (Peters, 1994; Keller, 1995). For the first time I viewed learning from the point of view of the learner and not the teacher. This probably marked the beginning of my journey in exploring the notion of critical thinking. In 1997 I was employed as a contract lecturer at the then Peninsula Technikon.⁸ Since then, I have become a permanent staff member at the university and have taught courses such as Life Sciences, Chemistry and Technology content and methodology to pre-service student teachers. Currently I am also involved in preparing students for their school-based experience. My research and development focus has been on interactive learning and the enhancement of critical thinking in the curriculum. My involvement in the critical thinking group, which focused on pedagogy that facilitates critical thinking, I've already alluded to previously. As described, the focus was on argumentation as one methodology that has the potential to enhance critical thinking. However, for me, this focus was limited, as it did not provide a deeper and broader rationale for the notion of critical thinking in relation to science teacher education explicitly, hence my interest in setting out on this exploration.

1.12 Overview of the study

This chapter provides the background to and rationale for the study which involves an exploration of notions of critical thinking contextualised in science teacher education. It

⁸ Peninsula Technikon merged with the Cape Technikon to become the Cape Peninsula University of Technology in 2005.

also presents a preliminary literature review of notions of critical thinking in education as a prelude to a more in-depth interrogation of the concept in the literature. Furthermore, my own biography *vis-à-vis* notions of critical thinking as a science educator is presented and methodological aspects of the study are briefly explained. Key aspects of subsequent chapters are highlighted, which serve as an overview of the study.

In Chapter 2 I elucidate my interpretive hermeneutic research design, which involves a conceptual and deconstructive analysis of notions of critical thinking as it manifests in the literature, dominant South African educational discourses, teacher education policy and school science curriculum documents. The research approach involves subsequent cycles of expansion on notions of critical thinking to culminate in an elaborated conceptualisation which has relevance to science teacher education. At the core of my exploration is the argument that teacher professional judgement is a constitutive component of critical thinking and hence needs to be considered in any teacher education programme.

In Chapter 3 I embark on the analysis, as the first phase of my analytical cycle, by searching for constitutive meanings (Fay, 1975:70–91) and conceptual gaps in the literature, related to notions of critical thinking and teacher professionalism. Through reflective deliberation on what the literature reveals and my own practice as a teacher educator, I identify features of critical thinking relevant to teacher education. The chapter culminates in the development of a tentative conceptual framework on notions of critical thinking.

In Chapter 4 I use the tentative conceptual framework developed in Chapter 3 as an analytical framework to describe the historical shift in the South African education discourses as outlined by Cross, Carpentier and Ait-Mehdi (2009:475–503) and situate notions of critical thinking and the role of the science teacher in this discourse. The chapter culminates in an expanded conceptual framework which includes perspectives on notions of critical thinking that range from conservative to liberal, radical, and postmodern.

In Chapter 5 I review and analyse the South African policy documents on teacher education. Firstly, I present my analysis of policy documents as a linear trajectory from earliest to most recent in the context of the unfolding teacher educational milieu since 1994. In my analysis, I focus on how the policy documents depict the purpose of teacher education and whether there may be a link with critical thinking, either explicitly or

implicitly, using the expanded conceptual framework developed in Chapter 4 as an analytical framework.

In Chapter 6 I explore the main themes on critical thinking and science education that emerge from the literature, focusing on teaching and learning approaches that enhance critical thinking in the science classroom. Consideration of the methodological and epistemological aspects of science education informs notions of critical thinking related to science teacher education. These insights are included in an elaborated conceptual framework.

In Chapter 7 I use the elaborated conceptual framework on notions of critical thinking in science teacher education developed in Chapter 6, to investigate how notions of critical thinking are articulated in the physical science school curriculum documents for the FET phase.

In Chapter 8 I deliberate on how the conceptual elaboration of notions of critical thinking relates to the idea of a decolonised African university in science teacher education. I highlight rationality as constitutive of critical thinking and argue that different ways of knowing can have rationality at its core.

In Chapter 9 I summarise and reflect on the emerging insights from my study as they relate to the four research questions and discuss their implications for science teacher education.

1.13 Conclusion

The exploration of notions of critical thinking in this study is the beginning of an attempt to present a coherent operational conception of the notion of critical thinking contextualised in South African education generally as well as in science teacher education specifically. While conceptions of critical thinking from the literature were introduced, the presentation as it stands at the moment is too generalised. It is intended that as this dissertation develops, so too a perspective of critical thinking will emerge that could serve as a coherent guide to the development of science teacher education curricula. I intend to do this through consecutive cycles of literature and document analysis in the context of South African educational discourse and science teacher education. Insights of notions of critical thinking from the analysis will, it is hoped, inform science teacher education programmes.

CHAPTER 2

IN SEARCH OF CONSTITUTIVE MEANINGS

2.1 Introduction

The key purpose of this study is to clarify notions of critical thinking in education through perusal of the literature and policy, with the intent of developing a conceptual elaboration that would inform teacher education programmes. Hence, in this chapter I elucidate the methodological framework and research methods which inform my exploration. I explain my choice of research methodology, which is interpretive theory, as well as my research method which is a conceptual and deconstructive analysis of the notion of critical thinking as it manifests in the literature, South African teacher education policy, and school physical science curricula. I also elaborate on my research design which involves a two-fold process. At the first level I search for constitutive meanings, following Fay (1975:70-91), of notions of critical thinking in the literature that could inform the development of a conceptual elaboration of the construct pertaining to science teacher education. In addition, the deconstructive aspect of my analysis involves identifying conceptual gaps, that is, what is not there, in line with Adams' approach (2004:104-115).⁹ Both constitutive meanings and conceptual gaps are included as dimensions of my developing conceptual framework. At the second level, relevant versions of the conceptual elaboration, developed at level one, are used as an analytical framework to explore notions of critical thinking in South African educational discourses, teacher education policy, and school physical science curricula. Emerging insights from the analysis will, it is hoped, inform approaches to critical thinking in science teacher education. It is hoped that my account of the selected research methodology and methods is sufficiently plausible to the reader and that any obscure aspects will become clearer on further reading of my dissertation.

⁹ Adams (2004) did a conceptual analysis in which he also searched for constitutive meanings and conceptual gaps in his analysis of the Norms and Standards for Educators document.

2.2 Methodology and methods

My research design is interpretive hermeneutics which contains two parts: my research methodology, which is interpretivism, as the intention is to understand how notions of critical thinking feature in the literature and policy documents, and my research method, which involves a conceptual and deconstructive analysis of text.

My methodology, that is, the over-arching theoretical framework or lens which guides my research, is interpretive theory which highlights the embedded nature of meaning. That is, context matters. In addition, the researcher's own biases influence the nature of the investigation as well as the outcomes of the research. Findings then, are not necessarily generalizable, but they can highlight significant aspects for consideration and possible future intent. As Howe (1998:19) contends, '*subjectivities count*' and ... '*social arrangements are irremediably interest-, power-, and value-laden and thus need to be carefully examined or deconstructed*.' Hence, in line with interpretive theory, in my exploration of critical thinking, I am sensitive to the possibility of multiple or contested meanings which emerge. In addition, I consider how notions of critical thinking manifest in the context of South African educational discourses, South African teacher education policy, and school curriculum requirements in physical science education specifically, as this is the context of my own working life as an educator.

Fay (1975:70–91) points out that interpretive theory developed out of the tradition of analytical philosophy of which conceptual analysis as a research method is appropriately aligned. He gives an account of the interpretive paradigm by highlighting three aspects which I attempt to concretise with a suitable example of my own as well as refer to their significance to my study. Firstly, he links action to meaning. That is, the intent of an action can be interpreted within the given context. Secondly, action descriptions imply an acceptance of social practices, which an interpretive social scientist should make explicit, and thirdly, these social practices have certain shared assumptions, conceptions or definitions which Fay terms *constitutive meanings* (1975:76). For instance, a researcher could observe the actions of a teacher in the classroom and then interview the teacher about what he or she intended. This could fit within the realm of an interpretive study which acknowledges and highlights the voices of the research participants. Furthermore, the practice of teaching in a formal school context may be influenced by a set of *constitutive meanings* around aspects of teaching and learning shared by its members which may inform their conduct, often implicitly or unconsciously. For example, the hierarchical nature

of the education system, the curriculum prescription, as well as the nature of the school context, may influence teachers' conduct. The participating member of that social practice might not be in a position to articulate these *constitutive meanings* explicitly. This is possibly the task of the researcher who should be aware that these articulations are open to interpretation. Fay develops this further and points out that *constitutive meanings* may be related to other *constitutive meanings* which underlie the social world of which they are part.

However, I will not be conducting any interviews, as my method of choice is hermeneutical (Robson, 2002:196–197), that is, it involves a textual analysis of the relevant literature applicable to critical thinking as well as an analysis of policy documents. Hermeneutics is an approach originally associated with the interpretation of biblical texts. Variations of interpretation were influenced by various perspectives which could be literal, moral, contextual, and mystical, among others. Alvesson and Sköldberg (2009:91–143) distinguish between objectivist hermeneutics and alethic hermeneutics. In objectivist hermeneutics, the researcher would attempt to understand the meanings and acts of authors and creators of texts of bygone times through intuitive and empathetic re-enactment. There is thus an attempt at aligning the understanding of the researcher with something objective, outside of the researcher. The authors point out that alethic hermeneutics, on the other hand, transcends the subject/object problematic. Rather than attempting to find an explanation for causal connections, it focuses on the *revelation of something hidden* (Alvesson & Sköldberg, 2009:96) and the understanding of underlying meaning which may be currently relevant. The former approach searches for objective criteria of validation while the latter is more likely to engage with plausibility in interpretation. The authors acknowledge that even though these two approaches may appear incompatible, reconstructed original meaning of text may have current significance. They describe various emphases for the hermeneutic process. These emphases may involve the researcher's looking for a pattern of interpretation consistent with aspects of the text, or selection and interpretation of text could involve placing it in its socio-historical context. However, Alvesson and Sköldberg (2009:100) point out that originality in research could also be achieved by re-contextualising the text in a new or different context. An awareness of the researcher's own pre-understanding could inform a reflective dialogue through the asking of questions and *listening* to the answers. This imagined dialogue in turn could initiate arguments and counter arguments. The authors (2009:91-97) address the alethic hermeneutic circle whereby preunderstanding informs interpretation, and as

new insights develop in the process, these form the basis of the next level of interpretation. I now turn to the significance of hermeneutics to my own study.

Gadamer (2004:268-382) expounded at length on interpretive hermeneutic understanding. I should like to draw on two aspects which I feel are applicable to my study: firstly, the notion of fore-conception or fore-structure, which he draws from Heidegger (1962) and secondly the idea of *horizon*. According to Gadamer (2004:268-382), the reader or researcher is influenced by his or her own traditions and preconceptions when interpreting text and this affects understanding. An awareness of this creates possibilities for opening up to other perspectives encountered. In this way new insights are developed and we reach a new understanding, which is not necessarily better, as he puts it, but we understand in a *different way* (Gadamer, 2004:296). Gadamer (2004:301) develops this further by introducing the notion of horizon. Gadamer (2004:301) refers to the horizon as the range of vision that includes everything that can be seen from a particular vantage point. Gadamer (2004:301) indicates that the task of historical understanding also needs a suitable historical horizon. The implication is, as Gadamer (2004:305) points out, that as inquirers, our current range of vision or our horizon of the present cannot be fixed but is constantly being formed as we have to test our own prejudices when encountering the past, hence understanding involves a fusion of these horizons. Hence in my exploration of notions of critical thinking I reflected on my own biography and notions of critical thinking in an attempt to situate my horizon. This awareness I brought with me into the research process with the conscious intention of being open to any other perspectives that could arise. In my study I attempted to make sense of notions of critical thinking by reflecting on how they could be applicable in different historical contexts in South Africa during and after the apartheid era. In an attempt to uncover my own preconceptions, I reflected on my personal educational biography and how this may have influenced my notion of critical thinking, with the realisation that I may encounter other perspectives different from my own, and hence possibly come to a different understanding.

Holroyd (2007:1-2) notes that the intent within the interpretive hermeneutic tradition is not to develop a procedure for understanding. Rather, it is to elucidate conditions that lead to understanding. The author likens this to a type of reflective discovery where the act of interpretation being foregrounded by pre-understanding is in the sense elucidated by Gadamer (2004:268-306). I agree with Holroyd (2007:7) that in a philosophically based study it is important to acknowledge the unique culture and history of the researcher, or the horizon in which he or she stands, as this opens oneself up to real possibilities that

exist within human consciousness, not necessarily only from the horizon of self, but also from the horizon of others and by implication, drives the direction of the research.

As also noted by Nilsen (2008:88), hermeneutics emerged as a way of examining text as part of the context in which it originated, which is what I try to do when examining literature on notions of critical thinking, historiographies of dominant South African educational discourses, South African teacher education policy, and physical science school curricula. In the literature, various authors present ideas in a particular way. The action of writing articulated in text allows for accessing and interpreting the voice of the author which makes it an interpretive study. The process involves an examination of literature on notions of critical thinking in education in search for *constitutive meanings* as presented by Fay (1975:70–91). Even though my study does not involve interacting with people, I have a particular interest in both the nature of teacher education policy and school science curricula because of my work as a teacher educator and my involvement with science pre-service teachers. Hence, my responses to and mediation of these documents are not wholly objective but open to interpretation.

Thus, aligned with this interpretive methodology is my research method or the technique I used to conduct my research enquiry, which is a conceptual and deconstructive analysis of the notion of critical thinking in relation to science teacher education specifically as it emerges in the literature, South African teacher education policy documents, and school science curriculum documents. It is conceptual in that I present a philosophical argument in which I try to disseminate the logic at play as well as reveal the inherent tensions that may exist in notions of critical thinking in the context of teacher education. It is deconstructive in that I do not view the meanings that emerge as neutral or fixed. While these meanings become manifest hermeneutically through the historical, relational and contextual influences in which they operate these meanings may be imbued with a sense of possibilities yet to come. As such, my research has a hermeneutical deconstructive orientation. It is deconstructive in the sense that even though I explore notions of critical thinking from the horizon of self (Gadamer, 2004:268-382) in an auto-ethnographic sense, I am also open to multiple perspectives, including underlying meanings which may not be explicit yet hint at what might be in the context of science teacher education. I thus link the notion of critical thinking more closely with the premise that professional judgement is a constitutive component of critical thinking in teacher education and hence, needs to be a consideration for any teacher education programme. That is, I present the teacher's professional judgement as an enabling condition or principle for operationalising critical

thinking in the classroom. So, the main argument that guides my analysis is based on the principle that teacher education programmes need to promote professional judgement as an enabling condition for the development of critical thinking, as this emphasises the cultivation of the critical mind (Burbules & Burk, 1999) that has the potential for exposing exploitative and self-seeking agendas. With this orientation in mind, I set out to develop a conceptual and analytical framework which serves as a basis for the investigation of how the notion of critical thinking is conceptualised in the dominant discourses in South Africa,¹⁰ particularly the recent discourse related to the decolonisation of African universities, as well as in South African teacher education policies and physical science school curriculum documents.¹¹ I focus on these two kinds of documents as the former guides the development of teacher education programmes and the latter informs teacher pedagogy. It is hoped the emerging insights from the study have the potential to inform science teacher education curriculum development. Hence, if I were to reformulate my exploration as research questions, they would appear thus:

1. How do notions of critical thinking prevalent in the dominant educational discourses in South Africa impact on science teachers' conduct?
2. How do notions of critical thinking manifest in South African teacher education policy post 1994?
3. How do notions of critical thinking manifest in South African physical science school curriculum documents post 1994?
4. How does the conceptual elaboration of critical thinking in science teacher education relate to the notion of a decolonised African university?

While my enquiry does assume a philosophical form, it sources data such as literature and policy documents as well as using self-reflection to aid the exploration. Understanding emerges through iterative cycles of comparison and reflection. Even though literature and policy documents both deal with data sources in written form, Nieuwenhuis (2007:82–83) warns that it is important to distinguish between the two. He points out that the literature review provides an overview of scholarship in the selected discipline under study, while the documents serve as a data source for the phenomenon under investigation. While I agree with Nieuwenhuis's distinction (2007: 82–83), my analysis of the literature also serves to inform the selection of those dimensions or constitutive meanings of critical thinking which

¹⁰ Chapter 4.

¹¹ Chapter 5 and 7 respectively.

in turn provide guidelines for my analysis of the policy documents. I'll elaborate on this later in the chapter.

2.3 Conceptual analysis and deconstructive analysis

In itself, conceptual analysis can be limiting if it remains an intellectual exercise on clarification of meaning. However, extrapolation of meaning to relevant contexts, such as science teacher education applicable in this study, can elevate the constructs explored to a level of practice informed by a deeper understanding. Kahn and Zeidler (2017:542) note that conceptual analysis is both a creative and a systematic methodology that can be used to explore constructs. This could involve testing common usage of a term, exploring different contexts in which the term applies or does not apply, or even identifying contexts where its use is unclear or fuzzy. They point out that some analyses even go beyond lived experiences and could verge on the inventive or the imaginative, thus '*opening up the possibility for the unforeseeable*' (Biesta & Stams, 2001:70).

Although my emphasis is on literature and document analysis, which is presented as text, I did not resort to looking for common themes and patterns with the concomitant coding of emerging categories in the way that conventional content analysis suggests (Grbich, 2007:111–123). Instead, my literature analysis sought emerging trends in concepts aligned with notions of critical thinking, more in the line of identifying constitutive meanings as advocated by Fay (1975:70-91), as elucidated previously. These meanings I incorporated as important dimensions of my developing conceptual elaboration. Furthermore, my document analysis involved looking for manifestations of notions of critical thinking contextualised historically in the South African educational milieu. Hence, my method is not a content analysis but a conceptual analysis, as I shall elaborate on presently.

I now embark on a discussion on an approach to conceptual analysis before describing the specific research design I used.

As a start, I align myself with Petocz and Newbery's (2010:126) broad description of conceptual analysis as the analysis of concepts, terms, variables, constructs, definitions, assertions, hypotheses, and theories. They point out that the process involves examining these for clarity and coherence, critically scrutinising their interconnected relations and identifying assumptions and implications. In short, it amounts to a critical enquiry of concepts. Yet, when viewing the conceptual analysis method through an interpretive lens, dealing with concepts may be more nuanced than this description. When pursuing a

conceptual analysis, a number of approaches can be used. One can look at a dictionary definition of a term and consider its relevance to the investigation at hand. However, if this is the sole method, then it tends to be rather positivistic as it neglects to consider the shades of meaning of the term in operation in different contexts and through diverse perspectives. I turn to Hirst and Peters (1970:17–41) to clarify what I mean. An effort to identify a logically necessary condition for a term as suggested by Hirst and Peters (1970:17–41) may be a way of uncovering its underlying meaning. Yet, they note further that the necessary logical condition may operate in one context but not in another. They point out that a conceptual analysis involves examining the use of the words in order to discern the principle or principles that govern their use. The difficulty with this is that these principles are also subject to interpretation and any conclusions reached need to be contextualised. My intention therefore is not to try to uncover the essence of the term, which I believe is not possible. Terms have shifting meanings, depending on how they are interpreted and used historically and contextually. Hence, this positions the methodology of my study within the interpretive tradition as pointed out earlier. This implies that a concept has a particular meaning, depending on the way it is used and the setting in which it operates or is applied. Furthermore, I agree with Hirst and Peters (1970:9) that a conceptual analysis in itself has no point unless there is some underlying purpose to this investigation and serves as a necessary preliminary to answering some other philosophical question. Thus, the frequently proffered assumption that critical thinking would enhance educational quality justifies an examination of the notion of critical thinking in relation to education generally and teacher education specifically, and it is hoped such clarification has the potential to inform the development of science teacher education programmes.

2.4 Research design

Coombs and Daniels (1991:27–42) distinguish between three purposes or types of conceptual analysis: conceptual interpretation, conceptual development, and conceptual structure assessment. I incorporate the first two purposes into my research design. The emphasis of my study thus involves conceptual interpretation as well as conceptual development in the context of science teacher education as I describe next. I use constitutive meanings as presented by Fay (1975:70–91) to interpret notions of critical thinking in the literature. This is in line with conceptual interpretation as presented by Coombs and Daniels (1991:27–42). I then deliberate on the emerging notions and attempt

to identify conceptual gaps which may be relevant to the professional role of the teacher. This is the deconstructive orientation (Derrida, 1982) of my study, where I ponder on what is not there. This notion of what is not there, creates the possibility of something emerging, that is, of something yet to come *vis-à-vis* notions of critical thinking. I use the insights gained to develop a conceptual elaboration of notions of critical thinking. In this way my study involves a conceptual development as suggested by Coombs and Daniels (1991:27–42).

My research design consists of a layering approach in which I attempted levels of enquiry which lead to emerging insights. These insights informed the direction of the next level of enquiry. While I provided a broad description of the literature specific to critical thinking in Chapter 1, it was by no means complete. However, it served as a springboard for my exploration. Hence, it started at a broad level where I consider notions of critical thinking in teacher education generally and moved to a more constrained level where the focus of my deliberation is on science teacher education specifically. That is, the focus initially started with the analysis of literature on critical thinking in education. It then moved to an analysis of South African educational discourses, teacher education policy, and school science curricula. At each level of analysis, I considered implications for the nature of teacher education programmes. I returned to the literature again and again to inform and deliberate on insights gained. These insights informed and contributed to the progressive development of the conceptual elaboration on notions of critical thinking. The culmination of this process was the emergence of a conceptual framework which is envisaged could inform science teacher education programmes. In addition, in line with interpretive research, I reflected on and included my own insights as a teacher educator based on my experience over the years.

Figure 2.1 on page 35 depicts the process involved in the development of the conceptual elaboration on notions of critical thinking in science teacher education. In Chapter 3 I started by deliberating on the literature on critical thinking in education generally, searching for salient features of critical thinking or emerging constitutive meanings (Fay, 1975:70–91). I then pondered on how these identified features might relate to the role of the teacher. In accordance with my argument that the teacher's professional judgement is constitutive of notions of critical thinking, I deliberated on how this would manifest in practice. Hence the notion of reflexive praxis was included as an integral feature of critical thinking in a teacher's working life. This was the start of a tentative conceptual elaboration. In addition, in line with my interpretive research design, I argued that teachers operate

from particular perspectives and hence notions of critical thinking could potentially be influenced by particular outlooks that impact on their practice, whether consciously or unconsciously. So, in Chapter 4, I orientated my study by contextualising notions of critical thinking in perspectives that appear in South African education discourses as presented by Cross et al. (2009:475–503). These perspectives range from conservative, through to liberal, radical and postmodern. The inclusion of these perspectives resulted in the emergence of an expanded conceptual framework on notions of critical thinking. I was now in a position to use this expanded conceptual framework in Chapter 5, to analyse notions of critical thinking in South African teacher education policy post 1994, guided by the dimensions developed in the tentative conceptual elaboration. At this stage the conceptual elaboration was still incomplete, as it needed to be contextualised in science teacher education. So, in Chapter 6, I examined the literature related to pedagogy that supports the development of critical thinking in the science classroom. This exploration which focused on the professional conduct of the science teacher, culminated in an elaborated conceptual framework. This extension related to two aspects, namely the pedagogical focus endorsed in the science education literature as well as those pedagogical aspects selected and facilitated by the teacher that would enhance critical thinking in the science classroom. I was now able to use the elaborated conceptual framework to analyse how notions of critical thinking manifest in selected South African school physical science curriculum policy documents in Chapter 7. Additional considerations involved reflecting on how the call for a decolonised curriculum would affect the nature of science teacher education programmes. So, in Chapter 8 I modified the elaborated conceptual framework to accommodate considerations of decoloniality and science teacher education, finally resulting in an adapted conceptual framework on notions of critical thinking in science teacher education.

2.5 An approach to the analysis

The analysis consisted of two phases, each of which comprised two levels. The first level of analysis entailed building the conceptual framework on notions of critical thinking. The second level of analysis entailed using the appropriate version of the conceptual framework to analyse policy documents. Figure 2.2 on page 36 depicts the process of building the dimensions of the elaborated conceptual framework.

2.5.1 Phase one: Towards an exploration of teacher education policy (green shading)

The first phase of the analysis culminated in exploring notions of critical thinking in South African teacher education policy post 1994.

Level 1: An analysis of the literature on critical thinking and South African educational discourses

At the first level, my conceptual analysis entailed finding constitutive meanings of notions of critical thinking in the literature and in the context of educational discourses in South Africa. I then deliberated on these meanings in relation to science teacher education and identified conceptual gaps in terms of policy and pedagogy. My reflections led me to formulate additional dimensions of critical thinking that addressed these conceptual gaps and I included them as components of a tentative conceptual framework (A) and an expanded conceptual framework (B). The latter framework was used to analyse South African teacher education policy at the second level.

Chapter 3: Development of a tentative conceptual elaboration

Analysis of education literature to identify emergent **features** (constitutive meanings) of notions of critical thinking related to a teacher's role culminating in a tentative conceptual framework.



Chapter 4: Development of an Expanded Conceptual Framework

Use of the tentative conceptual framework to analyse notions of critical thinking in South African educational discourses resulting in the addition of perspectives on critical thinking culminating in an expanded framework.



Chapter 5: Analysis of teacher education policy

Use of the expanded conceptual framework to analyse notions of critical thinking in South African **teacher education policy** post 1994.



Chapter 6: Development of an Elaborated Conceptual Framework

Emerging insights from the analysis of literature on critical thinking in science education informed the expansion of the conceptual framework. Two additional components were added: a **pedagogical focus** and **key pedagogical aspects** that enhance critical thinking in the context of science education, culminating in an elaborated conceptual framework.



Chapter 7: Analysis of physical science curriculum documents

Use of the elaborated conceptual framework to analyse notions of critical thinking in selected South African physical science curriculum documents post 1994.



Chapter 8: An adaptation of the Elaborated Conceptual Framework

Considerations of how the elaborated conceptualisation of critical thinking in science teacher education relates to the notion of a decolonised African university, resulting in the adaptation of the elaborated conceptual framework.

Figure 2.1 The process involved in the development of the conceptual framework on notions of critical thinking in science teacher education (Linear format)

LEVEL 1 IDENTIFYING CONSTITUTIVE MEANINGS AND CONCEPTUAL GAPS

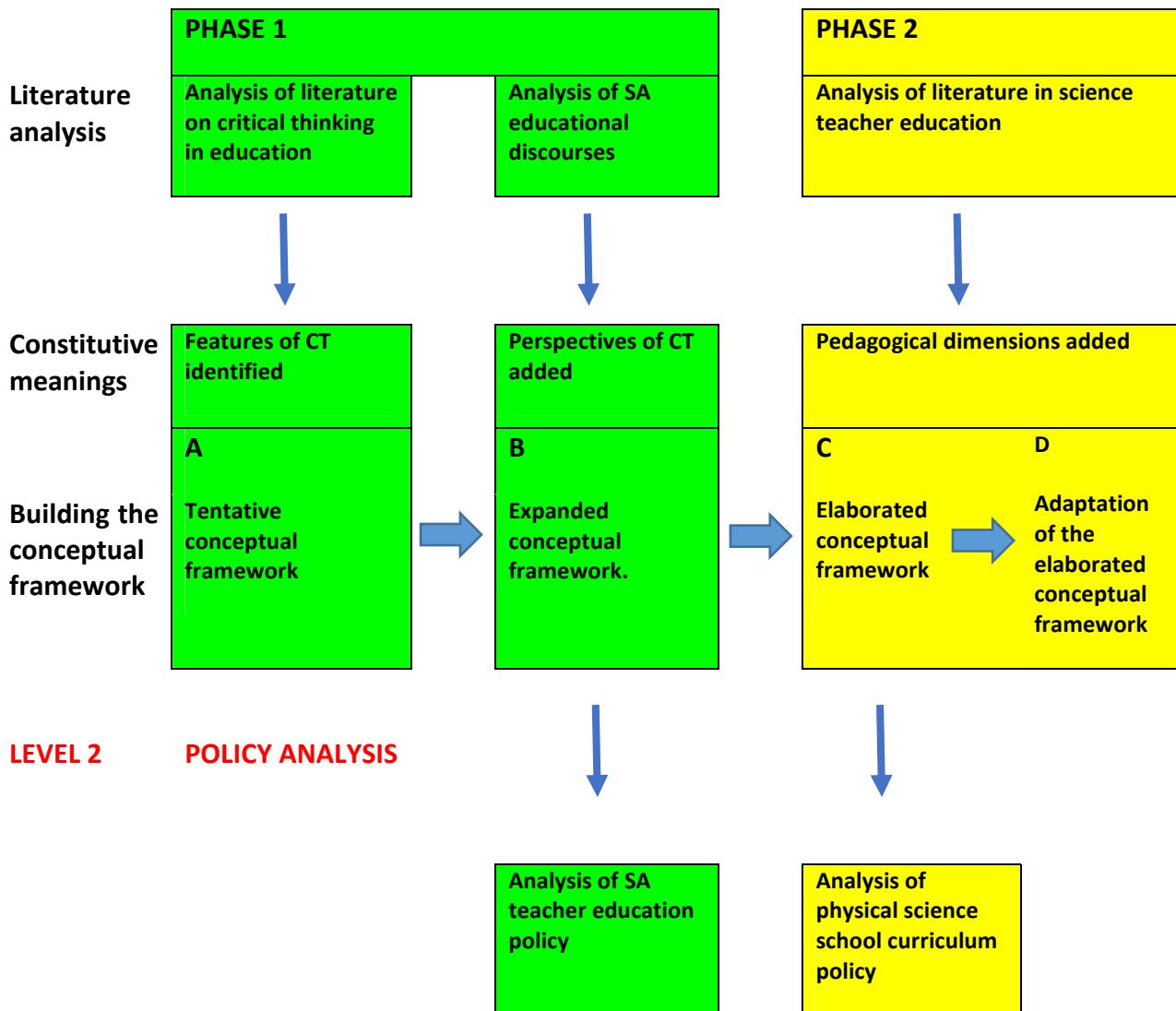


Figure 2.2 The process involved in building the dimensions of the elaborated conceptual framework on notions of critical thinking in science teacher education

Level 2: An analysis of teacher education policy

At the second level, I used the expanded conceptual framework (B) to determine in which way those aspects identified are aligned with how critical thinking manifests in teacher education policy.

2.5.2 Phase two: Towards an exploration of physical science curricula (yellow shading)

The second phase of the analysis culminated in exploring notions of critical thinking in physical science school curriculum policy.

Level 1: An analysis of science teacher education literature

Similarly, at the first level of analysis, constitutive meanings from the literature on science education and science teacher education were examined and conceptual gaps identified, resulting in the inclusion of additional constitutive meanings related to pedagogy and relevant to a science education context. This culminated in the construction of an elaborated conceptual framework (C).

Level 2: An analysis of school physical science curricula

At the second level of analysis, the elaborated conceptual framework was used to analyse physical science school curriculum documents in the Further Education and Training band post 1994.

2.5.3 The elaborated conceptual framework on notions of critical thinking in science teacher education

Further deliberations on the elaborated conceptual framework in relation to an African university and a decolonised science teacher education curriculum resulted in the final adapted conceptual framework (D) on notions of critical thinking.

2.6 Discussion

In many studies a conceptual framework guides the research and is often linked to a theoretical point of departure. In my study, however, the conceptual framework is one of the outcomes of the research informed by the literature and resulting in a meta-synthesis of concepts, where constitutive meanings or conceptual gaps inform the development of the various formats of the conceptual framework. The approach therefore is both hermeneutic and comparative in nature (Jabareen, 2009:49–62). When I refer to a

conceptual elaboration of notions of critical thinking, I refer to the process involved in progressively building various formats of the conceptual framework. The resulting formats of the conceptual framework are then used as a guide for analysis when exploring manifestations of notions of critical thinking in the selected policy documents. Throughout the exploration I draw on my own experience as a teacher educator to probe emerging meanings and possible underlying assumptions of notions of critical thinking related to pedagogy in science education. Any claims that I make about teacher conduct in the study should be regarded as a reflection of my hermeneutical embeddedness in the teacher education arena.

2.7 Conclusion

In this chapter I explained my research design which involved an exploration of notions of critical thinking through iterative cycles of analysis and reflection. I was guided by the constitutive meanings of Fay (1975) as a way of identifying the key dimensions of the conceptual framework developed. In turn, appropriate versions of the framework served as an analytical tool to explore notions of critical thinking in teacher education policy and physical science curriculum documents. In addition, I deliberated on how these conceptualisations would be applicable to the notion of a decolonised teacher education curriculum, all of which I shall describe in greater detail in the subsequent chapters of my dissertation. Further deliberation on the emerging insights from the investigation culminated in suggesting ways of approaching notions of critical thinking in science teacher education, which I shall discuss explicitly in Chapter 9.

CHAPTER 3

THE TEACHER'S PROFESSIONAL JUDGEMENT AND CRITICAL THINKING

3.1 Introduction

In the previous chapter I discussed my research design and methodology. In this chapter I continue to explore the main themes on critical thinking that emerge from the literature and present teacher professional judgement as a constitutive part of critical thinking. In line with my research method, which involves a conceptual and deconstructive analysis of the notion of critical thinking, I proceed to analyse the key concepts that pertain to notions of critical thinking and teacher professionalism. I use the insights gained to identify constitutive meanings common in the literature. I then argue that these constitutive meanings identified are not sufficient in the context of teacher education. Furthermore, in my search for conceptual gaps, I expound on conceptions of teacher education and make the case that the teacher's professional judgement is a constitutive component of critical thinking and hence needs to be considered in any teacher education programme. In addition, I discuss aspects of teachers' working lives where professional judgement may be required. These deliberations lead to a conceptual elaboration of critical thinking which articulates the nature of the teacher's profession. After this elucidation, I then proceed to develop a tentative conceptual framework of critical thinking related to a teacher's professional conduct.

3.2 Common elements of critical thinking

My own reading of the literature as already divulged in Chapter 1 yields notions of critical thinking that are quite diverse, yet there are common elements I could draw on to develop a conceptualisation that would inform and guide my study. An initial attempt to encapsulate notions of critical thinking could read as expounded below.

Critical thinking is the conscious application of the mind, which involves the utilisation of reasoning skills, and operates within a particular context and for a particular purpose. It could have a dispositional dimension, thus can be motivated by certain values and attitudes which range from the egocentric or socio-centric to the more altruistic. An absence of context makes the thinking irrelevant and abstract. An absence of purpose makes the thinking an academic exercise and an absence of those higher-order cognitive

skills associated with critical thinking could make the thinking procedural, unreflective and superficial. This formulation of critical thinking aligns with the work of Hindes and Bakker (2004:84), where they contend that the specific kind of reasoning associated with critical thinking has to be context specific and purposive.

Furthermore, in my search for a conceptual elaboration of notions of critical thinking I came across Mason's work (2007:339–349). Mason (2007:343–344) identified the following features of critical thinking:

- The skills of critical reasoning
- A critical attitude
- A moral orientation
- Knowledge of the concepts of critical reasoning
- Knowledge of a particular discipline

While Mason's conceptual framework is helpful, it is still a generalised version and possibly located within the rationalist, Western tradition. For the purposes of my study it is a good starting point as it aligns with my reading of the literature as well.

However, this attempt to engage with the notion of critical thinking is insufficient for the purposes of my study. A more coherent perspective is needed if it is to be of any value to the development of teacher education programmes. It needs to be augmented with considerations of the role of the teacher. I thus return to the idea of critical thinking as constitutive of the teacher's professional judgement. In order to deepen my insights, I proceed to do a conceptual elaboration of the key concepts related to critical thinking and teacher professional judgement. I consider the terms in themselves and in relation to teacher professional conduct.

One can consider various approaches when pondering on the exploration of a term. For example, when contemplating the term 'critical thinking', a decision could be made on whether to consider the two words separately or as a unit or a coherent idea or concept. Once this decision has been made, and justified, one could then attempt to make logical connections with how the term is used or perceived in different situations and from different perspectives. This is a more nuanced way of analysing a concept than merely being guided by the dictionary definition.

The use of conceptual and deconstructive analysis as a research method thus could present the overt as well as underlying meanings in relation to other notions in the context of the area under investigation. However, Higgs (2002:170) notes in his presentation of Derrida's work on deconstruction (Derrida, 1978) that even contextual stability is questionable and hence all meanings are destabilised, thus better understandings emerge if this instability of meaning is acknowledged. So, if one were to apply a deconstructive analysis, then slippage in meaning is accepted as a more nuanced perspective. However, while there may be slippage in meaning, ideas as articulated in words, whether spoken or written, may have sufficient commonality for overlapping meaning within the context of time and space in which we operate. Derrida (1978) suggests that all concepts have traces of the past embedded in them, while their current use furthermore hints at something still to come. Hence the two approaches, that is, conceptual analysis and deconstructive analysis, are not necessarily mutually exclusive. In addition, shades of meaning are conveyed not only in the shape and form of the word itself or in the context in which it is expressed, but subtleties of speech and expression may also intuitively convey meaning. Children are particularly sensitive to such exchanges so that what is coming out of the mouth of the teacher, for instance, may not coincide with the subtle expressions in the face, eyes, or body language. A look can convey more than the uttered words. Hence, an elaboration of perspectives, bearing in mind inconsistent and dynamic educational contexts, could help to clarify meaning further. In addition, meaning can also be derived from what is left out, which could be a conscious or unconscious consequence, depending on the intent, or not, of the speaker or author. The unsaid or unwritten therefore could also determine the direction of meaning. What follows is my attempt to elaborate on important concepts in teacher education *vis-à-vis* the notion of critical thinking.

3.3 An approach

I highlight and elaborate on concepts of professional judgement and praxis as constitutive elements of critical thinking in teacher education. That is, I argue that the teacher, by virtue of his or her profession, constantly encounters situations in which judgements are required. These judgements may be a result of considered deliberation over a period, for example, making choices when planning a series of lessons, or it may require a seemingly instantaneous response, for example, responding to a learner's contribution in a classroom setting. The quality of the judgement will affect the consequence of the choice made. I

consider aspects of the teacher's professional milieu and describe instances where judgement may be required.

Having pointed out the limitations of providing dictionary definitions of concepts, I still proceed to do so, but merely as a starting point for the rest of the discussion. I start by examining definitions of constructs I consider relevant to my study. So, the most pertinent term is the word 'critical'. This word is used in many contexts but I shall explore its meaning in itself and in relation to education in particular. I provide definitions of the terms I think will be relevant to my argument. I then elaborate on their significance by contextualising these terms in the realm of teacher education.

Critical - The word 'critical' has many connotations which can range from a cognitive process of the mind such as judging or interpreting something, to a significant moment, event, state of being or action which has implications depending on the context.¹² However, it is to the former meaning that I turn my attention. In the *Shorter Oxford English Dictionary* (1973:458) it appears thus: '**1.** Given to judging; esp. fault-finding, censorious... **2.** Involving or exercising careful judgement; nice, exact, punctual... **3.** Occupied with or skilful in criticism.' My focus in this dissertation will deliberate on the second definition: the exercise of judgement rather than judging or fault-finding as depicted in the first definition, because negative criticism as punitive censure and devoid of positive educational intent is of very little value to education.

Thinking - *Thinking* is presented as a mental activity or an activity of the mind. 'The action of THINK. **1.** Thought, cogitation, meditation, mental action or activity... **2.** The holding of an opinion or opinions; judging, mental viewing; opinion, judgement, belief... Given to thinking; having special, or well-trained powers of thought; thoughtful; reflective intellectual' (*Shorter Oxford English Dictionary*, 1973:2287).

The idea of exercising thoughtful judgement appears in both definitions, hence my contention that critical thinking would involve a judgement, and in the context of teacher education it would entail a professional judgement. That is, 'to use the mind to form ideas, judgements, etc.' (*Heinemann English Dictionary*, 1989:1144). Let us now turn to the notion of what it means to be professional.

¹² For example, such notions of critical thinking could be formulated in the following way: 'The health of the patient is *critical* and there is little hope of a complete recovery,' or 'The bombing of Pearl Harbor was a *critical* event that precipitated the entry of the United States of America into the Second World War.'

Professional - This term can be related to a career focus or it can be used to distinguish an activity such as sport or art practised socially versus its being a career. For example, a professional cricketer practises his sport as his profession. The former use of the term is depicted in the *Shorter Oxford English Dictionary* (1973:1680) as follows: '1. Pertaining to, proper to, or connected with one's profession or calling. 2. Engaged in one of the learned or skilled professions.' I shall consider the notion of being professional as it refers to the teaching profession. In the *Heinemann English Dictionary* (1988:859) a profession is presented as 'an occupation, especially one requiring advanced education and special training'.

Judgement - The notion of judgement is often used in a trial or court of law. I shall not be considering the term in this context. Rather, I shall consider judgement as it is related to discernment in teaching encounters and educational deliberations. Among many definitions presented, I am drawn to this one: 'The faculty of judging, that function of the mind whereby it arrives at the notion of anything; the critical faculty; discernment' (*Shorter Oxford English Dictionary*, 1973:1140).

The dictionary definitions of the key concepts under investigation have their limitations because they lack context and perspective. I offer them as a way of setting the scene for a more contextual examination. I now turn to a more nuanced discussion of the concepts taken as a coherent idea by considering the link between professional judgement and critical thinking in the context of the teaching profession and teacher education.

3.4 Conceptions of teacher education

The concept of education, in its formal sense, has evolved, and this is dealt with adequately in Hirst and Peters (1970:17–41). They point out that education involves content and aims as well as methods and procedures which may be driven by various underlying principles. They link the notion of education with processes that promote desirable states of a person that involve breadth and depth of knowledge and understanding. If one takes this as a working concept for education, which is rather broad, then the role of the subject teacher would be to enhance the breadth and depth of knowledge and understanding, together with the concomitant skills in the disciplines they teach. This definition does not focus on the value aspect per se, but the value aspect could be inherent in the notion of 'desirable states of a person'. However, what is desirable? As Hirst and Peters put it (1970:40): '*But how do we determine which states are desirable?*'

Hence, as they say, ‘analysis sets up further problems’. In an effort to contain this, I will confine myself to teacher education in South Africa and elaborate on pertinent aspects in the next chapter. What processes should be put in place in a teacher education programme that would bring about a desirable state in which breadth and depth of knowledge and understanding are enhanced and how is this linked to critical thinking? Taking it further, what is the nature of the knowledge and understanding that should be developed in an education student? This is a complex question. As a start, it is commonly accepted that teachers teach. This is their core activity. What then is teaching? Hirst (1973:163–177) approaches this question as follows. He points out that teaching can assume many different forms which may be synonymous with things you do when you are not teaching. Thus one cannot characterise the notion of teaching by the kinds of activities a teacher does, such as demonstrating, explaining, questioning, and so on. Hirst (1973:163–177) links the activity to its purpose or intention. If the intention is to effect learning, then the person is teaching. He indicates that teaching does not necessarily imply learning but it does necessarily imply the intention of bringing about learning by someone. The two concepts are interdependent. However, whether learning actually happens when the person is teaching can be debated. Furthermore, this begs the question: What is learning? Hirst (1973:163–177) points out that the consequence of learning is a changed or new state of a person. The learning may be a result of the intended goals of teaching or it may not be.

Aspects of teaching and learning would therefore be key concerns of a teacher education programme. In addition, considerations of educational contexts, learning theories, and educational influences will all be part of a teacher education programme with the hope that it will lead to promoting the breadth and depth of aspirant teachers’ knowledge of education. Opportunities to practise will further consolidate this knowledge and understanding. Moreover, the crucial aspect of the content knowledge of the discipline itself as well as the ability to initiate students effectively into this discipline, that is, pedagogic content knowledge (PCK) as highlighted by Shulman (1986), should also be emphasised. Furthermore, when considering science teacher education, which is the focus of my study, it is not plausible to expect that science teachers should turn their learners into scientists. Schools hardly have the capacity to do that. Yet, there has been a change in emphasis in various countries over the years in terms of what kind of science should be taught in schools. Inherent in these changes has been the notion of what scientists do. These trends range from an emphasis on teaching science content, to other aspects like

the science, technology and society movement (Solomon, 1987; Hart & Robottom, 1990; Osborne, Simon & Collins, 2003), indigenous science knowledge (Ogunniyi, 2004; Le Grange, 2007), scientific literacy and nature of science concerns (Lederman, 2007) and so on. How these trends become part of school curricula is not a focus of this study. Suffice is to say that the curriculum developers for a variety of reasons may be partial to one or other approach. The teacher therefore has to grapple with the demands of the school curriculum. Teacher education programmes thus have to sensitise education students to ways of dealing with the school curriculum with insight and discernment. However, teacher education programmes are also governed by teacher education policy. Alignment with these policies is crucial if an institution is dependent on government finance, and teacher accreditation of their graduates. I now turn to notions of professionalism in teacher education.

3.5 Limits of professionalism

As per definition, professional judgement must of necessity be linked to teaching as a profession. Carr and Kemmis (1986:7–9) point out three aspects which distinguish professional from non-professional occupations. Firstly, the approaches used by members of a profession are based on theoretical knowledge and research, that is, they are supported by a body of systemically produced knowledge. Secondly, the principal commitment of their members is to the wellbeing of their clients. Thirdly, and more significantly in my opinion, members of the profession, who are normally governed by ethical codes related to the profession, reserve the right to make autonomous judgements free from external, non-professional controls and constraints. Carr and Kemmis (1986:7–9) point out that theory and research play a much less significant role in teaching than in law or medicine, while the learners, parents, local community, government, and employers can all make claims to be considered bona fide clients whose interests may not necessarily coincide with what teachers believe to be in the educational interests of their learners. The most constraining aspect, however, is in the area of autonomous judgement. Carr and Kemmis (1986:7–9) note that even though teachers have some authority to make independent choices in the context of their classroom practice at the individual level, they operate within hierarchically arranged institutions where they have very little control over educational procedures and policy at the collective level. More than three decades later, their insights still seem relevant.

3.6 The reflective aspect and professional judgement

Many demands are made on the teacher. Teachers are confronted with expectations from education departments, school management, governing bodies, parents, the media, and not least, the learners they teach. Teacher education policy governs initial teacher preparation and provides a guideline for teacher education curricula at universities. Universities are expected to prepare education students to teach in schools where the main documents which guide teacher conduct are the school curriculum documents. As these curriculum documents change from time to time, how do universities prepare students to interact with these documents? How can they be assisted in making considered choices on aspects of teaching and learning?

Furthermore, the profession of teaching cannot be identified by a particular field of expertise such as science, languages, or history. Rather, it is distinguished by teachers initiating and orienting learners into epistemic and methodological knowledge and insights associated with a particular field at various levels in a formal environment such as a school or university. Hence, aspects of professionalism could focus on the way in which this process unfolds and how teachers navigate educational contexts in order to make professional judgements that best serve their learners. So, I would like to extend this notion of professionalism a little further by referring to Kelly (1995:135), who makes the now generally accepted point that there should be more to being a teacher than the transmission of knowledge and skills. Kelly (1995:135) writes about the need for democratic practices to drive formal education in schools and universities. He argues that a democratic educational ethos best supports the reflective component of a teacher's role as it is this reflective dimension which informs autonomous judgement and distinguishes the professional from the technician. Herein lies the criticality. But what makes the judgement critical? Judgement can often manifest in decisions made or actions chosen by the teacher. The ability to navigate bureaucratic constraints and hierarchical educational systems requires a critical capacity that is informed by critical reflection. While there may be rules and practices to abide by in educational institutions, these should still be subject to critique and evaluation. Barnett and Standish (2003:215–233) acknowledge Derrida's position on the necessity of the responsibility of judgement as an educator. A critical judgement would presuppose appropriate and pertinent reflection or deliberation. Another question one might well ask, 'What distinguishes superficial reflection from critical reflection?' Professionalism informed by critical reflection could involve having the conviction and confidence to justify the decisions we take based on sound educational

standards (Bailin & Siegel, 2003:181–193) on the one hand, but also the humility and curiosity to question or reflect on those decisions when confronted with a different view or unintended consequences on the other hand. The reflective teacher who cultivates critical capacity will be involved in exploring and creating ideas as an individual or in collaboration with others, drawing on a repertoire of knowledge, skills and experience, probing and becoming aware of the limits of the experience and knowledge and seeking to enquire critically in respect of those issues pertinent to the quest. According to Kelly (1995:141), this is best nurtured in an authentic, democratic ethos which, he warns, is being significantly eroded because of political and economic agendas and hence resulting in the deprofessionalisation of teachers.

Kelly (1995:136) points out that teachers in a democratic society should be assisted to recognise the problematic nature of knowledge, of values, and thus of education itself. The author highlights the reflective aspect by noting that teachers need to learn the importance of constantly evaluating their own practice in terms of the mode of delivery and nature of the curriculum, which he asserts are conceptually quite different and hence they should draw on different skills, techniques and understanding. Both kinds of reflection manifest in the norms and standards for educators (DoE, 2000), now superseded by a more recent policy document on teacher education (DoE, 2015) which I elaborate on in Chapter 5. The former kind refers to a reflection on ‘self’, while the latter kind refers to a reflection outside of self, which in this case is the curriculum and which I shall refer to as the reflection on ‘other’. So, this reflective process is in fact an evaluative process whereby teachers are exercising their professional judgement. A consideration of the integration of the two aspects, that is, pedagogy and content, has also been an aspect of much deliberation in educational circles, encouraged by the notion of pedagogical content knowledge (PCK) popularised by Shulman (1986:4–14). I should like to add a third dimension of reflection – the educational context of the teacher – which may be localised or much broader.

In the context of the classroom, teachers need to apply their professional judgements in a variety of ways such as planning learning experiences, managing classroom interactions, and assessing learner progress. Allal’s study (2013:20–34) on teachers’ professional judgement when assessing learners’ progress summatively, highlights both the individual cognitive and the socially situated aspects of teachers’ judgements. Following Wenger (1998), Allal (2013:20–34) notes that cognitive acts carried out independently are still considered to be strongly influenced by the collective practices of a professional community. Hence, the conduct of the teacher in the classroom, even in the process of

making autonomous choices, may be bound by his or her educational community and context consciously or unconsciously. Biesta (2013:690) however notes that the increase in top-down prescription of both the content and form of education has significantly reduced the opportunities for teachers to exert judgement. However, anecdotal reports among South African teachers, who operate within complex educational contexts on a daily basis, reveal they often prefer to be told what to do without having to think too much about it.

Biesta (2015:75–87) develops this notion of teacher judgement and educational professionalism further by considering the purpose of education and linking it with the need for teacher professional judgement. He contends that even though scholars may claim the importance of the teacher in education, teachers are often viewed as ‘factors’ that need to perform efficiently. There is a tendency to forget or ignore the fact that the teacher is a discerning human being, and as an educational professional, should have scope for judgement and discretion. He problematizes the language of learning as too vague in educational discourses and practices, as according to him, it stops people from considering key educational questions of content, purpose and relationships, that is: what is being learned, for what purpose, and from whom? Biesta (2015:75–87) argues that the normative view of *good* education should drive professional judgement. He suggests three domains of educational purpose. I shall elaborate on these as I think they are pertinent to the interrogation of the term ‘judgement’ within the context of teacher education. They are, firstly, qualification, which is concerned with the transmission and acquisition of knowledge, skills and dispositions; secondly, socialisation, which refers to the reproduction of existing social structures, norms and traditions in all their varied forms; and thirdly, subjectification, which emphasises agency, initiative and self-responsibility on the part of the student. Biesta (2015:75–87) contends that judgement is required in all these three spheres of educational purpose, but that often the domain of qualification, which emphasises academic achievement, is prioritised and the other two neglected. Although the consideration of the purpose of education as elucidated by Biesta (2015:75–87) is helpful in obtaining an overview of domains in which teachers need to navigate and exercise their judgement, it is not necessarily helpful in considering their day-to-day encounters, which I shall interrogate next.

3.7 Reflective domains

The notion of the reflective practitioner as expounded by Schön (1983, 1987) has been discussed at great length in the literature; it is, however, not necessarily the focus of this dissertation. As reflective practice has become such an embedded notion in teacher education, where it is presented as one of the key aspects of enhancing pedagogy in all fields, it is worth elaborating on. The action research cycle has been presented as a way of encouraging reflection and improving classroom practice where evidence of reflection is often required through the writing of reflective journals (Chetcuti, 2007; Hume, 2009; McGarr & Moody, 2010). Other ways of articulating such evidence is through group discussion and reporting. However, various scholars have indicated that student teachers tend to exhibit low levels of reflection (Bruster & Peterson, 2013; Cain & Harris, 2013; Poom-Valickis & Mathews, 2013).

Similarly, in my own experience, I have observed that student teachers tend to recall, describe and comment on aspects of their classroom practice experience at a rather superficial level. Students don't try to provide reasons why things unfold as they do and tend not to contextualise the selected episode or incident. One responsibility of a teacher education programme could be to introduce students to ways which will elicit deeper levels of reflection. Perhaps providing students with various strands of consideration as options for reflection such as learners' learning, students' own learning, educational contexts, educational theory, students' own biographies and inclinations, and so on, might deepen the reflection. Possibly those strands could be followed until saturated, then brought together again in terms of future choices. While one can provide pointers to students as well as approaches that could help them, it may come across as mechanistic scaffolding. While it may help to get them started, they should also be encouraged to identify the salient issues themselves, and be allowed to explore those, depending on their own contexts and inclinations.

McGarr and McCormack (2016:36–52) note the tendency for counterfactual thinking. They comment that often teacher education programmes may be complicit in maintaining student teachers within a pre-reflexive counterfactual thought process. By counterfactual thinking, they mean that students tend to highlight negative episodes in their practice and, possibly imbued by embedded notions of a teacher's role based largely on their own experiences, they indicate what they should have done in order to prevent the negative episode. Solutions such as 'being stricter' or 'not smiling' or being 'better prepared' are

often offered as solutions to discipline problems in the classroom. A common practice in such programmes is for students to reflect on their lessons taught and suggest ways in which they can be improved. Such reflections are constrained when they are limited to the student's own choices and actions. The authors advise that reflection can be deepened if broader contextual aspects are considered as well. They note that the often recommended 'plan, reflect and revise cycle' may simply be seen as a way of finding quick solutions to emerging aspects in the classroom rather than taking the time to consider alternative perspectives.

McGarr and McCormack (2016:36–52) suggest that students should be encouraged to reveal the beliefs and assumptions that are linked to any prospective solution. In this way students may acquire some insight into what drives their choices. The other dilemma is the question of students feeling obliged to perform in a way that in their minds is acceptable to their mentors and supervisors. Hence, a quick response to improving practice may counter critical reflection, as the emphasis is on results. In addition, the complexity of a packed curriculum can exert pressures which compel teachers to move on, thus discarding those potentially emerging seeds of reflection which can enhance criticality. Pressure to perform and display an acceptable level of competence as suggested by McGarr and Moody (2010:579–591) thus may discourage experimentation and trying things out. The authors reported that in their own practice, they shifted the requirement for student teachers to reflect on each lesson taught at their host schools to choosing only two aspects in their teaching experience that they needed to reflect and report on. Their concern was the lack of critical reflection exhibited by the students in the first option because of the excessive workload of the first model, hence the shift to the second option. McGarr and Moody (2010:579–591) indicated that the value of the new model allowed students to reflect across multiple contexts rather than focus on single lessons. However, the authors found that even though the new model was perceived by students as enhancing their own insights by focusing on broader recurring themes across class groupings, student reflections still remained at the level of technical rationality, following Down and Hogan (2000). That is, student concerns were mainly concerned with aspects of improving their own performance, rather than with more comprehensive socio-political concerns. Given that students may perceive performance as a key criterion for success, this is not surprising.

EI-Dip (2007:24–35) summarises a notion of reflection that has rationality at its core, in which reflection involves conscious deliberation that results in justifiable choices and actions. The author summarised different models of gauging reflexivity in teacher education. These models ranged from descriptive, and encompassing a single, taken-for-granted perspective, to critical, deep reflection encompassing the questioning of assumptions and guided by considerations of multiple perspectives and contexts. Clearly, moving students towards the latter type of reflection should be a consideration of a teacher education programme as it would enhance the degree of professionalism that they bring to the choices they make.

If I were to extend this notion of reflection to a teacher's daily professional interactions, then it is useful to refer to those aspects of reflection as reflective domains or domains of deliberation. Various scenarios inform teachers' professional choices. Teachers need to reflect on how to conduct themselves in the classroom as well as how they would initiate and navigate learners in the field that they are teaching. As indicated before, the former is a reflection on 'self', that is, deliberating on the teacher's own actions or attributes. These can relate to aspects of pedagogy, content knowledge or educational philosophy, while the latter is a reflection on 'other', that is, on the progress of the learners, and on the educational context in which the teacher is working, as well as other influences such as formal or informal networks the teacher may be engaged with. Table 3.1 lists some zones of deliberation which I shall call 'reflective domains' that inform a teacher's praxis, where praxis refers to action informed by critical reflection. The list is by no means exhaustive. Despite the linear presentation, the interplay between the domains is multi-layered, dynamic and complex. Viewed in this way, it is incorrect to relate the reflective component to one instance of decision making, as teachers are constantly having to reflect on matters and make decisions. The decision to give a particular class group homework on a Friday afternoon may very well be informed by a deeper reflection on the nature of the task and the value it would bring to substantive learning. However, it may simply be expedient or serve as a punishment for 'bad' behaviour, which in the greater scheme of things might also involve deliberative reflection and considered action.

Rancière (1991:36) asserts that one cannot distinguish between levels of intelligence when reflecting. The same intellectual potential can be applied to different circumstances or situations of reflection. I quote at length as I feel that his anticipative perspective may be of particular significance to the nurturing of reflective practitioners in beginner teacher

education as it concretises ways of initiating students into developing their professional judgement. According to Rancière, 1991:36–37:

In all cases, it is a question of observing, comparing, and combining, of making and noticing how one has done it. What is possible is reflection: that return to oneself that is not pure contemplation but rather an unconditional attention to one's intellectual acts, to the route they follow and to the possibility of always moving forward by bringing to bear the same intelligence on the conquest of new territories.

Table 3 .1 Reflective Domains

Self-reflective domain	Other-reflective domain
<p>Reflection:</p> <ul style="list-style-type: none"> • on content competence • on pedagogy • on educational philosophy • on own biography • on experience 	<p>Reflection:</p> <ul style="list-style-type: none"> • on people <ul style="list-style-type: none"> Progress of individual learner Progress of learners in general Expectations of and interactions with colleagues, parents, school managers • on field or subject <ul style="list-style-type: none"> nature of the field or subject curriculum requirements academic and assessment requirements • on educational context <ul style="list-style-type: none"> Classroom context <ul style="list-style-type: none"> Dynamics of class group Dynamics of teaching and learning processes Availability and suitability of resources School context <ul style="list-style-type: none"> Administrative and organisational matters Educational ethos Socio-economic context Historical context • On formal and informal influences <ul style="list-style-type: none"> Formal and informal networks and influences

In Table 3.2 I have delineated those aspects that may influence teacher praxis into three categories. They are the teacher's own attributes, the nature of the social and professional interactions with others, and the educational contexts. Once again, the nature of the

influence of any of these aspects on teacher praxis, by themselves or in various combinations, is multi-dimensional, multi-faceted and dynamic. These may range from distinct and identifiable aspects on the one hand, to overlapping, integrated and merged on the other hand. The teacher makes choices based on his or her own circumstances. The teacher's focus is two-pronged, that is, a focus on own praxis and a focus on learners' progress, hence, self-reflective and 'other' reflective. Yet, there is a dynamic relationship between the two foci.

Table 3.2 Aspects that could inform teachers' praxis

Personal	Social and professional interactions	Educational contexts
Biography of teacher	With learners	School
Professional education	With colleagues	Country
Experience	With parents	Policy
Subject competence	Education officials	Curricula
Pedagogic style	Family	Subject field
Philosophy of teaching and learning	Friends Acquaintances Strangers Transitory exchanges Informal exchanges Formal exchanges	Teaching resources Media Social Networks

I now turn to Dunne and Pendlebury (2003:194–211), who point out that many scholars have been drawn to the construct of 'practical reason' in efforts to throw light on the kind of knowledge related to good teaching, especially in consideration of teacher education programmes intent on assisting students in becoming practically wise persons. They further note that such programmes could focus on an aspect of teacher education that contributes to the development of deliberative dispositions required for democratic citizenship. I should like to take this idea of the wise person further by considering the need for teachers to make appropriate choices or judgements in their educational contexts. Judgement, according to Dunne and Pendlebury (2003:194–211), is an ability to recognise situations, cases or problems, which may not be clearly specifiable or

straightforward, and to deal adequately with them. They very aptly present the notion of judgement as an iterative process in which the person has to navigate resourcefully general as well as particular aspects of a situation, drawing on experience, knowledge, sensitivity to context, and creative insights to exercise judgement. In addition, they contend that cognitive abilities alone are not sufficient and further highlight personal qualities such as patience, courage, and steadfastness to make appropriate judgements despite criticism and consequences. Where does that leave student teachers who are limited in experience and pedagogic insights, compared with an experienced teacher?

One of the main tasks of a teacher education programme is initiating students into the teaching profession, where the critical capacity, based on professional judgement, should be emphasised. Opportunities for engagement in critical dialogue around matters of teaching and learning could enhance students' capacity to reflect and deliberate on aspects of professional practice. They could be encouraged to implement some of their ideas when they participate in the teaching practice component of the programme, which may be campus based during microteaching sessions or school based when they are at schools during their internships. The teaching programme should also encourage links with educational theory, their own or that of other scholars, as an aspect of their deliberation.

A dilemma exists in that the development of the critical capacity relates to the teacher's individual praxis in terms of his or her own professional conduct and pedagogic choices. These may be the result of conscious deliberation or informed by experience, yet seemingly arising as spontaneous and intuitive. However, the criticality that they are expected to imbue in the learners they teach is not necessarily only related to themselves and their conduct. Rather, it could also be allied to the subject they teach. Their notion of critical thinking as well as their grasp of their subject could inform their professional conduct. That is, they need the necessary epistemic expertise to make the choices that would encourage the growth of critical thinking in their learners specifically, through the subject they teach. To put it differently, enhancing their own critical thinking capacity within the context of their profession is one thing, while enhancing the critical thinking capacity of the learners they teach is another. I shall elaborate on the discipline-specific aspect of critical thinking in science education in Chapter 6.

3.8 An attempt at developing a conceptual elaboration

So, to reiterate, constitutive meanings of notions of critical thinking could include cognitive skills and dispositional aspects. If I were to bring it into the realm of a teacher's working life, then I could include the teacher's professional judgement as an additional feature, where the teacher operates in the context of the discipline taught. Such judgement will involve reflection on self and reflection on other, as I've discussed previously. The judgement is thus purposive and contextualised. It is a judgement which presupposes reflection and informs practice. This practice informed by reflection can be termed reflexive praxis. It is this notion of reflexive praxis, acknowledged as a conceptual gap that can be regarded as an enabling condition for the enhancement of critical thinking in the context of the teacher's role in the classroom. Here follows my first attempt at developing a tentative conceptual elaboration of critical thinking which involves considerations of the role of the teacher. Such a conceptual elaboration could include the features as presented in Table 3.3.

It is accepted within the critical thinking movement that cognitive skills as elaborated on previously are important in critical thinking. This implies that the thinking may involve some form of cognitive conflict in which the thinking is not necessarily procedural or clear cut. In terms of cognitive skills, the literature presents an alignment between the ability to reason and critical thinking. One way of conceptualising reasoning is as a way of 'figuring things out', rather than mimicking or following unquestioningly. That is, applying rational reasoning skills which incorporate all those cognitive abilities associated with critical thinking. So, what will help the teacher to 'figure things out' in the science classroom? It would help if the teacher has the necessary knowledge and understanding of educational as well as science concepts and content to inform judgement. If this is lacking, then having the drive to acquire such knowledge and understanding could assist the teacher's ability to make sound professional choices. The dispositional aspect may imply a particular perspective that informs the teacher's conduct. I shall elaborate on this further in Chapter 4. The content or discipline-specific aspect I have included as part of the teacher's domain of operation; thus, how it may be applicable to science education specifically. So clearly this conceptual elaboration situates teachers' professional judgement and practice at its core, even though it is not specifically noted in the features presented. It is subsumed by the notion of reflexive praxis, which implies the evaluative exercise of professional

judgement to inform practice. While all modes of thinking may have purpose and be contextual, I still consider these features sufficiently important to include them as part of my conceptual elaboration as they provide the milieu for the thinking.

Table 3.3 Features of critical thinking related to a teacher's role

Features of critical thinking	An elaboration of what they could include
<ul style="list-style-type: none"> • Purposive 	These may include consideration of teaching and learning goals.
<ul style="list-style-type: none"> • Contextual 	These may be related to the discipline as well as to the context of the educational environment.
<ul style="list-style-type: none"> • Involve rational reasoning skills 	Particularly those thinking skills associated with critical thinking which could entail an assessment of reasoning based on the pursuit of evidence, clarity, accuracy and coherence.
<ul style="list-style-type: none"> • Have a dispositional aspect 	The inclination to question and seek accuracy and truth or a moral and value-laden orientation.
<ul style="list-style-type: none"> • Involve reflexive praxis 	Practice where professional judgement informs action operating within a particular reflective domain.

3.9 Discussion

While I consider aspects of a teacher's working life to inform my conceptual elaboration, as this is what the student teacher is ultimately being prepared for, I am aware that my interest in doing this is to consider implications for teacher education programmes. However, the issues are more complex than the way it is presented. Frelin (2014:264–273) notes that many education researchers have acknowledged teaching experience as being important when making informed judgements on various matters. In practice, teachers are often confronted with emerging issues which need immediate responses; these Frelin (2014:267) refers to as 'hot action' from Beckett (1996:147). She draws on Dreyfus, Dreyfus and Athanasiou (1986), who postulate that what is seemingly an intuitive response to an emerging issue could be related to an association with patterns in similar situations

which have worked before, without our necessarily being specifically aware of what they may be. In this way past experience and practice could inform responses to emerging issues. This puts it in the realm of sensing rather than knowing. In addition, applying professional judgement to an emerging incident may not necessarily be a once-off occurrence and the consequences of the action chosen by the teacher may lead to changed conditions in the classroom that may necessitate more judgement and action, where each result informs the next move. Frelin (2014:264–273) suggests that focusing on analysing a series of judgements might be a way of enriching contextual understanding in constantly changing educational situations. Student teachers cannot draw on their experience to the extent that experienced teachers can, as they may have limited experience and possibly naïve emerging insights. A teacher education programme should provide opportunities for student teachers to take risks, to ‘try things out’, to experiment, to reflect on various aspects of their practice and not be too daunted by the consequences, as long as they contribute to developing their own insights and professional memory. Yet, such episodic occurrences are not the only times when teachers draw on their professional judgement as I have outlined when presenting reflective domains of operation previously.

While my focus has been on the kind of judgement which informs thoughtful action, there are other orientations or approaches that one could use when deliberating on the notion of judgement. For instance, one could take a neurological approach and explore somatic conditions of the brain that influence judgement, particularly judgement related to moral or value-laden decisions. This route has been of interest to researchers working with people who display deviant social behaviour or who have suffered brain damage caused by accidents. They used neuroimaging to explore whether parts of the brain are related to the interplay between reason and moral judgement. (Greene & Haidt, 2002; Moll & De Oliveira-Souza, 2007). In the arena of cognitive psychology applicable to education, Piaget (In Inhelder & Piaget, 1958) has been the most prominent proponent of age-related stages in cognitive development. It follows that teachers need to be aware of the cognitive stage of development of learners so that they can make appropriate decisions on the nature of the tasks they set their learners. In addition, this awareness can also assist teachers to shift their learners’ abilities to enable them to address more mentally challenging tasks.

Studies suggest that significant changes in the brain, particularly in the prefrontal cortex during early adolescence, could be linked to improved cognition. Steinberg (2005:70)

found increased efficacy in logical reasoning and information processing with age. However, Steinberg (2005:72–73) acknowledges the significance of the affective domain and emotions in adolescence, particularly when making risky decisions in real-life situations such as drinking or engaging in unprotected sex. Watt (2004:78), however, objects to the cognition–emotion dichotomy and suggests that emotion is an extension of cognition, not something that is counter-posed to it.

Jacobs and Klaczynski (2002:145–149) argue against a linear view of cognitive development from less to more complex cognitive abilities. While there is general acceptance in many studies that adults are capable of systematic reasoning, the authors (2002:145–149) claim that often these studies are done under ideal conditions and do not take judgement biases into account, particularly for social beliefs. Social constructivist theories of learning as epitomised by Vygotsky (1978) which emphasise that social interaction and cultural contexts impact on learning and thinking have countered cognitive constructive theories of learning as typified by Piaget. In science education, scholars (Shayer & Adey, 1993; Adey, 1999) have incorporated both theories when devising interventions that focus on teaching approaches that enhance critical thinking in learners.

King and Kitchener (2004:5–18) note that there seems to be an alignment with individuals' assumptions about knowledge, that is, their epistemic cognition and the nature of their reflective judgement. They present a reflective judgement model that describes a progression aligned with people's epistemological assumptions when making judgements about ill-structured or controversial issues that are not clear cut. These assumptions coincide with different ways of justifying beliefs. The progression ranges from pre-reflective through quasi-reflective to reflective thinking, where at the one end of the spectrum, knowledge is viewed as certain or authoritative, and judgement is absolute. Often, the judgement is informed by unsubstantiated beliefs or opinions. Reflective thinkers at the other end of the spectrum re-evaluate their knowledge claims depending on the emerging contexts and available information. They use reason and evidence to support their judgement and are continually open to new perspectives as knowledge is constructed and reconstructed. It could be assumed that the preservice teacher, as an adult learner should be able to develop a reflective capacity that would augment critical thinking in the classroom. Significantly, King and Kitchener (2004:5–18) advance the consistent finding that development in reflective thinking seems to unfold in a slow, steady manner, and that interventions could assist students in enhancing their reflective judgement. They suggest

including ill-structured problems into the curriculum, providing discipline-specific contextual support as well as opportunities for engaging students in reflective tasks to stimulate optimal functioning at abstract rather than concrete levels.

Furthermore, in the field of psychology, studies have shown that there are many factors other than educational considerations that influence teachers' judgement of learners' ability. For example, preconceived ideas that teachers may have because of hearsay or prejudices could interfere with teachers' perceptions of learners. The tendency to label them unfairly as deviant or slow, despite evidence to the contrary, could influence their engagement with and expectations of learners' performance and ability. Studies have found that teachers continue to hold negative expectations of children, misinterpreting their behaviour, and resulting in a halo effect that clouds their judgement. Such ill-conceived judgement can occur in various situations of classroom dynamic and may relate, among others, to aspects of learner ability (Foster & Ysseldyke, 1976; Powell & Siegle, 2000), gender (Dee, 2007), and socio-economic background, culture and ethnicity (Cooper, 2003; Elhoweris, 2008; McKown & Weinstein, 2008; Mason, Gunersel & Ney, 2014). An awareness of this is crucial to avoid unfair and bigoted educational practices.

3.10 Conclusion

Coney (2015:515–528) speaks of critical thinking as a response to a crisis or a dilemma or a state of impasse or a problem which necessitates a need for critical thinking. I agree that critical thinking may be required in such instances and the teacher has to apply professional judgement to address the situation. The response will depend on the severity or nature of the situation and the teacher may need to draw on cognitive capacities supported by other aspects such as intuitive memory, experience of similar occurrences, situational awareness, empathy, and so on. However, professional judgement should not be limited to crises or challenging situations only. There may be moments or situations which present conditions of accelerated learning and heightened enquiry in the classroom. These moments may be lost if the teacher doesn't use his or her critical judgement, firstly to recognise such situations and secondly to respond to them in ways which will heighten insights, spur enquiry and accelerate learning. However, this is still in responsive mode. Teachers can also take the initiative and create conditions for intensifying the will to learn in their learners. These are conditions in which the teacher summons learners to exercise their own will to learn (Rancière, 1991:1–43). It assumes an intellectual capacity based on an equality of intelligence and hence the inherent potential to learn through one's own

endeavours. In this way, the learner is emancipated rather than being dependent on what Rancière (1991:1–43) refers to as the ‘master explicator’. Hence, the teacher’s knowledge is not a precondition for learners’ learning.¹³ In this way the teacher summons the learners to draw on their own intellectual resources to explore new or elaborated intellectual terrains. Clearly the teacher in Rancière’s tale (1991:1-43) is operating from a particular perspective which brings me to the realisation that the conceptual elaboration of notions of critical thinking presented here is insufficient. It does not take into account the perspective from which the teacher operates. I shall attempt to address this aspect in the next chapter.

In this chapter I deliberated on key concepts related to critical thinking and the teaching profession. I argued that critical thinking in teacher education is linked to professional judgement and hence a teacher education programme should lay the basis for critical professional judgement. I provided a justification for this line of argument by highlighting the reflective component of a teacher’s work, resulting in praxis rather than practice. Finally, I developed a tentative conceptual elaboration of critical thinking in the context of the teacher’s educational practice. In the next chapter, in pursuit of a further conceptual amplification, I explore how the notion of critical thinking manifests in the educational discourses in South Africa and discuss the implication of these manifestations on the teacher’s conduct.

¹³ Rancière (1991:1-43) so aptly illustrates this when he draws on the tale of Jacetot, the French schoolmaster, who could not speak Flemish, yet he summoned his Flemish students to learn French through their own efforts by using a bilingual text. Jacetot used a bilingual edition of François Fénelon’s *Les Aventures de Télémaque* (1699) as a mediating text for Flemish students to use by themselves, in order to learn French through their own efforts.

CHAPTER 4

DOMINANT EDUCATIONAL DISCOURSES IN SOUTH AFRICA

4.1 Introduction

In the previous chapter I developed a tentative conceptual framework of notions of critical thinking in the context of the teacher's professional role. In this chapter I continue with the elaboration by exploring how the notion of critical thinking manifests in the educational discourses in South Africa. This is my attempt to contextualise notions of critical thinking historically in South African educational discourses. Peters (2007:350) makes the point that too often the movement of critical thinking tends to treat thinking ahistorically, focusing on universal processes of logic and reasoning. I acknowledge that the discussion up to this point has drawn on mostly Western thinkers within the logical, rationalist tradition of critical thinking, precisely because the critical thinking movement originated in this milieu. I now attempt to embed notions of critical thinking in South African educational discourses. I use the interpretive lens to deliberate on perspectives of critical thinking in the various educational discourses presented. I do this in order to gain insights into how these contexts may affect the conduct of teachers in general and science teachers in particular. Here, the analysis entails examining notions of critical thinking in the context of the dominant educational discourses that prevailed in South Africa during and after apartheid. This exploration addresses Research Question 1: How do notions of critical thinking prevalent in the dominant educational discourses in South Africa impact on science teachers' conduct?

4.2 Perspectives on notions of critical thinking

Discernible in the literature are various perspectives from which the conceptualisation of critical thinking is drawn as pointed out previously. The emphasis on reasoning skills only, devoid of values and context, can be located within a positivist framework. Bloom's (1956) taxonomy or Facione's (1990) inventory of critical thinking skills could possibly fit into this category, although in later works the author and co-authors (Facione & Facione, 1992; Facione et al., 1995) highlight the dispositional aspect of critical thinking. By adding the dispositional dimension, notions of critical thinking are broadened somewhat and can be located within the interpretive framework, where subjective perspectives and worldviews influence understanding. Siegel (1988:23) notes that a person may have the capacity for

critical reasoning but not the disposition to actually do it. Bailin, Case, Coombs and Daniels (1999:285–302) identify five types of intellectual resources needed for critical thinking. These are background knowledge, operational knowledge of appropriate standards, knowledge of key concepts, possession of effective heuristics, and possession of certain vital habits of mind. Heuristics refer to strategies used by people to monitor or guide performance in different kinds of thinking tasks. Bailin et al. (1999:293–294) offer some examples, such as the usefulness of thinking of consequences when formulating a certain plan of action or perhaps to elucidate and concretise the thinking by suggesting examples that may be applicable. They note that the critical thinker needs a rich repertoire of heuristic devices to facilitate his or her thinking tasks. These vital habits of mind (Bailin et al. (1999:293–294) could emphasise the value or dispositional aspect of critical thinking and may include such qualities as respect for reason and truth, an enquiring attitude, open-mindedness, fair-mindedness, and so on, which underscore a belief in integrity and responsible action. Paul's strong sense critical thinking (2012:255–287) also emphasises the same kinds of values as the aforementioned. Liberal notions of critical thinking that stress the autonomy and perspective of the individual, while drawing on democratic values and contexts, can also be located within an interpretive paradigm. On the other hand, linking critical thinking with pedagogy that promotes emancipation, as part of a collective vision for a more just society, places notions of critical thinking within the critical paradigm. The three philosophical perspectives presented here, that is, positivist, interpretive, and critical, are not unlike the sociological perspectives, that is, conservative, liberal, and radical discourses presented by Cross et al. (2009:475–503) in their analysis of the South African educational milieu during and after the apartheid era. I draw on these perspectives as identified by the authors to consider notions of critical thinking in the contexts described below.

4.3 The South African context

Cross et al. (2009:475–503) point out that there has been a shift in the discourses and essential characterisations of the educational milieu in South Africa from the apartheid to the post-apartheid era. According to the authors, these discourses range from the liberal and Afrikaner nationalist discourses of race and ethnicity through the short-lived radical and neo-Marxist discourses of the seventies and eighties of social class and gender, to a mixture of constructive and postmodern discourses that accentuate nation building, identity and cultural diversity in an essentially neo-liberal paradigm. Such an educational

historiography is relevant to my study as influences and traces of how things were impact on how things are.

In accordance with my interpretive lens, I make the claim that the teacher exercises professional judgement, and thus consciously or unconsciously operates from a particular perspective. The educational context in which the teacher operates, possibly influenced by the socio-political milieu as well as education policy expectations, could impact on teachers' professional judgement and hence their professional conduct. With this in mind I now turn to the South African educational context.

4.3.1 Christian National Education and fundamental pedagogics

Cross (1986:186–187) observes that essentially, during the apartheid era, the prevailing Christian National Education (CNE) proclaimed that education must be adjusted to the worldview of the Afrikaner which emphasises the Christian philosophy of life, Calvinistic beliefs and the principle of nationalism in education. This nationalism focused on cultural preservation in terms of traditions, religion, language, and so on, particularly of the Afrikaner, and hence justified keeping the races apart at all levels of society, especially in aspects of education. In his book, *Education for Barbarism*, Tabata (1980:26–36) provides a lucid portrayal of the origin of CNE. He points out that the particular brand of Afrikaner Calvinism, namely that of the Dutch Reformed Church in South Africa, was nurtured in an arid cultural wilderness and degenerated into bigotry, narrow fanaticism and rabid nationalism. According to Tabata (1980:26–36) the forebears of the present-day Afrikaners, isolated from the influence of humanism, were shut off from the strong current of rational thought on man, nature and society that spread through Western Europe in the eighteenth century. In his words:

They missed that age of criticism and enquiry that was to question everything hitherto regarded as sacred and immutable; they missed that age of scepticism which submitted ideas and established institutions to the scrutiny of reason, when all values, the nature of society and man's position in the universe had to be reassessed. In a word, the forebears of the present-day Afrikaner did not come into contact with the keen ideological struggles of the Age of Enlightenment in Europe, the age of Reason – as it has been called – when dogmatism and bigotry had to give way to progressive thought (Tabata, 1980:28).

In my attempt to get to the root of fundamental pedagogics during the apartheid era, Morrow (1990:175) points the way. He asserts that the notion that different 'population groups' have different and incompatible 'cultures' is a convenient myth which not only provides the rationale for the type of social engineering that materialised in South Africa

but in addition underpins the theory of education called fundamental pedagogics. Cross (1986:187) relates that fundamental pedagogics emerged in the seventies, within the positivist and phenomenological tradition, as a new theory and philosophy of education based on CNE. Cross et al. (2009:485), in their account of the educational historiography in South Africa, note that the proponents of fundamental pedagogics emphasised a so-called ‘objective scientific’ approach to education devoid of theory, values and politics. Yet, in effect, it served to reproduce and institutionalise those traditions, manners and customs that were aligned with Afrikaner ideals. I now turn to notions of critical thinking operating in this context.

Richard Paul (2012) writes prolifically on critical thinking and how to foster it at all levels of educational delivery in the USA. He distinguishes between weak sense and strong sense critical thinking (2012:255–287). Weak sense critical thinking refers to the self-serving critical person who may apply a range of accepted and highly sophisticated intellectual resources for ego-centric or socio-centric purposes, while strong sense critical thinking refers to the fair-minded critical person whose critical thinking skills are internalised in the service of balanced truth, rationality, autonomy and self-insight. Intellectual traits such as intellectual humility, intellectual courage, intellectual empathy, intellectual integrity, intellectual perseverance, faith in reason and fair-mindedness are all pertinent to strong sense critical thinking. According to Paul (2012:666), socio-centrism refers to the assumption that one’s own social group is inherently superior to that of others and thus the dominant worldviews of this group are correct, reasonable and justifiable as in the case of Afrikaner Christian Nationalism. Closer to home, this theme is addressed by Wally Morrow (1989:151–169), who counter-poses critical thinking with doctrinaire thinking, where he presents a ‘doctrine’ as any system or web of beliefs which embodies a coherent pattern of not only thoughts, but also feelings and practices. He asserts that these two types of thinking are profoundly incompatible with each other. According to Morrow (1989:151–169), the doctrinaire thinker deals with external criticism by dismissing the criticism as insanity, disobedience or ignorance, and in this way manages to maintain a self-righteous stance in the face of criticism. Morrow (1989:151–169), writing during one of the upsurges of the anti-apartheid struggle,¹⁴ considers the notion of critical thinking, with fundamental pedagogics in mind, as a model for developing his ideas, although he indicates that he could have similar problems with many other doctrines that are followed uncritically, such

¹⁴ This article was first published in the Proceedings of the Kenton Conference in 1986, after a fresh wave of school unrest.

as, for example, ‘Marxists’ or ‘behavioural psychologists’. Although Paul (2012:255–287) still regards critical thinking for socio-centric purposes, in the narrow or weak sense, as critical thinking, I am inclined to agree with Morrow (1989:151–169) that the thinking embedded in Christian National Education and fundamental pedagogics is delusional, based on a false premise of white superiority and thus incompatible with critical thinking. In this case, the cognitive skills associated with critical thinking serve a socio-centric educational purpose that is narrow, exclusive and closed minded in outlook operating in an oppressive socio-political context; in short, doctrinaire thinking as designated by Morrow (1989:151–169). Despite this allegation of doctrinaire thinking, proponents of fundamental pedagogics might claim that they in fact have highly critical thinkers among their ranks. Morrow (1989:168) contends this claim is a kind of an illusion, as the ‘critical thinking’ is isolated from other parts of their belief system and that the persistence of their fundamental beliefs *‘turns out to be little more than the uncritical wielding of an unexamined formula’* (Morrow, 1989:168).

Teacher education programmes in Afrikaner universities as well as in ‘black’, ‘coloured’ and ‘Indian’ universities and teachers’ colleges, in the apartheid era, were based on fundamental pedagogics. The latter institutions were under the ‘trusteeship’ of the Afrikaner state and hence most staff members at these universities and teachers’ colleges were Afrikaners, whose practices were rigidly controlled. Science teachers were expected to follow the syllabus in the way it was prescribed and focus only on the permissible content. This context negated teacher professional judgement unless exercised in the narrow parameters of the subject being taught. Despite this control, there were contesting voices among the ranks of the oppressed, and awareness of their subjugation did not make them passive recipients of an ideology that sought to keep them in their place. In this milieu of general repression, science education in schools was presented in a very didactic way as a fixed body of knowledge and academically neutral. The perspective on notions of critical thinking is thus a conservative one, where cognitive reasoning is restricted to the confines of the discipline.

4.3.2 Liberalism

In its pure sense, the rallying cry of the French Revolution of ‘liberty, equality, fraternity’ could serve as the exemplification of liberal thought. Liberal education would be able to function most effectively in a liberal democracy, where aspects such as autonomy of thought, basic human rights, freedom of expression and association, and tolerance of the

other are allowed without fear of consequence. These would also be features of a liberal education. Not so in apartheid South Africa. Liberal discourses in South Africa, though a contested discourse in relation to Afrikaner nationalism, were still essentially discourses of the ruling classes and did not serve a transformative agenda. Liberalism in South Africa during the apartheid era was also somewhat tainted by accusations of paternalism (Cross, 1986:185–197), and the attempts to ameliorate these extreme conditions of subjugation experienced by black people in South Africa through assimilationist and egalitarian policies which were unable to effect fundamental change. Nonetheless, it co-existed as a counter to the extreme application of apartheid education.

Liberal discourses continue to manifest in the new, post-apartheid South Africa, albeit in a different way. Enslin (1999:175–186) argues that in its South African expression, the view of liberalism may be contemptuous, possibly because of the historical role of liberal influence in apartheid South Africa as well as the questioning of the appropriateness of liberal education in non-Western countries. Yet she argues that the new democratic order in South Africa presupposes essential distinguishing features of liberalism.

She refers to the White Paper on Education and Training (DoE, 1995) and indicates that the transformed education system envisaged in the new democracy rests on a set of liberal principles as I've described previously. Secondly, she points out that the White Paper endorses independent and critical thought, presenting this as a feature of liberal education which emphasises the development of autonomy as its central aim and of critical thinking as a necessary feature of autonomy. Enslin (1999:175–186) then tracks these characteristics of a liberal education to other policy and curricula documents, such as the *South African Schools Act, No 84 of 1996* (Republic of South Africa, 1996b) and Curriculum 2005 (DoE, 1997). At the level of teaching and learning in schools, learners are expected to develop certain capacities for democratic citizenship associated with critical thinking, for example, the ability '*to investigate, reflect, use evidence appropriately, construct reasoned arguments, make sound judgements and take appropriate action*' (Enslin, 1999:177). Hence, the notion of critical thinking manifested here is one of democratic citizenship and social justice informed by liberal influences.

The concept of liberalism thus takes on a different form in the old and new South Africa. In the former, the emphasis was on the amelioration of those rigid, oppressive apartheid structures which constricted economic and social development, while in the latter, liberal influences contribute towards the building of a new nation at the dawn of the democratic

state. In such an environment, the science teacher should be able to exercise autonomous professional judgement without fear of censure and seek to engage all learners in non-threatening and enabling contexts. However, neo-liberal tendencies quickly overtook the rhetoric of liberal intent.

4.3.3 Neo-liberalism

In an analysis of the National Qualifications Framework, also known as the NQF, an education blueprint formulated by the joint efforts of the Department of Education and Department of Labour (DoE & DoL, 2002), Allais (2003:305–323) argues that the drive towards democracy and the neo-liberal economic agenda have been incompatible and that the pressures of the latter have been dominant. Van der Walt, Bolsmann, Johnson and Martin (2003:275) contend that in a neoliberal discourse, universities have increasingly been reconceptualised as potentially profitable corporations and sites of investment that should be run according to private sector managerial principles and profit-making imperatives. This shifted the model of the traditional, autonomous university, focused on academic concerns and research, to a ‘market university’ suited to the production of information commodities or skilled personnel. They note that this move towards fiscal austerity impacts on all aspects of university decision making. For instance, aspects of academic staffing, curricula and research priorities are determined by considerations of profitability.

Education generally and teacher education specifically could not escape the all-pervasive grip and influences of neo-liberalism. In the late nineties the rationalisation policies of the new government spurred on by global contexts and the pressure of the structural adjustment policies of the World Bank and the International Monetary Fund saw unprecedented retrenchment of teachers, including experienced science teachers (Harber, 2001:13–17) and the closure of all the colleges of education in the name of equity and redress. Some of the colleges were absorbed into selected universities. Even at the universities, teacher education was being ‘downsized’, with some teacher education programmes under threat of closure while others lost their status as education faculties and were downgraded to departments. This process was complicated further by the merger of many higher education institutions nationally. These events provide a context for this period but do not serve as the focus of my study. Suffice it to say that curriculum concerns were not uppermost on the agenda as the whole profession was in survival mode, ironically from the very state which purported to support it.

Yet, at the same time, together with the effects of the neo-liberal economic agenda, teachers and teacher educators were confronted with a new outcomes-based education system which was almost a wholesale adoption of policies and programmes from countries such as New Zealand (Allais, 2003:310) The mode of educational delivery was expected to change to encourage autonomous learning and critical and creative thinking. This necessitated a change in teaching and learning approaches from the former rote-based didactic, top-down delivery of content to interactive engagement based on constructivism. Subsequent revisions to the school curriculum have diminished the emphasis on outcomes somewhat, together with the rhetoric of the need for the development of critical thinking as the shift to an instrumentalist view of education has become more entrenched. Hence, liberal notions of critical thinking fit in the Western rationalist tradition which favours autonomy of thought and tolerance of other perspectives. This intent, however, despite the rhetoric, is curtailed by market influences in a neo-liberal shift. Notions of critical thinking in a neo-liberal paradigm thus are driven by budgetary considerations.

4.3.4 Radical discourses

Cross et al. (2009:475–503) give quite a clear account of radical voices that challenge the nationalist and liberal discourses. They refer to the heightened conflict in education demonstrated by the growth of the Black Consciousness Movement, based mainly in schools and universities in the early seventies, the uprisings of 1976, and the school boycotts of the eighties (2009:485–486). They point out that from the radical standpoint, any attempt to grasp the history and dynamics of education in South Africa cannot be isolated, but must be done with reference to broader economic, social and political processes – this being the main difference with the liberal discourse (Cross et al., 2009:488). The short-lived ‘people’s education for people’s power’ in the mid-eighties, though subject to critique, attempted to provide an alternative view to the ruling class discourses. Hyslop (1988:183–209) relates that at a conference convened by a wide range of organisations involved in the education struggle, a decision was made to set up crisis committees around the country that would create a network of Parent, Teacher and Student Associations (PTSAs) which would constitute an alternative education authority, thus challenging state control of education. For many reasons, which I shall not go into here as it is not the focus of the dissertation, these could not be sustained.

In terms of teaching and learning, as mentioned earlier, the work of Paulo Freire (1996:52–67) epitomises this radical tradition the best and was an inspiration for many anti-

establishment educational activists during the apartheid era. Although not wholly adopted in the South African educational struggle, I draw on his work as he presents pedagogy for teachers that effectively exemplifies this perspective.

According to Freire (2004:33), critical thinking occupies an integral part of this approach, which in essence seeks to bring people to an acute awareness of their own condition of oppression and further stirs them, through their inherent understanding of their situation, to do something about it. He encourages '*reflection and action upon the world in order to transform it*' (Freire, 2004:33).

The revolutionary role of the teacher is one of engagement rather than prescription. The teacher, who has faith in the learner's capacity to think and articulate his own social reality, enters into a dialogue with the learner, and together as co-investigators, they develop insights which illuminate these oppressive conditions and develop ways of combatting them. The agenda is an emancipatory one for both teacher and learner. The quest is towards becoming fully human (Freire, 2004:25–56). Freire warns that prescriptive dialogue controlled solely by the teacher rather than engaged dialogue involving teacher with learners has the danger of degenerating into paternalistic manipulation. There is a joint effort to engage in critical thinking and the quest for mutual humanisation. Freire is very definite about the notion of critical thinking and the role of true dialogue in needing as well as generating critical thinking.

...true dialogue cannot exist unless the dialoguers engage in critical thinking – thinking which discerns an indivisible solidarity between the world and its people and admits of no dichotomy between them – thinking which perceives reality as process, as transformation, rather than a static entity – thinking which does not separate itself from action... (Freire, 2004:73).

Hence, here we see a notion of critical thinking which takes into account the dynamism of an ever-changing world and the inseparable connection of people within it. But this connection to the world is not a passive one over which people have no control and to which they need to adapt. Herein is the crux of criticality. They are able to reflect and act on their world in order to transform their own reality in pursuit of becoming fully human or authentically emancipated. Dialogue thus articulates thought and facilitates reflection for action. In the critical education tradition, as exemplified by Freire (2004:73), the role of engaged dialogue and reflection for transformative action in the context of a changing world are the elements crucial to critical thinking. Hence, engaging critically with regard to

science and society issues would align well with the critical perspective, particularly on aspects of bias or the impact of scientific endeavours on people and the environment.

4.3.5 Africanisation of the curriculum and decolonisation

More recent discourses and public discontent with the way academia conducts its affairs have emerged, compelling higher education to take another look at what they do. The current call for a decolonised curriculum by students as a spinoff of the #FeesMustFall movement (Naicker, 2016) became a powerful voice for such a re-examination. Demands for the decolonisation of the curriculum have been placed firmly on the agenda and prompted a flurry of symposia and a call by the then Minister of Higher Education and Training, Blade Nzimande (Nzimande, 2015), for universities to address these demands through building African universities that are globally engaged. The argument is that all manner of economic, social and cultural impediments militates against successful progress of black students in higher education. One of the main accusations is that there has been no authentic transformation in universities, despite the increase in black student enrolment, and that their Eurocentric (read colonial) orientation still serves the descendants of the colonisers and does not acknowledge, let alone address, the lived experiences of the African student in a fundamental way (Ramoupi, 2014; Mbembe, 2016). Students are therefore compelled to adapt to the prevailing academic orientation. For example, there are claims that the science taught at universities and schools can be labelled a Western view of science, and hence not necessarily relevant to the African child. Heleta (2016:1–8) addresses epistemic violence, in which he claims that the largely Eurocentric curriculum reinforces white dominance and privilege. This dominance is a consequence of a negotiated settlement in which the underlying economic and social inequalities remain entrenched, including inequalities in higher education, despite the achievement of political equality. While the acknowledgement of indigenous knowledge systems may be a move in the right direction, it could be argued that such acknowledgement is still being viewed from a coloniser perspective. The notion of Indigenous knowledge systems in science education is an emerging emphasis which manifests in school science curriculum policy, but I shall elaborate more fully on this aspect in Chapter 6 and Chapter 8.

These calls for a decolonised curriculum form part of the unfolding South African historiography. Such calls which draw attention to and expose the ongoing subjugation of

the previously subjugated classes could very well fit into the radical realm where notions of critical thinking are driven by an emancipative agenda.

4.3.6 Postmodern discourses

As indicated previously, Cross et al. (2009:475–503) refer to constructivist and postmodern discourses in relation to aspects of nation building, identity and cultural diversity, contextualised within a mainly neo-liberal paradigm as an unfolding historical phenomenon. The notion of postmodernism is a difficult concept for me to interrogate because of the multiplicity of meanings that have been presented by various scholars. Bloland (1995:521–559) highlights two orientations of the notion of postmodernism: postmodernism as a perspective that tries to make sense of disparate cultural, economic, political and social changes in varying contexts, and postmodernism as a historical period, possibly even viewed as late capitalism or an advanced form of capitalism (Jameson, 1984:53–92). Either way, Bloland (1995:521–559) notes that postmodernism problematizes the major assumptions and assertions of modernity. These include instrumental rationality and canonical scientific processes that have contributed to forging a consumer society, of which higher education forms an integral part. Postmodern characteristics, according to Longstreet (2003:14), are doubt, uncertainty, conflicting values, potentially an endless variety of responses to issues or problems, as well as the contradictory weight of personal and cultural perspectives. Longstreet points out that despite the disparate stances on postmodernism, a unified theme is '*making space for different ways of knowing and being*' (Longstreet, 2003:11).

Hargreaves (1994:31) posits that purposive, rational thought related to aspects of teaching and learning are often an emphasis for teacher education programmes. While he acknowledges that the mastery of content and skills is important, he claims that in a postmodern era, '*critical judgments about the social contexts of learning*' (Hargreaves, 1994:7) are central to the teacher development agenda. These would involve aspects of moral intent, emotional investment and political awareness, which are not as easily planned for and packaged in educational curricula (Hargreaves, 1994:7–34).

Shifting postmodern notions of critical thinking may be more applicable to a society in flux, in which the hidden and the taken for granted are also considered as important, where one pushes the boundaries beyond the concept in itself. I include the postmodern, even though it was not elaborated on as clearly as the other discourses in Cross et al. (2009:475–503). At this stage in my dissertation I do not provide a comprehensive articulation of what this

may mean but further exploration will divulge more, hence I place the postmodern perspective as an important one for consideration.

4.4 Discussion

I have attempted to interrogate notions of critical thinking in the various educational discourse traditions in South Africa from the apartheid era to the present as highlighted by Cross et al. (2009:475–503) in an effort to respond to Research Question 1. That is: How do notions of critical thinking prevalent in the dominant educational discourses in South Africa impact on science teachers' conduct?

Discernible in the discourses were various educational orientations. These ranged from the social engineering model of education which is underpinned by Christian National Education and fundamental pedagogics versus liberal education, to people's education in the eighties, underpinned by ideas of emancipation and transformation, through the onset of the new democracy and neo-liberalism as well as calls for a decolonised curriculum. Democracy or the striving for democracy does not necessarily manifest in all contexts as an enabler of critical thinking. This construct is associated with strong sense critical thinking rather than weak sense critical thinking as described by Paul (2012:255–287). Morrow's essay (1989:151–169) in support of critical thinking operates on the basis of two assumptions: that education and critical thinking are conceptually linked and that critical thinking is worth trying to foster. The implication is that only that learning which contributes to people's ability to think critically is educative.

In education under apartheid, Harber (2001:41) points out that the curriculum, based on the racial ideology of CNE, was constructed to discourage critical thought, enquiry and discussion and to encourage domination and submission. In such a milieu a good science teacher was one who could transfer a body of accepted scientific content, devoid of social and environmental contexts, effectively and efficiently. While the educational context as highlighted by the dominant discourses outlined do influence teachers' conduct, there is no clear-cut relationship between context and teachers' conduct. Despite the oppressive state apparatus which sought to subjugate the education of the oppressed, it would be wrong to assume that teachers accepted this state of affairs submissively and carried out the intent of the *herrenvolk* unquestioningly. There are accounts of teachers opposing these laws and playing a conscientising role in the classroom (Wieder, 2003). However, the damaging impact of the apartheid policies cannot be dismissed. Reports of unprofessional conduct of

teachers, such as high levels of absenteeism, corporal punishment, drunkenness and low morale in particularly poor communities have been highlighted (Christie, 1998; Harber, 2001). Independent and critical thought that contributes to the development of democratic citizenship was highlighted in a liberal educational tradition, where the teacher can exercise autonomous judgement in the classroom without fear of reprisal. Furthermore, in the radical educational discourse, the striving towards emancipation through authentic dialogue was emphasised. Here the teacher has a particular responsibility to engage learners in ways that will expose unequal and unjust processes and practices. The shift from the lofty ideals of social justice and redress towards a neoliberal discourse, as well as the more recent calls for relevancy and greater authenticity in the curriculum, presents fresh challenges to navigating notions of critical thinking. Aspects of teachers' professional judgement as essential components of critical thinking are worth considering as important in teacher education programmes, in the light of ever-changing educational contexts.

4.5 Further elaboration on the conceptual framework

To recapitulate, in the previous chapter I developed a tentative conceptual framework of notions of critical thinking related to the teacher's role, including purposive and contextual features and the application of rational reasoning skills with possible underlying dispositional dimensions and constituting a reflexive praxis. The latter was informed by the teacher's professional judgement. In addition, the teacher may operate from a particular perspective which could be in line with the dominant discourses described by Cross et al. (2009:475–503). I should like to argue that teachers operate from a particular perspective which may range on a continuum from conservative, to liberal, to critical and postmodern, as outlined in Table 4.1 below.

Table 4.1 Perspectives of notions of critical thinking

Conservative	Liberal	Radical	Postmodern
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Despite this attempt to delineate different perspectives of critical thinking, we should bear in mind the complex, dynamic nature of education, and these delineations simply serve as a guide for making sense of the notions of critical thinking. They are not absolute. They are broad strokes and cannot articulate more nuanced notions of critical thinking which are more likely to be complex and multifaceted. In addition, while there may be many

perspectives that could frame notions of critical thinking, I chose to highlight these four and delimit others,¹⁵ as those selected align with the dominant educational discourses emerging from the South African historiography as outlined by Cross et al. (2009:475–503). Such an alignment is pertinent to the South African context. Table 4.2 overleaf includes perspectives of critical thinking as an additional dimension and hence presents an elaboration of notions of critical thinking as related to a teacher's professional role. From each perspective or genre, features of critical thinking may still apply.

While it could be argued that many forms of thinking operate from a particular perspective and may involve purposive, contextual and dispositional features, it is important that all five features be regarded together as this provides the realm for critical thinking in the context of the teacher's professional conduct.

Table 4.2 An expanded conceptual framework of notions of critical thinking related to the role of the teacher

PERSPECTIVES OF CRITICAL THINKING	Conservative	Liberal	Radical	Postmodern
FEATURES OF CRITICAL THINKING	Purposive Contextual Rational reasoning skills A dispositional aspect Reflexive praxis			

4.6 Conclusion

In this chapter I described the historical shift in the South African education discourses generally and situated notions of critical thinking and their implications for the conduct of the science teacher in this discourse specifically. A consideration of the role of the teacher in the various educational trends in South Africa helped to clarify perspectives on critical

¹⁵ For instance, a pragmatic perspective could very well inform a teacher's conduct *vis-à-vis* notions of critical thinking.

thinking and their implications for teacher conduct. I attempted to provide a context in which the teacher is expected to exercise professional judgement. The purpose of this historical overview was to contextualise and provide some insights into the nature of the emergent teacher perspectives that could impact on their professional conduct. The conceptual expansion that emerged from this deliberation presents a continuum of perspectives from conservative through liberal to radical and finally postmodern. Each perspective or genre includes the features of critical thinking as presented previously. As the conceptual expansion stands now, it could serve as an analytical framework to analyse how perspectives and features of critical thinking manifest in teacher education policy, which I proceed to do in the next chapter.

CHAPTER 5

TEACHER EDUCATION POLICY: IDEOLOGICAL INTENT VERSUS CONTEXTUAL PRESSURES

5.1 Introduction

In South Africa there are myriad issues in education generally and in teacher education specifically that require attention, issues of equity and redress being at the top of the agenda. Getting it right therefore, will require the consideration of aspects such as teacher recruitment and provision, infrastructure and resources, and so forth.

Even though attention to teaching and learning may be significantly lower on the priority scale, the frequent curriculum changes to basic education do indicate that these aspects are drawing attention at national level. Whether these changes have had any positive effect on the quality of teaching and learning is unclear, as a correlation cannot be assumed. With the onset of the new democracy, the focus was on a very broad school curriculum which could be interpreted in many ways. The consensus was that teachers were professionals and should have the freedom to make autonomous decisions in terms of what and how they taught provided they operated within the parameters of very broad outcomes. Similarly, the initial guidelines (DoE, 2000) for the development of teacher education programmes presented broad parameters as well, which were aligned with the first post-apartheid school curriculum policy documents: Curriculum 2005 (DoE, 1997) and the revised National Curriculum Statement (DoE, 2003). Subsequent refinements of the school curriculum saw a constriction of these freedoms to a situation where the later requirements (DoE, 2011) are considerably more prescriptive. How do teacher education programmes respond to these changes? They have to orientate their students with regard to aspects of curriculum requirements on the one hand, yet also have a more autonomous agenda on the other hand. However, national educational policies change, often subject to the whims of changing hierarchies in government agencies. Teachers should have the capacity to function effectively and navigate the educational demands of their profession despite changing policies or curriculum requirements. Institutions of higher education, therefore, should have a broader vision of what constitutes quality delivery in teacher education programmes.

To date, no education policy guidelines exist for science teacher education or for any other subject specialisation for that matter. Although there is the intention to form professional learning communities for the various disciplines (DoE & DHET, 2011:14), it is assumed that science teacher education falls under the ambit of general teacher education. My interest in science teacher education could then be seen as an elaboration of teacher education policy, and hopefully in the analysis I shall be in a position to extrapolate aspects of general teacher education to science teacher education.

In the previous chapter I explored how notions of critical thinking manifest in the dominant educational discourses in South Africa. This culminated in a conceptual expansion of the construct. In this chapter I review the South African policy documents on teacher education since the onset of the new South African democracy. The intention is to utilise the conceptual expansion developed in Chapter 4 as a guide to analyse how notions of critical thinking manifest in teacher education policy post 1994 as formulated in Research Question 2.

To reiterate, my conceptual expansion presents four perspectives or genres: conservative, liberal, radical, and postmodern, each of which comprises five features of critical thinking applicable to the role of the teacher. These are purposive and contextual, involving rational reasoning skills, a dispositional aspect, and a reflexive praxis.

5.2 An approach

I present my analysis of policy documents as a linear trajectory from the earlier to most recent in the context of the unfolding teacher educational milieu since 1994. First, I present a synopsis of each document to lay the basis for my analysis. I then use my expanded conceptual framework developed in the previous chapter as an analytical tool to examine how notions of critical thinking manifest in the teacher education policy document. Finally, I discuss the implications of the insights gained for teacher education programmes.

Two phases can be discerned in post-apartheid teacher education policy development. In both phases, two types of documents emerge: a strategic plan that provides broad policy guidelines for initial and continuous professional development of teachers, and a teacher education policy document that provides specific guidelines for teacher education programme development and qualification pathways. See table 5.1 below.

Table 5.1 Strategic plans for the professional development of teachers and teacher education policy documents in phase one and phase two

Phase one		Phase two	
Teacher Education Policy	Strategic Plan	Strategic Plan	Teacher Education Policy
Norms and Standards for Educators (DoE, 2000)	The National Policy Framework for Teacher Education and Development in South Africa (DoE, 2007)	Integrated Strategic Planning Framework for Teacher Education and Development in South Africa: 2011–2025 (DoE & DHET, 2011)	Policy on the Minimum Requirements for Teacher Education Qualifications (DHET, 2011) Revised Policy on the Minimum Requirements for Teacher Education Qualifications (DHET, 2015)

5.3 Phase one

5.3.1 Norms and Standards for Educators

The first teacher education policy post 1994 was the Norms and Standards for Educators (DoE, 2000), commonly known as the ‘Norms and Standards’ document. In it, educators are designated as all persons who teach or provide professional educational services at any public school, further education and training institution or departmental office at all levels of operation from the school context to district and regional levels. (DoE, 2000:3). The document provides guidelines for the articulation of academic pathways that lead to teacher qualifications as well as a description of the roles and their associated applied competencies and standards needed for teacher development.

The seven roles of an educator as depicted in the document are meant to provide a description of what it means to be a competent teacher and also provide the exit- level outcomes for an initial teacher qualification. Each role is associated and aligned with a set of three applied competences or norms. These are presented as practical competence,

foundational competence and reflexive competence. An elaboration of each competence is set out in the document as follows:

Applied competence is the overarching term for three interconnected kinds of competence:

- *Practical competence* is the demonstrated ability, in an authentic context, to consider a range of possibilities for action, make considered decisions about which possibility to follow, and to perform the chosen action.
- It is grounded in *foundational competence* where the learner demonstrates an understanding of the knowledge and thinking that underpins the action taken.
- It is integrated through *reflexive competence* in which the learner demonstrates the ability to integrate or connect performance and decision making with understanding and with an ability to adapt to change and unforeseen circumstances and to explain the reasons behind these adaptations (DoE, 2000:4).

In line with outcomes-based education (Spady, 1994), a detailed set of associated criteria describes how the competencies can be demonstrated for each role presented. I provide a visual representation of the roles described in Figure 5.1. Each prong in the diagram represents one of the roles of the educator. The concentric circles represent the competencies expected in each of these roles.

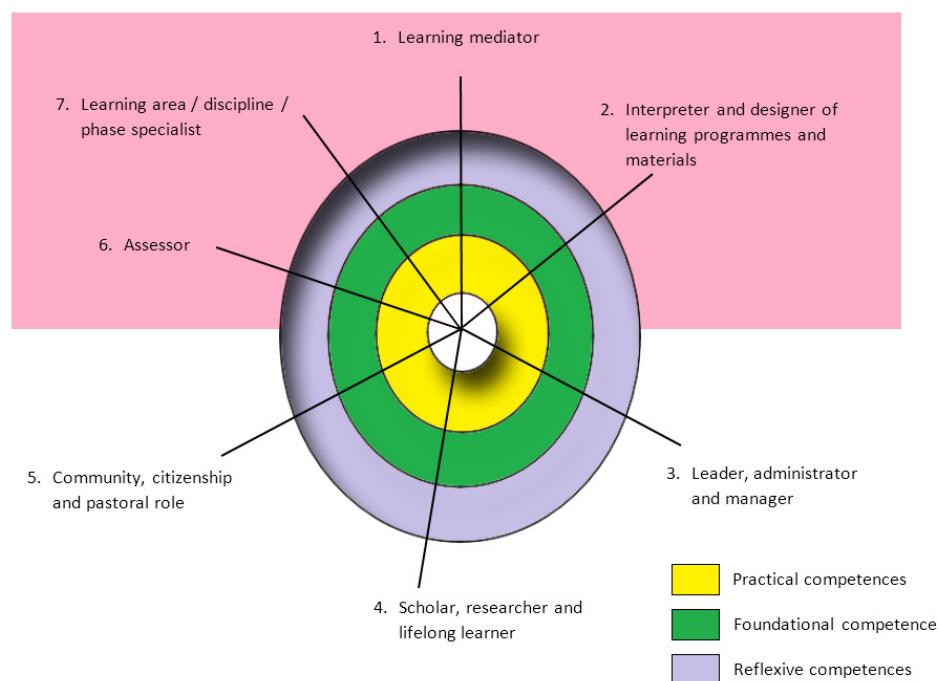


Figure 5.1 Seven roles of educator in norms and standards document

One is struck by the wide range of all-encompassing attributes depicted in the seven roles of the teacher as described in the document and which I shall discuss shortly. Can it be a called a profession when the teacher means all things to all people? As Morrow (2007:11) points out: '*It makes greater demands than any individual can possibly fill.*' This realisation probably served as one of the main motivations to constrain the role of the teacher in subsequent policies, which I shall elaborate on later, but it has served as an important guideline for the development of teacher education programmes for about a decade. Morrow (2007:3–20) claims that the 'Norms and Standards' document fails to recognise the formal (related to the teacher's primary task) and material elements (related to variations in context and action) of the concept of teaching. Such expectations could result in pressures on a teacher's working life that far exceed their primary function. Firstly, Morrow (2007:3–20) observes that by referring to the term 'educators' as the full range of employees, from teachers in schools to district managers in the education department, confuses the role of each and results in an ambiguity of emphasis which possibly would present challenges to any teacher education programme. Morrow (2007:11) points out that what the 'Norms and Standards' document does is to present the seven roles of the teacher as a formal definition of teaching, while in fact it is a list of possible material elements of teaching. While Morrow (2007:3–20) introduces a useful perspective of the document in its entirety, I now proceed to look in greater detail for manifestations of notions of critical thinking specifically.

Four out of the seven roles focus on aspects of teaching and learning (in the pink area in Figure 5.1).

These four roles see the teacher as

- a mediator of learning – in a way that is sensitive to the diverse needs of learners in a variety of contexts,
- an interpreter and developer of learning materials and programmes – in a way that is suitable to the context and needs of the learner,
- an assessor of learning – using various assessment strategies for both formative and summative assessment, and
- a phase or discipline specialist – able to use a variety of strategies to facilitate learning successfully.

It is specifically pointed out in the policy that the seventh role, that of a phase or discipline specialist, is the over-arching role as it is this role which determines the purpose of the qualification and hence serves as the focus for the design of the qualification, that is, the development of a teacher who is a discipline or a phase specialist. At the lower levels of schooling the teacher is a phase specialist. For example, the Foundation Phase incorporates Grade R, and Grade 1–3, while the Intermediate Phase incorporates Grade 4–6. At the higher levels, the teacher is a learning area or discipline specialist. For example, the teacher is a science teacher or a language teacher. The purpose of the qualification will determine which aspects are emphasised and the way in which the roles and competencies are integrated (DoE, 2000:5).

The view of the teacher is one of a professional who is able to use autonomous judgement to make appropriate decisions that would facilitate learning when planning, executing and reflecting on teaching and learning practices. The reference to critical thinking is particularly prevalent when referring to reflexive competences, where the aspirant teacher is expected to demonstrate critical judgement with due consideration of different types of learner needs and varying educational contexts.

Here are some demonstrable reflexive competences presented under the learning mediator role (DoE, 2000:9):

- *Critically evaluating the implications for schooling of political social events and processes and developing strategies for responding to these implications.*
- *Critically reflecting on the ways barriers to learning can be overcome.*
- *Critically reflecting on the degree to which issues around HIV/Aids have been integrated into learning.*

Clearly, the teacher is expected to take individual aspects of a learner as well as comprehensive contextual aspects very seriously when critically reflecting on ways of mediating learning. While the document does not specify the nature of such critical reflexivity, it does imply the kinds of thinking skills required interspersed throughout the description of competencies. Phrases such as interpreting, evaluating, and adapting, and making justifiable educational judgements based on knowledge and understanding of the discipline, learners to be taught, and context of the learning environment, are prevalent. This is in line with the kinds of cognitive skills associated with critical thinking.

While my focus in this dissertation is on aspects of teaching and learning in the science classroom, the other three roles provide a broader perspective of the nature of the teacher in the South African classroom. These roles envisage the teacher as a:

- Leader, administrator and manager
- Scholar, researcher and lifelong learner
- Community activist intent on promoting values and attitudes that encourage good citizenship and democratic practices in a supportive and caring environment.

These three roles relate to aspects of educational leadership, personal professional development and democratic citizenship. This last-mentioned role, which presents the teacher as an activist in the school community intent on promoting democratic values and practices, extends the role of the teacher beyond the conventional boundaries of classroom practice. Yet, interactions in the classroom and the way in which a teacher engages the learners while teaching the discipline could give insights into the extent to which the teacher subscribes to democratic principles, consciously or unconsciously. For instance, by creating an epistemic climate (Brownlee, Ferguson & Ryan, 2017:4) in which learners feel free to let their voices be heard, even if it is a minority opinion or utterance and not necessarily aligned with dominant norms and practices, then that teacher is adhering to democratic principles. It is this last role which is firmly aligned with the transformative goals of a new South Africa and may be the kind of approach favoured by Nussbaum (2002:289–303) as described in Chapter 1. More than a decade later, this role appears diminished in subsequent policy as I shall relate later in the chapter.

In line with the findings by Enslin (1999:175–186) in her review of important South African education policy documents post 1994, it seems that a liberal perspective on notions of critical thinking dominates encompassing all those features identified in the conceptual elaboration developed in Chapter 4. The teacher is expected to make autonomous, rational decisions based on appropriate educational judgement with due consideration of purpose and context. This perspective is transformative in relation to the previous conservative educational epoch. It also verges on the radical perspective when the teacher is expected to play a pivotal role in promoting democratic values and practices inside the classroom as well as in the broader community.

While the competencies expected to be displayed by beginner teachers or recent graduates are commendable, they seem to be presented in isolation to the complex and

challenging educational contexts of South Africa. Not even broad descriptions of the pervasive inequalities or conditions in South African schools, which are the working contexts of the teachers' lives, are described. That is, the emphasis is on competencies without providing a more detailed description of the complex educational landscape in South Africa. It is in this arena where the strategic plan which emerged seven years later might assist in concretising what these challenges may be, and to which I now turn.

5.3.2 National Policy Framework for Teacher Education and Development in South Africa

By 2007, the norms and standards document still served as policy for the development of teacher education programmes and provided the basis for the emergence of a more generalised strategic plan, the National Policy Framework (NPF) for Teacher Education and Development in South Africa (DoE, 2007). While the document refers to the challenging socio-economic conditions which militate against smoothly functioning schools, the main concern is on addressing the lack of suitably qualified teachers. In essence, the document provides broad guidelines for initial and continuous teacher professional development. The stated aims of the NPF are to provide a strategy for the recruitment, retention and professional development of teachers. It proposes that national and provincial education departments collaborate with the South African Council for Educators (SACE) to provide an enabling environment that will facilitate professional development of teachers. The important role of teachers in preparing young people intellectually, morally and culturally for the needs of a democratic South Africa in the twenty-first century is acknowledged. One can assume that the moral and cultural aspects are aligned with democratic principles and perspectives. Thus, the purpose of teacher education, both initial and continuing, is instrumental. Implied is the ability of teachers to facilitate the development of people who can participate in and contribute to a democratic South Africa. The type of teacher who can do this should be competent and dedicated, and able to provide a high quality of education based on ethical and professional standards of conduct. Here too the framework refers to the 'Norms and Standards' document (2000) to describe a competent teacher. Such a teacher is a specialist in a particular subject; a specialist in teaching and learning; a specialist in assessment; a curriculum developer; a leader, administrator and manager; and a lifelong learner; as well as a professional who plays a community, citizenship and pastoral role.

Despite all these numerous roles and expectations of a quality teacher as outlined above, it was acknowledged in the NPF that the most critical challenge for teacher education in

South Africa was the limited conceptual and content knowledge of many teachers, resulting in poor learner achievement. The poor socio-economic contexts in which many South African teachers operate exacerbate this problem.

The plan presents teacher education as having the essential role of equipping teachers to prepare succeeding generations of children with the necessary knowledge, skills and values that will enable them to address South Africa's vast social inequalities such as poverty, unemployment, health, environmental issues, and so on. A tall order and rather idealistic. How can solving the problems of a country be the responsibility of a facet of the education system? This outlook implies that society is a product of education and ignores all the other complex dynamics of a country. While education may very well be a key consideration for national development, this reliance on education to address national problems was short sighted, and contextual pressures soon overrode ideological intent, thus resulting in a new wave of policy as outlined in phase two.

5.4 Phase two

Phase two ushers in a fresh strategic plan (DoE & DHET, 2011) for teacher professional development as well as specific teacher education policy guidelines (DHET, 2011; DHET, 2015) for higher education institutions for the development of teacher education qualifications.

5.4.1 Integrated Strategic Planning Framework for Teacher Education and Development in South Africa: 2011–2025

The Integrated Strategic Planning Framework for Teacher Education and Development in South Africa: 2011–2025 (DoE & DHET, 2011) is a document developed through the collaborative endeavours of the various stakeholders in teacher education who participated in the Teacher Development Summit in July 2009. Among the participating organisations were teacher unions, councils such as the South African Council for Educators (SACE) and the Education Labour Relations Council (ELRC), the Education, Training and Development Practices Sector Education and Training Authority (EDTP SETA), the South African Department of Education and the Higher Education South Africa – Education Deans' Forum (HESA-EDF). It is the intention that the plan presented in this document be viewed as part of an ongoing, dynamic process with the purpose of improving the quality and development of teacher education over time. The time period envisaged for the implementation of the plan is from 2011 to 2025. Two main thrusts are

discernible, namely output (teacher supply and deployment), and implementation (teacher development, appraisal and support). The development of this plan runs concurrently with the development of a new teacher education policy (DHET, 2011).

A large portion of the integrated plan addresses the needs of in-service teachers. Ways in which in-service teachers can be supported and developed professionally are presented. However, the focus of my study is on pre-service teacher education, hence I shall now elaborate on that aspect of the plan.

The provision of formal teacher qualification programmes is acknowledged as being mainly the responsibility of higher education, that is, the universities. In the document it is pointed out that among other aspects, teacher quality has also been identified as an area that needs attention. The point is made that the Policy on the Minimum Requirements for Teacher Education Qualifications (DHET, 2011) defines standards at a generic level for all teacher education qualifications, in line with the requirements of the Higher Education Qualifications Framework (HEQF). In addition, it is noted that more specific standards need to be developed that relate to the areas of expertise in which teachers need to specialise. These would be left to subject experts and those operating in the field of teacher education. It is envisaged that a national network of accredited service providers will cater for multiple needs for 'more and better' teachers (DoE & DHET, 2011:15–16). The establishment of professional learning communities (PLCs) by provincial education departments (PEDs) operating largely within the formal educational structures is presented as supporting quality delivery of education for in-service teachers (DoE, 2015: 13–14). The development of teacher knowledge and practice standards is presented as the responsibility of universities, subject-based professional teacher associations and the professional arm of teacher unions under the auspices of the Department of Higher Education and Training (DHET). While the document presents time frames for strategic goals for teacher supply, development and support for quality education, it does not give a notion of what constitutes quality. This is left to the envisaged experts who will collaborate to bring these goals into effect. (DoE & DHET, 2011:29–30). Notions of critical thinking do not emerge explicitly. Suffice it to comment that collaborative endeavours are supported and encouraged, which implies an acceptance of different role players contributing to teacher education development, and hence an acceptance of different notions of what comprises quality. Perhaps an examination of the most recent teacher education policy document, to which I now turn, will throw more light on the matter.

5.4.2. Policy on the Minimum Requirements for Teacher Education Qualifications

The policy on the Minimum Requirements for Teacher Education Qualifications (DHET, 2011), commonly known as ‘MRTEQ’ and its revision known as the ‘revised MRTEQ’ (DHET, 2015) which is currently the accepted, official version, describes pathways to secure a teacher qualification. The revisions are mostly technical in nature and refer to changes in credit allocation and alternative titles for certain qualifications, which are not the focus of this study.

The document clearly depicts the requirement that all service providers of teacher education programmes should address the challenges of poor content and conceptual knowledge among teachers. In addition, programmes should provide contextual offerings that address the challenging legacies of apartheid, as well as provide students with competencies that would enable them to deal with diversity and transformation.

‘MRTEQ’ (DHET, 2011) and subsequently the ‘revised MRTEQ’ (DHET, 2015), replaces the Norms and Standards for Educators document (DoE, 2000), yet acknowledges the significance of the seven roles as functions carried out by the collective teachers in a specific school. Rather than focusing on the seven roles, the document focuses on the inter-connections of different types of knowledge and practices that teachers can draw on in order to inform their praxis in different school contexts. I use the term praxis as it emphasises a reflective component that informs practice.

It also refers to types of learning that could possibly serve as the guiding principles for programme design. Five types of learning are presented as associated with the acquisition of knowledge for teaching purposes. It is suggested that these types of learning be integrated throughout the teaching programme. They are disciplinary, pedagogical, practical, fundamental, and situational learning (DHET, 2015:10–11). There is an attempt to describe what all these types of learning entail.

For instance, disciplinary learning refers to the study of various aspects of educational theory as well as the study of specific school subject matter, for example, science or languages.

Pedagogical learning refers to aspects of teaching and learning which would incorporate knowledge of learner and context as well as knowledge of how to facilitate learning within the discipline.

Practical learning refers to learning to teach through practice and from practice by exposure to a variety of methods, whether in simulated or authentic contexts.

Fundamental learning emphasises learning to converse in a second language as well as becoming efficient in ICT and academic literacy. The latter would encourage further development in higher education.

Situational learning refers to learning about the diverse educational contexts that exist in SA.

The minimum set of competencies for beginner teachers as set out in Appendix C (DHEC, 2015:62) refers to the ability of teachers to have a strong content base, be knowledgeable about curriculum aspects, and able to plan, manage and assess learning competently in various school contexts as well as be responsive to the varied needs of their learners. I provide an illustration of how the various competencies (rectangles) can be linked to the learning types (circles) in Figure 5.2.

I've used lines to link the learning types with what I deem to be the most likely competencies. Note that practical learning could potentially draw on all the competencies, while disciplinary learning seems more relevant to those competencies linked in the figure. Others may differ with my emphasis.

This document has a much narrower focus than the previous 'Norms and Standards' document in that, in the main, it seems to be restricted to the types of learning that support classroom practice. Even the terminology has changed and the general term 'educator' has now been replaced by the more specific term 'teacher'. It is specified in the document that a teacher is a school-based educator whose core responsibility is that of class-based teaching in a school as distinct from other educational roles. Once again, no explicit guidelines for teaching specialised subjects or phases are presented. It is noted that such specialist foci will need to be developed by relevant teacher education communities of practice. Such communities of practice in science education have emerged to a larger or lesser degree in the form of teacher support clusters (Mitchell & Jonker, 2013; Jita & Mokhele, 2014) at local levels.

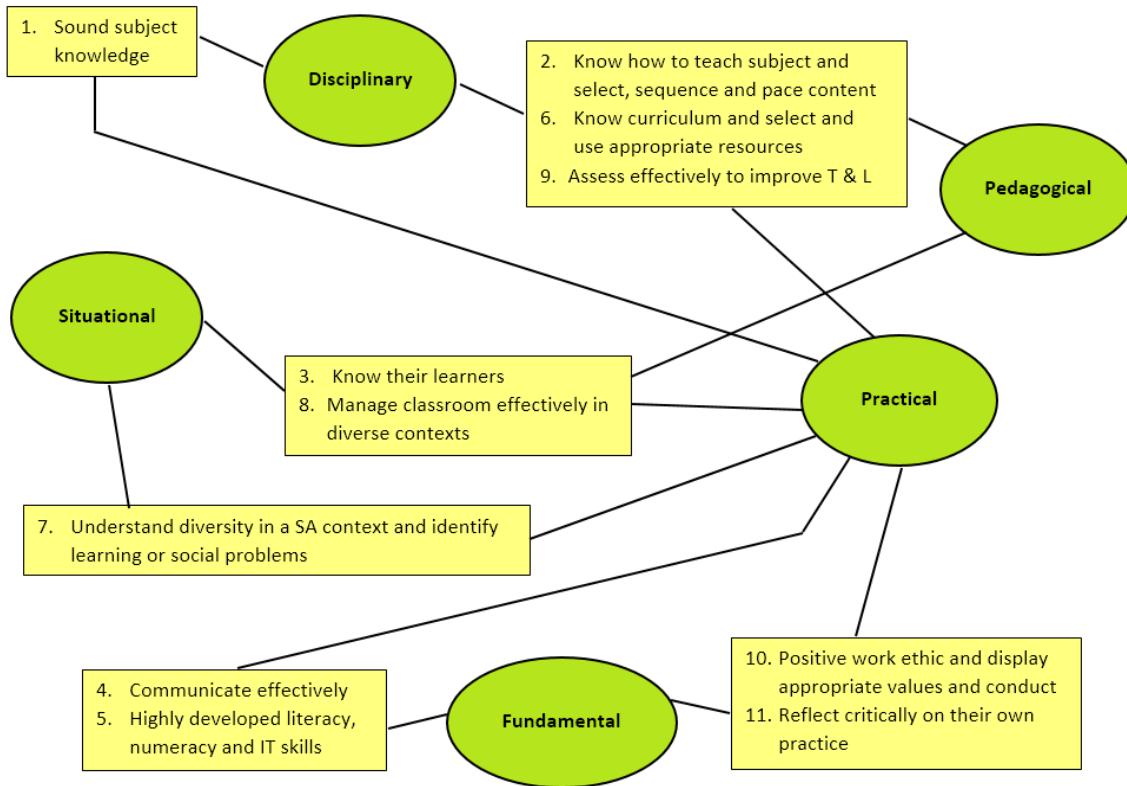


Figure 5.2 Types of learning in the 'revised MRTEQ' with its associated competencies

Even though reference is made to teachers being able to operate in diverse classroom contexts, there is no specific reference to the promotion of democratic principles and community interaction. General aspects such as well-developed literacy, numeracy and ICT competencies are highlighted as well as attitudes and values that promote and contribute to the teaching profession in a positive way. For instance, the purpose of the Bachelor of Education degree, as presented in the document (DHET, 2015:22–28), is to develop qualified classroom teachers who can demonstrate focused knowledge and skills in the teaching of particular specialisations (phase/s or subjects). The document highlights aspects such as taking initiative and responsibility in an academic and professional teaching environment.

Point 11 of Appendix C (DHET, 2015:64) specifically emphasises the ability of newly qualified teachers to reflect critically, backed by theory and informed through interaction with colleagues, to improve their own practice in response to their specific educational context. This encompasses the notion of reflexive praxis in which professional judgement informs practice and aligns with features of critical thinking depicted in my conceptual elaboration previously.

What are the implications of this document for teacher education programmes? When viewed strategically, the implication is that the five types of learning suggested will culminate in a knowledge mix that will enable the graduates to teach effectively in the diverse contexts in which they may find themselves. The integrated knowledge mix will vary in emphasis and content, depending on the type of qualification. In Appendix B, the document depicts exit-level competences to assist programme design (DHET, 2015:60–61). For example, a Bachelor of Education degree which is set at level 7,¹⁶ presents exit level competences or level descriptors. I draw on three of them, depicted below, which may have links to critical thinking.

Level descriptor 2 – *Enhances flexibility in changing circumstances* (DHET, 2015:60) and

Level descriptor 6 – *Demonstrates initiative and responsibility in an academic and professional context* (DHET, 2015:61).

Both these descriptions imply the need for professional judgement and reflexive praxis when faced with contextual challenges. Level descriptor 2 seems to refer to the nature of the service provider, while level descriptor 6 seems to refer to the student.

Level descriptor 4 – *Provides for a deep and systematic understanding of current thinking, practice, theory and methodology in an area of specialisation* (DHET, 2015:60).

Here the description seems to refer to the nature of the service provider. In the case of a science teacher qualification, the area of specialisation would be two-pronged. That is, the student teacher would have to be encouraged to reflect on an understanding of theories and practice of education as well as on theories and practice of science in order to make strategic decisions in the science classroom. Features of critical thinking as depicted in the conceptual elaboration are implied and limited to classroom practice. A more conservative perspective thus seems prevalent.

Although the complex educational landscape is acknowledged and the expectation is that a teacher education programme should prepare graduates to deal with diversity and transformation, the teacher's role in promoting democratic citizenship specifically and what that might entail is not alluded to.

¹⁶ The document notes that the exit-level competences are taken from the descriptions of the purpose of the qualifications at the different levels in the Higher Education Qualifications Sub-Framework (HEQSF).

5.5 Discussion

The South African Council for Educators (SACE) is an organisation that has been legislated to facilitate the registration and professional development of teachers in South Africa. Its vision is to promote professionalism among all educators. It is worth taking a closer look at two strategic documents on professional conduct, namely, the SACE Draft Professional Teaching Standards (SACE, 2018) and the SACE Code of Professional Ethics (SACE, n.d.). However, these two documents should be viewed against the backdrop of the Manifesto on Values, Education and Democracy (DoE, 2001) which draws on the fundamental values depicted in the South African Constitution (Republic of South Africa, 1996a). My focus when examining these documents is on how the teacher is expected to apply his or her professional judgement. The professed orientation for all these three documents is one of nurturing democratic values in education which surpass language, culture or social background and highlight social justice, equality, human dignity, responsibility, and reconciliation. Embedded in this broad vision are values of tolerance, openness to other, unbiased dialogue and the striving towards a sense of a shared national pride. It follows that teachers are expected to conduct themselves in ways that nurture these values. This implies being ethically and morally principled in how they engage with one another, their learners, and the broader school community, as well as being accountable to the daily demands of their profession which could include aspects such as responsibility to their work commitments and epistemic competency. The document presents 16 strategies that underpin these ‘values in education’ initiative and recommends that each school should have its own action plan. It is acknowledged that such values cannot be taught in a didactic way. Rather, the implication is that values should be role-modelled and generated through discussion and debate. Some of the strategies include concrete proposals such as including art, sport, religion, and history into the school curriculum for all learners in ways that will encourage learners to engage with one another. However, considerations of how this could unfold are open to deliberation. This value-laden emphasis accentuates the purpose of education to prepare learners, not only for the workplace, but also for responsible citizenry. Thus, the implication is that a teacher operating in the milieu described would ideally be expected to make responsible and autonomous judgements at many levels in his or her daily work life. This orientation fits quite well with the first phase of teacher education policy development as described earlier in the chapter.

The SACE code of professional ethics (SACE, n.d.) presents codes that are in line with the manifesto of values described above. It is expected that teachers respect the human dignity of learners and engage with them in a compassionate and responsible way by respecting their belief systems, their right to privacy and confidentiality, and their individuality, and by striving to assist them to reach their full potential. Furthermore, educators are expected to promote gender equality and strive to maintain a safe physical environment for their learners. Similarly, engagement with parents, community members and colleagues should be respectful, responsible and in agreement with the values referred to previously. In addition, teachers are expected to behave in a way that enhances the reputation of the profession rather than in a way that undermines it, such as indulging in reckless or illegal activities. Teachers also need to acknowledge the collaborative and collegial nature of their work as well as the legal authority of the employer. There is no allusion to the quality of teaching and learning other than the expectation that teachers ought to keep up with educational trends. Disciplinary procedures are outlined for any breach of the code of ethics. The point form style of the document does come across as quite prescriptive, and unless we in teacher education programmes engage with its underlying implications, it can simply be viewed as a controlling mechanism for teachers. SACE's role, through its code of professional ethics document, thus comes across as regulatory. On the other hand, the SACE Draft Professional Teaching Standards document (SACE, 2018) is an attempt to enhance the professionalism of the teacher is a way that recognises the professional judgement of the teacher and is a move in the right direction. Standards in themselves can be limiting if they serve only as checklists for acquiring or improving professional qualifications in an instrumental way. The ten standards depicted in the documents are presented as interlinked and represent the culmination of an extensive international literature review as well as conceptualisation and collaboration among key educational stakeholders. In summary, teaching is presented as based on ethical commitment and collaboration; it is driven by the vision of social justice and equality similar to the two previous documents I outlined. The sixth standard is relevant to my study, where it indicates that teachers make thoughtful justifiable choices as reflective practitioners on all aspects of teaching and learning. Such reflection can be linked to other standards depicted which refer to the learning environment, the nature of the subject, the language used, curriculum requirements, teaching methodologies and assessment practices. This document, once finalised, can complement the SACE code of ethics and can serve as a useful point of departure for our deliberations on quality teaching. However, the document itself is rather

neutral and could possibly feature in any country as a set of principles for teacher professional standards. The complex features of the educational landscape of South Africa are missing. Teachers are treated as if they are homogeneous. That is, despite the allusion to acknowledging different types of learners, teachers are depicted as if they are all the same and their different educational trajectories, experiences and beliefs are ignored in the document. The complexity and nature of the contexts of the schools where they finally teach are also not discussed or referred to. While these documents could be useful additions to highlight the nature of teacher professionalism, they should not be regarded as conclusive; rather they could serve as a basis for discussion and interpretation.

5.6 Conclusion

I set out to explore notions of critical thinking in teacher education documents in a response to the research question, 'How do notions of critical thinking manifest in teacher education policy post 1994 in South Africa?' I used my conceptual expansion developed in the two previous chapters as an analytical framework for my exploration. The first strategic plan and teacher education policy as described in phase one comes across as a response to South Africa's apartheid past and the urgent need to transform the educational milieu to a more just one. It seems to be a way of setting right the wrongs of the past. While critical thinking is an acknowledged cross-curricular requirement for all programmes in higher education, the dominant perspective in phase one is a liberal democratic one in which the teacher is required to promote democratic citizenship as an aspect of nation building. The teacher is viewed as a professional capable of making autonomous judgements. However, a mere decade later, it was back to the drawing board, where the high ideals of ideological intent collapsed when confronted with major socio-economic and educational challenges. Phase two presents a more sobering and limited responsibility for teacher education where the perspective on critical thinking is a conservative one largely related to effective classroom practice. What are the implications of such a perspective for teacher education programmes? Rousseau (2014:167–186) refers to the need for epistemological diversity and warns against using the knowledge mix referred to in the policy document as a checklist to address accreditation prescriptions and other narrow instrumentalist purposes. To counteract this, she recommends that the curriculum, teacher educators, student teachers, the diverse teaching environments in which students find themselves, and the educational challenges that exist in South Africa, all become active partners in contributing

to the development of a shared vision that will serve as a conceptual fabric for the development of a dynamic curriculum that is open to constant reappraisal. I agree with Rousseau (2014:167–186) that recontextualising (Bernstein, 1990) policy should be a collaborative endeavour that pushes the boundaries beyond bland prescriptions of rules and procedures. Service providers could be confronted with new revisions of teacher education policy in the future, and considered, collaborative responses to such changes are more likely to favour authentic learning. Currently I have not yet made the link with science teacher education, but I shall do so as this dissertation unfolds. I start this process in the next chapter by reflecting on what the literature reveals in respect of critical thinking and science education as a prelude to an analysis of the South African physical science curriculum for the FET band, post 1994.

CHAPTER 6

PEDAGOGY THAT SUPPORTS CRITICAL THINKING IN THE SCIENCE CLASSROOM

6.1 Introduction

In the previous chapter I used the expanded version of my conceptual framework on critical thinking to analyse teacher education documents in South Africa and deliberated on the implications of the insights gained on teacher education programme development. While this dealt with general teacher education, I now attempt to hone in on how notions of critical thinking may be applicable to science teacher education specifically. Hence, in this chapter I deliberate on the nature of the science discipline and its implication for classroom practice. Furthermore, I explore the literature on the type of pedagogy that has the potential to support and enhance critical thinking in the science classroom. I use the insights gained from this exploration to extend my conceptual elaboration on critical thinking within the context of science teacher education.

Science as a discipline has been developed over the ages through contestation and consensus. It comprises certain practices, forms of knowledge and traditions which inform its nature, its progression as a discipline, as well as the innovative pathways pursued. The teacher has to initiate learners into the discipline of science in ways where they are not perceived as passive recipients of the accepted ways of thinking and doing, but also has to put them in a position to participate and to open the potential for more involved participation in scientific matters if inclined, albeit at an introductory level. However, science teachers are rarely scientists themselves, so this expectation that they need to initiate their learners into the processes of science is quite demanding. Even if they were scientists, it still requires a degree of reflection and discernment to be able to provide their learners with an understanding of the array of activities that scientists are involved in, particularly if the hypothetical scientist occupies a specific niche in science. Hence, to an extent it remains a theoretical endeavour and puts the obligation on a science teacher education programme to provide some awareness of the nature of scientific enterprises.

I assert at the outset that it is not the purpose of school to turn all learners into scientists, or historians for that matter. Their future professional choices are entirely linked to their own biographies. However, if science is taught as a subject, then the least we can do at school is to initiate the learners into developing some awareness of the nature of the

discipline as well as of the processes that contribute towards developing the discipline. Similarly, education students, intent on becoming teachers, should cultivate appropriate insights into the nature of the subject they teach, for which the university should take some responsibility. Hence, in science teaching as in any other specialisation, the development of content expertise as well as pedagogical expertise should be considered an important aim of a teacher education programme. This perspective supports the enhancement of scientific literacy as a key goal of science education.

6.2 The nature of science and science education

Lederman, Antink and Bartos (2014:285–302) indicate that the development of scientific literacy, an acknowledged goal of science education, emphasises the knowledge, processes and products of science as well as its application in making informed choices in personal and broader societal contexts. This involves considerations of the nature of science and the nature of scientific inquiry¹⁷.

Monk and Dillon (2000:72–87) provide a useful summary on the changing perspectives on the nature of scientific knowledge and the nature of the scientific method. This ranges from the view of the scientific method as empirical enquiry where only what can be observed in the natural world informs scientific knowledge, to a broader perspective known as positivism. This latter approach acknowledges that scientists can formulate theories about phenomena which may be observable or unobservable. These theories can then be tested and confirmed or proved through empirical tests. They point out that an alternative position as popularised by Karl Popper (1972) is ‘falsification’, as there can never be sufficient objective evidence to prove something because it is always open to further tests and refutation. Furthermore, they note that another way of looking at the nature of science is by considering the history and practice of science. Monk and Dillon (2000: 72–87) call attention to the work of Thomas Kuhn (1962), who suggests that rather than thinking about scientific advance as a cumulative progression of scientific knowledge, it should be viewed as uneven variations in viewpoints and theories. They remind us that Kuhn (1962) introduced the term ‘paradigm’, which represents scientific ideas or perspectives that are coherent.

¹⁷ The term scientific ‘inquiry’ rather than scientific ‘enquiry’ to signify scientific investigations and processes is more commonly used in the science education literature, hence my use of the former term when referring to scientific processes.

I am guided by Lederman et al. (2014:285–302) for consideration of the nature of science in terms of its implication for science education and the role of the teacher. As already pointed out, they suggest that a scientifically literate individual should have an understanding of the nature of science (NOS) as well as of scientific inquiry (SI). They consider how ideas on the nature of science and scientific inquiry have implications for the learning of science. Lederman et al. (2014:285–302) accept that the nature of science as presented in the research literature refers to the nature of scientific knowledge, and while they acknowledge that their formulation is not definitive, it is nevertheless a useful way of looking at what science is and how it should be taught. They point out that the generalised consensus currently is that scientific knowledge may be tentative, empirically based, subjective, and socially and culturally embedded. As distinct from the nature of science or scientific knowledge, Bartos and Lederman (2014:1150–1184) present scientific inquiry as the *characteristics of the processes through which scientific knowledge is developed* (Bartos & Lederman, 2014:1153). However, the tendency to present scientific knowledge as a fixed body of knowledge still prevails in many South African schools. In addition, conceptions of scientific inquiry are often linked to standard recipe-type practical work (Hattingh, Aldous & Rogan, 2007; Ramnarain, 2010). I shall elaborate on how the intention of school curriculum policy in South Africa has attempted to change teachers' perceptions and behaviour in the next chapter, particularly with regard to scientific inquiry. So, the nature of science or scientific knowledge refers to the epistemological aspect of science, while scientific inquiry refers to the processes involved in the acquisition of scientific knowledge, which is the methodological aspect of science. Çorlu and Çorlu (2012:515) put it thus: '*Scientific inquiry develops students' abilities to question the researchable events of nature in a critical way.*'

Both these aspects are important considerations for the development of pre-service science teacher programmes. Yet, this is not sufficient. Pedagogical considerations that deal with ways of initiating learners into the processes and products of science are also important.

6.3 Reading, writing and communicating science

Accessing scientific text can also be problematic. Sagiannis and Dimopoulos (2018: 387–405) highlight scientific language as a neglected aspect of learning to teach science. They concur with Bernstein (1996) that school science is a recontextualised form of real science. Even so, the language of school science approximates the discourse of real

science. The science teacher's role could be to initiate the learners into scientific discourse as a contribution to the enhancement of scientific literacy. Sensitising student teachers to ways of doing this could thus be an important aspect of an initial science teacher education programme. In their study, Sagiannis and Dimopoulos (2018:387–405) presented special features of scientific language depicted in scientific texts which play a pivotal role in scientific discourse and the construction of scientific meaning. These were, among others, unfamiliar technical terms, symbols and notations, as well as syntactic complexity. They point out that programmes with effective science-literacy integration have sensitised students to both the nature and the role of the academic language of science, provided opportunities to reflect on the linguistic practices of the scientific community, and exposed students to the multimodal nature of scientific communication. I shall refer to multimodal approaches a little later in this chapter.

6.4 Critical thinking and science education

Having expounded on the nature of science, one might well ask the question, 'Where does critical thinking fit into all of this? It is to this question that I now turn. If one accepts that at the high school level in South Africa, the teacher is regarded as the subject specialist, then the teacher functions at two levels: firstly, as the subject specialist where he or she has an appropriate understanding of the nature of the subject, and secondly, as the education specialist where he or she has an appropriate understanding of aspects of teaching and learning. Enhancing critical thinking within the discipline would entail demonstrating high levels of pedagogical content knowledge (Shulman, 1986). This implies being able to distinguish critical thinking consciously from other kinds of thinking when making pedagogical decisions around matters of teaching and learning. For instance, in the science classroom, expecting a pupil to identify whether an element on the periodic table can be classified as a metal or a non-metal does not necessarily require critical thought, as this could be perceived as a basic knowledge question. However, expecting the pupil to apply his or her knowledge of the element to predict how it might react with an unknown element is a different matter. Here the learner is challenged to make a judgement based on his or her knowledge of the chemical characteristics of that element. This task might well fall within the realm of critical thinking, depending on how it is presented by the teacher. The task itself needs to be contextualised. The teacher needs to exercise judgement on when to present it to the learner, what form it will take and whether it will be an individual or a group activity, among other considerations. The response to the

challenge would incorporate judgement (Bailin et al., 1999; Coney, 2015), drawing on intellectual resources (Bailin et al., 1999) and possibly being able to articulate effectively using intellectual standards of clarity and depth (Paul & Nosich, 2012), among others. It also fits in with Nosich's (2008) contention that the only way to enhance critical thinking is to activate critical thought through practice. This activation of thought should be an accepted and sustained practice in teacher education programmes in all disciplines. With this in mind, one could well ask: What methods would a science teacher employ to enhance critical thinking in his or her learners? I now discuss approaches from the literature that have focused on the development of critical thinking in science education.

6.5 Approaches that enhance critical thinking in science education

In the next section I specifically consider and report on approaches to science education that are of a dialogical nature, as the growth of science through the ages, whether through contestation or consensus, has had social dimensions. I am guided by a socio-constructivist view of learning which recognises that learning is viewed as involving social and cultural processes rather than as a process confined to the individual mind alone, as pointed out by Newton et al. (1999:553–554). They assert that all disciplines have specialised language and allowing learners to think through and articulate their ideas about scientific phenomena in a social setting will enable them to become proficient in the norms of the language of science as well as contribute to a clearer conceptual understanding '*whose whole is more than the sum of the individual contributions*' (Newton et al., 1999:554).

In my mind, the way in which this process is facilitated by the teacher is crucial, if the outcomes as presented by the authors are realised.

6.5.1 Cognitive acceleration through science education (CASE)

The Cognitive Acceleration through Science Education (CASE) project (Shayer & Adey, 1981; Adey, Shayer & Yates, 1989; Adey & Shayer, 1990; Shayer & Adey, 1992; Shayer & Adey, 1993) is an intervention for in-service science teachers started in the early eighties in the United Kingdom. It is based on the work of Piaget (In Inhelder & Piaget, 1958) specifically and also incorporates the principles of Vygotsky's (1978) learning theories. The authors highlighted the problem that even though the formal operational stage of Piaget should be in operation in adolescence around the ages of 14 or 15, this was not the case. The CASE project had set out to investigate whether it was possible to accelerate ways of

thinking in adolescence from Piaget's concrete to the formal operations (higher order thinking) phase through employing particular strategies, and hence enhance their understanding of science concepts. Adey explains:

Formal operational thinking is characterized by the ability to hold a number of variables in mind at once, for example, to be able to weigh up two sides of an argument, to consider even-handedly the advantages and disadvantages of a particular course of action, or to be able to see both the separate and combined effects of a number of input variables (Adey, 1999:5).

Adey (1999:25) points out that the development of critical thinking requires that children are given the opportunity to exercise their own minds. The CASE approach is based on five pillars. They are cognitive conflict, the notion of construction (in Vygotskian terms within the zone of proximal development), the encouragement of metacognition, the idea of concrete preparation, and bridging. The teacher thus has to create a situation in which learners are cognitively challenged (cognitive conflict) and allow them to construct their own reasoning (construction) in an effort to address the challenge. In addition, teachers should encourage learners to think consciously about how they reasoned when addressing the challenge (metacognition). However, there needs to be concrete preparation on the part of the teacher to make sure that the challenge is intellectually stimulating and that as far as possible, other barriers to addressing the challenge are eliminated, such as language or possibly basic background knowledge. The fifth pillar, bridging, makes the link between the reasoning patterns developed in the CASE context with other contexts or situations. As CASE activities were not part of the normal school science curriculum, participating teachers were encouraged to teach them once every two weeks resulting in a total of about 15 activities for the year. It was hoped that these activities would enhance the learners' thinking and enable them to cope more effectively with their regular curriculum material. Adey (1999:11–15) points out that there have been significant gains on learners' academic achievement in schools that have had long- term interventions in CASE, including gains in other subjects like English (Shayer, 1999:883–902). A description of the CASE activities and the use of Piagetian reasoning tasks can be found in Adey (1999:11–15). The choice was to work with in-service teachers as it was felt that pre-service teachers do not have the necessary pedagogical expertise and management skills gained through regular classroom practice as was the case for in-service teachers. Since their initial work, many schools in the UK and elsewhere have used this approach.

6.5.2 Argumentation in science

Osborne, Erduran and Simon (2004:1016) point out that argumentation is an important aspect of science and science education. They assert that by getting learners to argue for or against a position and challenging them to refute items of evidence that do not support the position or theory that they are defending compels them to think about the issues and hence cultivates their critical thinking. The quality of the thinking is associated with the strength of the argument (Lin, 2014:1027–1028).

Argumentation was a specific intervention chosen by the Critical Thinking Group (Braund et al., 2007; Scholtz & Sadeck et al., 2008; Braund et al., 2011; Lubben et al., 2010) as highlighted in Chapter 1 to facilitate the development of critical thinking in the science classroom. This linkage project was initiated as a direct response to the requirement for critical thinking in Curriculum 2005. Participants in the project were science curriculum advisors in the WCED, science teachers and science educators, and researchers at tertiary institutions based in the Western Cape and abroad. The rationale was that if we could get learners to reason effectively in science, supported by appropriate teacher facilitation, then it would shift their thinking to a deeper level of justification for their ideas than what they would normally present. In this way also, they would be more likely be alerted to their own potential to think for themselves rather than being told what to think.

Kuhn (2010:810–824) asserts that a major way of operationalising critical thinking in specific knowledge domains such as science is through argumentation, which she describes as the process of resolving opinions and examining the cogency of premises and conclusions. To do this, certain reasoning abilities are required such as, for instance, the ability to analyse and evaluate evidence and data in order to make justifiable inferences. Thus, the opportunity to do this in the classroom possibly provides some insights into the way in which scientific knowledge is constructed. Erduran (2007:29) concurs, and argues that argument, that is, justification of claims with evidence, is fundamental to science, yet much of the teaching of school science is unscientific and focuses mostly on the outcomes of science. Providing an opportunity for learners to engage with evidence to formulate an argument is one way in which they can gain insights into how scientific knowledge is constructed. Osborne et al. (2004:997–998) make the point that both epistemological and social structures in the classroom are important factors for designing activities that foster argumentation. Hence, in terms of scientific knowledge, learners need to be exposed to multiple perspectives or explanations of phenomena as

well as the associated evidence which can be used in an argument to justify these perspectives in a social context in the classroom. It is hoped that by doing this, they will enhance their critical thinking capacity.

Our choice of argumentation was also informed by the realisation that substantial development and research had already been done in the United Kingdom (Osborne et al., 2004; Simon, Erduran & Osborne, 2006) on argumentation in the science classroom, and thus it would not be necessary to start from a clean slate. Their argumentation model that they felt worked in the science classroom and which we also adopted was the Toulmin model (Toulmin, 1958) which presented a framework depicting elements of an argument such as claims, counterclaims, warrants, backings and rebuttals. Although I concur with some of the critique of this model in terms of its limitations in clearly representing the complex and dialogical aspect of an argument (Nielsen, 2013), it still served as a useful tool in initiating student teachers into the rudiments of argumentation in science as well as assisting them in planning and conducting argumentation lessons. In addition, the approach was not dependent on specialised equipment and there was the possibility of integrating argumentation into the existing school science curriculum. Fourth-year student teachers were introduced to approaches that would facilitate argumentation in the science and technology classroom. They were also given opportunities to practise argumentation lessons in science classrooms at their host schools during the internship phase of their programme. They were encouraged to use prompts when facilitating these lessons. These included questions like: Why do you say that? Give a reason for your response? Where is the evidence for this? Do you agree? Do you disagree? What would someone say if they were to disagree? Is there anyone else who has further supporting evidence? Is there anyone else who thinks differently? Why? But what if the situation were different? Can you tell us more? All these questions were meant to encourage learners to think more deeply about justifying the validity of their position. Evidence for learners to interrogate can be presented in various ways such as case studies, pictures, tables, text, experimental data, and so on (Simon & Maloney, 2007:49–57). Argumentation tasks could be scientific or socio-scientific, open-ended or closed. In the closed task, alternative explanations are provided and the learners justify their choices through argued reasons (Braund et al., 2007:67–76). Other scaffolding techniques included role play, writing frames or cartoon characters in which learners were encouraged to consider alternative positions and justify the positions they held based on data or scientific theory.

6.5.3 Indigenous knowledge systems and dialogical argumentation.

Jegede (1997:1–20) cautions that the effects of globalisation and rapid technological development will have a negative effect on the social fabric of communities. He asserts that urban areas in Africa may reap the economic benefits of modern information technologies; however, the implications may not be as positive for the destitute in urban ghettos or for the rural poor. While I acknowledge that science and technology have transformative possibilities for African development, serious deliberations are needed to determine the nature of science education as a means to unlock the potential for progress in Africa. Jegede (1997:1–20) proposes that a conceptual ecocultural paradigm is consistent with science education in Africa. Such a paradigm caters for a sociocultural perspective and involves logical dialectical reasoning embedded in African metaphysics within the context of a changing global community. This would involve drawing on the African environment to produce information about natural phenomena, identifying and using African indigenous scientific and technological principles, and incorporating the values of human feelings in relation to and in the practice of technology. In this way the learner is enabled to construct new knowledge in terms of existing conceptual frameworks.

Jegede (1997:1–20) posits that school science projects the Western worldview and does not recognise variations among people nor the different worldviews learners bring into the science classroom. Jegede (1997:1–20) claims that the sociocultural factors within non-Western societies affect what and how a child learns. The author (1997:1–20) identified five predictors of sociocultural influences in respect of the learning and teaching of science in Nigeria. They are authoritarianism, goal structure, societal expectations, traditional worldview, and sacredness of science. For the purpose of my discussion I shall highlight the last two factors. Jegede (1997:1–20) claims that African society holds the notion that supernatural forces have some influence on belief systems that may contradict the scientific knowledge learners encounter. Learners tend to compartmentalise these diverse elements of knowledge in a harmonious co-existence and draw on them strategically, depending on the context they find themselves in. The author introduces the notion of collateral learning to explain this phenomenon.

Collateral knowledge therefore, is the declarative knowledge of a concept which such a learner stores up in long-term memory with a capability for strategic use in either the western or traditional environment (Jegede, 1997:11).

Similarly, a body of work (Aikenhead, 1996; Ogunniyi, 2002; Le Grange, 2007) has emerged where authors have grappled with the notion that children who are presented with scientific explanations may hold other worldviews that may contradict what they are introduced to in the science classroom. This integration or convergence of scientific views and indigenous views has been referred to as the ‘third space’ (Bhabha, 1994; Ogunniyi, 2002). Ogunniyi (2007:1189–1207) recommends that teachers should be able to facilitate science learning through using pedagogies that acknowledge and incorporate indigenous views.

Ogunniyi’s Contiguity Argumentation Theory (2002:68–75) postulates that different states of mind can coexist quite comfortably in a single individual and that these emerge in varied forms depending on the context in which they find themselves. For instance, a child who is expected to respond to a question in a science test may present the accepted scientific explanation, whereas the same child may find him/herself in a domestic context where the indigenous or common-sense explanation is accepted. Studies in this regard have been reported, for example, where learners hold alternative notions to the scientific explanation as to what causes lightning (Moodie, 1990; Meel, 2007; Loggenberg, 2012; Webb, 2013). Langenhoven, Kwofie and Ogunniyi (2009) argue that for a teacher to enhance critical thinking in the science classroom, he or she should be empowered to understand the nature of science, the nature of indigenous knowledge systems (IKS), and relevant pedagogy, and treat these alternative worldviews in an unbiased way.

Langenhoven et al. (2009) introduce the dialogical argumentation model as a framework to guide the facilitation of argumentation across worldviews in a science class. It involves individual tasks in which participants assume particular positions. They are then given an opportunity to engage in small-group discussions and then larger class discussions with the aid of a facilitator. It is essentially presented as a cognitive harmonisation process in which participants co-construct their ideas. This approach potentially allows different worldviews to be expressed and critiqued. However, there could be a risk in assuming that all participants are confident enough to express themselves, as with any form of social interaction, dominant personalities could override the views of more timid participants. The role of the facilitator is to make sure that this situation is minimised. One of the participant teachers in a study by Loggenberg (2012:22) indicated that the value of sensitising learners to indigenous worldviews on phenomena gives them an opportunity to examine critically the validity of information they are confronted with in their everyday lives. The implication is that addressing the validity of taken-for-granted, generally accepted

everyday concepts potentially enhances learners' capacity to think critically. In Chapter 8 I shall deliberate on indigenous knowledge systems and science education in more detail when considering the notion of a decolonised African university.

6.5.4 Philosophy for children

Advances in science have involved both competition and cooperation.¹⁸ The philosophy for children approach, advanced by Matthew Lipman and his associates (1974, 1993, 2003) fosters a spirit of collaborative exploration rather than antagonism or competition focusing on a winner. The emphasis is on developing critical thinking through philosophical dialogue (Daniel & Auriac, 2011:415) and the class is transformed into a community of enquiry where the child is encouraged to think for him or herself but in collaboration with others (Vansieleghem, 2006:175–179).

Lone and Burroughs (2016:3–25) argue that philosophical practice is fundamental to the human condition and that philosophical questions which, among others, may be epistemological or ethical in nature, are not necessarily the sole preserve of professional philosophers or a university philosophy class. The main thrust of the approach involves using age-appropriate discussion prompts to encourage questioning, dialogue and reflection in an enabling community of peers. These prompts may be a story, a video or a demonstration that serves as the impetus to promote collaborative exploration of the aspects under discussion. The questions asked by the learners serve as the foundation for the philosophical enquiry. The authors point out that higher-order questions that stimulate discussion are normally open ended and elicit a range of possible responses, while lower-order questions tend to be closed ended with a single right answer. The teacher facilitates the process in a particular way, with due sensitivity to the dynamics in classroom discussions in order to make sure that the repressed or underlying voices are also heard. They further note that the educational context that allows for these philosophical encounters should nurture respect for children and appreciation of their philosophical capacities while encouraging young people to think for themselves. It is hoped that in this social context children will reason through and attempt to seek further clarification on those aspects which they may find puzzling, thus nurturing their critical-thinking capacities.

In addition, Lone and Burroughs (2016:3–25) point out that in academic philosophy programmes at universities, students develop important skill sets such as analytical

¹⁸ Trying to decipher the structure of the DNA model is a good example of contestation and consensus.

thinking, critical literacy and logical argumentation. They argue for the expansion of philosophy to schools as philosophy's emphasis on questioning and independent thinking engages learners in thinking and reasoning about crucial questions that matter to them. Philosophy's emphasis on uncertainty also helps children to appreciate that there may be many perspectives to a particular issue and that there may not necessarily be only one right answer. They remark that philosophical questions engage children in thinking for themselves about questions where there may be no final or settled answers, and yet a new clarity emerges for them personally. In addition, allowing time for quiet reflection on the engagement provides learners with an opportunity to construct meaning from their experiences. Applying this methodology in science teaching where a tentative view of knowledge may not necessarily be emphasised has its challenges, yet there have been reports (Sprod, 1997, 1998) of successes in the science classroom with this approach. Sprod (2002:12) provides a clear outline of the approach in which he notes that the role of the teacher is one of a facilitator who should avoid being the source of knowledge or an evaluator of learner responses. Instead, the peer community takes on these roles. Some of the techniques he mentions are the use of a longer wait time to allow for thinking space, refraining from making judgemental comments, allowing children to see teacher puzzlement, and thoughtful use of questioning in order to encourage metacognition among the children. In this scenario professional judgement is crucial in deciding how and when to encourage cognitive moves by the learners. He notes that the process itself has value in stimulating reasoning ability and children should be made aware that there are not necessarily immediate and quick answers to the questions they explore. This is quite a sophisticated methodology and is supported by materials and teacher development programmes in many countries, particularly Australia (Burgh & Thornton, 2015; D'Olimpio, 2015).

6.5.5 Problem-based learning

Problem-based learning, with the most prominent application in the medical field, involves students working collaboratively to address a real-world problem which is ill-defined. That is, there is no one correct answer and there may be more than one avenue to address the problem. The focus is on self-directed learning where gaps in knowledge are constructed based on what is needed to address the problem, often across multiple domains or disciplines. The teacher is a facilitator and guide (Hmelo-Silver, 2000:235–266). Narrower variants of this methodology which operate within the discipline include project-based learning. For example, in science, the project may be a driving question which needs to be

addressed. The solution could be clarifying a question through an investigation or the design and development of an artefact that draws on scientific concepts. The teacher provides support to a greater or lesser degree depending on the educational context.

One of the goals of problem-based learning is the development of effective problem-solving skills (Hmelo-Silver, 2000:240–241). These could include all the types of thinking processes associated with critical thinking, such as the ability to analyse the problem and make reasoned judgements about the best course of action. Participants also need to reflect on, monitor and evaluate their choices and adapt them where necessary. Hmelo-Silver (2000:244–246) contends there are two dimensions that form part of a problem-based learning approach. The one is cognitive, where learners develop conceptual understanding through solving problems, and the other is social, where learners interrogate the problem in a group setting. Through careful questioning the teacher encourages learners to reflect on and justify their decisions and provide reasonable explanations for the choices they've made.

Kolodner, Camp, Crismond, Fasse, Gray, Holbrook, Puntambekar and Ryan (2003:496–497) advocate that deep and effective learning is best promoted by situating learning in purposeful and engaging activity. They suggest that their choice of Learning by Design, a project-based enquiry approach in learning science, is one such approach. The concepts learnt are embedded in the task. For example, science learners in middle school learn about forces and motion when they are given the task to design and build a miniature car with a propulsion system that enables it to traverse several hills. However, in my experience, one cannot leave the consolidation of science concepts to chance. Learners need to be alerted to the underlying science concepts, otherwise they may be lost. The teacher will rely on his or her professional judgement on how this may ensue.

Another variant of problem-based learning focuses on learning science in context. The context may be the urban or rural environment of the school, or socio-scientific issues that have some significance in the school community. There is a general consensus that this approach emphasises an active construction of knowledge, situated cognition, and collaborative enquiry (Campbell & Lubben, 2000; Rivet & Krajcik, 2004; Bruna & Vann, 2007; Eastwood, Sadler, Zeidler, Lewis, Amiri & Applebaum, 2012). Campbell and Lubben (2000:239–252) point out that proponents of contextual science teaching emphasise that it provides relevance to the learning of school science. A critique of this approach if used

exclusively is that learners may have gaps in knowledge as a result of not being orientated in respect of aspects which do not apply to the situation addressed.

6.5.6 Productive pedagogies

Edwards (2015:159–173) used the notion of ‘productive pedagogies’ as presented by Lingard, Hayes, Mills and Christie (2003) to highlight multimodal representations and enactments in the science classroom. One of the dimensions of productive pedagogies is ‘intellectual quality’,¹⁹ which foregrounds higher-order thinking, depth of knowledge and understanding and meta-language. Enactment in the classroom is through pedagogies that enable substantive conversation and elaborated written communication in problem-based tasks. The same scientific concepts can be addressed in multiple ways, such as hands-on practical assignments and experimental observation, oral and written descriptions, mathematical notations, tabular and graphical representations, and model building. Edwards (2015:159–173) argues that such multimodal enactments in the science classroom together with dialogic interaction assist conceptual understanding in science and cater for learners from different backgrounds. This approach is reminiscent of the ‘multiple intelligence’ of Gardner (1985)²⁰ who contends that learners learn differently and thus teachers should have a varying pedagogical repertoire that caters for different types of learners. A similar strategy was introduced to facilitate the development of science process skills in large, poorly resourced classes in South Africa, using paper and pencil activities (Johnson, Monk, Watson, Hodges, Sadeck, Scholtz, Botha & Wilson, 2000; Scholtz, Watson & Amosun, 2004). Learners were tasked to translate various forms of scientific representation from one form to another in a collaborative setting. It was hoped that through this translation they would be able to engage with the science concepts as well as develop science process skills such as observation, analysis, drawing conclusions, and so on. In this way learners are initiated into the methodological aspects of science.

6.5.7 Dialogue and the use of ICT

Knight and Littleton (2015:467–478) highlighted ways in which the shared use of information and communication technology (ICT) could be viewed as an individual or collective resource. They emphasised dialogue as an important aspect of learning with and through digital technologies. These include online interaction in all its forms. They support

¹⁹ The other dimensions are connectedness, supportiveness and engagement with, and valuing of difference (Lingard et al., 2003:7)

²⁰ Gardner (1985) identified seven types of learning or multiple intelligences. They are visual-spatial, bodily kinaesthetic, musical, interpersonal, intrapersonal, linguistic and logical-mathematical.

Vygotsky's (1978) ideas of social constructivism where children's 'intermental' experience influence their 'intramental' activity. 'Intermental' refers to cognitive activity related to the exchange of ideas when interacting socially, while 'intramental' refers to ways of thinking as individuals. The authors draw on Mercer and Littleton (2007:58–59) who developed a typology of dialogue that could potentially be exhibited. These types are disputational, cumulative and exploratory. While the first two types mentioned are characterised by disagreement and uncritical construction of common knowledge respectively, the last type mentioned involves conscious participation and critical construction of knowledge with more visible reasoning and justification of claims made. Knight and Littleton (2015:467–478) regard this 'interthinking' (2015:475) as educationally productive dialogue and potentially possible when mediated via digital technologies, without the limitations of time and space. This is in agreement with Wegerif's (2015:427–440) suggestion that digital technology has the potential to mediate, expand and deepen the 'dialogic space', thus allowing different voices and perspectives on aspects under consideration. I think that the converse is also true. A cacophony of voices online could dampen or mute the criticality. The challenge is finding meaning in those voices. Knight and Littleton (2015:467–478) maintain that thoughtful, digitally designed spaces have the potential to encourage co-representation, reflection and learning as characterised in the exploratory talk mentioned earlier. This ought to be an essential consideration for a teacher education programme in an era where our students are naturally drawn to and immersed in online digital technologies.

6.6 General considerations for enhancing critical thinking

If the teacher is not using any of these approaches discussed previously, how then would one recognise that a teacher is attempting to enhance learners' critical thinking? Aspects such as questioning techniques, nature of the tasks set for learners, nature of instructions, types of groupings, and nature of interaction between teacher and learners or learners and learners will all need to be taken into account.

Such a teacher would:

- create opportunities for learners to express their own ideas;
- encourage learners to justify their own ideas by drawing on evidence and theory;
- create an enabling environment where learners feel free to express themselves;
- encourage dialogue, debate and the sharing of views and information;

- encourage learners to question and probe data, views, assumptions, information;
- encourage independent, autonomous and self-directed learning;
- take learners' views and contributions seriously;
- encourage standards of quality in their work such as clarity, accuracy, etc.;
- pose questions and formulate tasks which encourage reflective thinking and metacognition;
- provide opportunities for learners to exercise their own minds, individually or collaboratively, through tasks that allow them to analyse, evaluate, infer, and so on; and
- use available technology such as YouTube, online discussion groups or social media in a way that would encourage learners to communicate and justify their ideas.

When presenting tasks to learners that are designed to foster critical thinking, the teacher has to use his or her professional judgement to determine how and when they are presented and how learners should be supported for optimum learning. The support could take the form of scaffolding techniques such as strategic questions, sensitising learners to key concepts, and so on. Finding the balance between providing support and allowing learners free reign to think for themselves is a matter of professional judgement. Aspects such as complexity of task, degree of structure and support, length of task, open-endedness, and position in teaching sequence are all aspects which need to be considered (Stott, 2008:11–13).

Stott (2008:13) suggests that conceptual engagement rather than procedural engagement with a task is more likely to foster critical thinking, yet she cautions that if learners do not have an acceptable level of procedural engagement, it could clog up working memory and restrict the capacity to engage conceptually. To her, procedural engagement, following Hobden (2006), means drawing graphs, manipulating equations, following lists of instructions, and so on, while conceptual engagement implies the ability to operate qualitatively with concepts, following Paul and Elder (2006). I imagine that plotting the graph correctly would be a procedural activity, while the ability to interpret the graph and reach appropriate conclusions within the epistemological and methodological context of the task, would approximate the conceptual understanding referred to by Stott (2008:13). The framework Stott (2008:59) uses to judge whether a task fosters effective learning includes the following criteria: the learners show interest in the task and are actively engaged; they display higher-order thinking; they succeed in completing the task, but with

effort; the task is challenging but within their capabilities; and the curriculum objectives are met. Stott (2008:1-59) uses higher-order thinking and critical thinking interchangeably. She relies on Lipman (1989:8) for guidelines to recognise whether learners demonstrate critical thinking. Such thinking is dependent on criteria, self-correcting, sensitive to context and enhances judgement. This is very useful when ascertaining how learners respond to individual tasks set by the teacher. The challenge is to assist the student teacher in making professional choices that would stimulate the kind of engagement Stott (2008:11-13) endorses.

Many of the methodologies described in this chapter have been trialled with in-service teachers. All these approaches may need to be adapted for preservice teachers who do not have much teaching experience. One way of dealing with this may be to have students experience these methodologies as learners, followed by facilitated reflection (Braund et al., 2011:S79–S93) on how they could work in the classroom. Further opportunities to practise the methodologies could augment the reflection.

6.7 An elaboration of notions of critical thinking within the context of science teacher education

I detect some commonalities in all the approaches presented from the literature, some of which include those features previously identified in my conceptual elaboration such as reflexive praxis and cognitive construction of ideas based on sound reasoning. Many of the generic approaches discussed above as well as those presented from the literature could very well be applicable in any discipline. However, as pointed out earlier, considerations of pedagogy which support the enhancement of the methodological and epistemological aspects of science as highlighted by Lederman et al. (2014) would contextualise it in the science teacher education realm. Notions of pedagogy are subsumed in reflexive praxis, so they already feature as part of the conceptual framework. What now needs to be added explicitly is a pedagogical focus on scientific knowledge (epistemological) and scientific inquiry (methodological). These are conceptual gaps which support the enhancement of scientific literacy and have relevance to science teacher education. In addition to this, I've identified constitutive meanings or common emphases from the science teacher education literature related to key pedagogical aspects that have the potential to enhance critical thinking. They involve the pedagogic choices the teacher makes when facilitating learning experiences in the science classroom. These key pedagogical aspects refer to the classroom context, the nature of the learning task and the pedagogy of the teacher as

elaborated on earlier in the chapter. That is, the teacher is expected to create an enabling environment which allows for learners to address challenging yet attainable conceptual rather than only procedural tasks through collaborative and dialogical enquiry and reflective constructive reasoning often framed by authentic contexts. Hence, socio-constructivist approaches where learners work together and interact with one another when addressing a scientific task or question, whether teacher led or learner initiated, seem to be the dominant pedagogy recommended in the literature for the enhancement of critical thinking in the science classroom. The teacher's role is one of a guide who uses appropriate scaffolding techniques and raises pertinent aspects of the task or question at hand, with the intent for learners to work things out for themselves. Such techniques are meant to encourage learners to reflect on and articulate their reasoning when addressing relevant aspects of the task. This articulation of their own reasoning allows them to reflect out loud and hence has the potential to facilitate metacognition, that is, thinking about their own reasoning as well as comparing their reasoning with those of others. In this way they refine their own ideas (Oliver & Venville, 2015:380). In addition to enhancing the quality of reasoning, it is claimed collaborative interaction also enhances other skills such as communication, task coordination, conflict resolution, problem solving, and so on (El Sayary, Forawi & Mansour, 2015:363).

I now present an elaborated conceptualisation of notions of critical thinking in the context of science teacher education. In this elaborated conceptual framework, I depict two further dimensions, namely a pedagogical focus and key pedagogical aspects. See Table 6.1 overleaf.

This elaborated framework includes a pedagogical focus within the context of science education that deals with ways in which the teacher initiates learners into the processes and products of science. The teacher's perspective of the nature of science or scientific knowledge as well as scientific inquiry will determine how science is taught in the classroom. The choices made by the teacher could reflect some or all of the features or pedagogical aspects applicable to critical thinking as outlined in Table 6.1. The pedagogical focus and key pedagogical aspects as highlighted in the elaborated framework could serve as important guidelines to enhance criticality in a science teacher education programme.

Table 6.1 An elaborated conceptual framework of notions of critical thinking within the context of science education and the role of the teacher

6.8 Conclusion

In this chapter I deliberated on the nature of the discipline of science as presented by various scholars. I then proceeded to highlight approaches from the literature which emphasised the enhancement of critical thinking in science education. Furthermore, I considered how these approaches could inform my conceptual elaboration of critical thinking in the context of science teacher education. Although the expanded framework developed in Chapter 4 provides a general guide for analysis, it is limited in identifying or providing guidance on the kinds of teaching and learning strategies needed to facilitate

critical thinking in the science classroom. This is where I am guided by what the literature on enhancing critical thinking in the science classroom reveals, hence my inclusion of the key pedagogical aspects (constitutive meanings) derived from the literature. Upon the realisation that many of the approaches recommended could very well be applied in other disciplines, I deliberated on the distinguishing factors of science which Lederman et al. (2014:285–302) refer to as the nature of science and scientific inquiry. Two key components, namely the epistemological and methodological aspects, were considered crucial components of a pedagogical focus in science education. The pedagogical focus then became an additional dimension in my elaborated conceptual framework. I am now in a position to examine South African physical science school curriculum documents using this version of the elaborated conceptual framework as an analytical tool in the next chapter.

CHAPTER 7

NOTIONS OF CRITICAL THINKING AND SCHOOL PHYSICAL SCIENCE CURRICULA

7.1 Introduction

In the previous chapter I developed a conceptual elaboration of critical thinking more applicable to the science teacher education context. The intention is to use it as an analytical framework to analyse how critical thinking manifests in the South African physical science school curriculum documents for the Further Education and Training (FET) band.

As mentioned previously, science teachers are not necessarily scientists, yet they are required to guide their learners to an understanding of the processes and products of science. Hence, to an extent, science activities in the classroom remain partially simulated endeavours if attempted at all. In the scientific world, emerging scientific knowledge could be a consequence of scientific inquiry. In the classroom context however, this may be quite problematic to enact. Often, what is presented as scientific inquiry in the science classroom are prescribed, standard procedures. At best, the teacher could get the learners to interrogate the current consensus on scientific knowledge and conventions. Getting learners to embark on an authentic scientific inquiry is more challenging.

So where do science teachers go for help when seeking clarification on how to initiate and guide their learners through the processes and products of science, of which scientific knowledge is a crucial component. One would expect that science school curriculum documents, in the absence of science teacher policy, would be significant resources to shed light on the matter. In this chapter my focus of analysis will thus be on the National Curriculum Statement (NCS) for Physical Sciences (DoE, 2003) and the Continuous Assessment Policy Statement (CAPS) for Physical Sciences (DoE, 2011). Even though the former document is no longer policy, it contextualises and provides insights into the nature of the current document as well as informs my discussion on how we, in science teacher education, can prepare student teachers to manage changing curriculum requirements.

Hence, I first provide a historical overview of school science curriculum renewal since 1994, after which I focus on the NCS and CAPS to try to ascertain whether it presents

opportunities for the enhancement of critical thinking in terms of teacher conduct in the physical science classroom. The analysis is informed by the elaborated conceptual framework of notions of critical thinking developed in the previous chapter, which includes insights gained from literature on critical thinking, pedagogy and science education. The focus of the analysis addresses Research Question 3: How do notions of critical thinking manifest in South African school physical science curriculum documents post 1994? I conclude by discussing implications for teacher education in changing curriculum contexts where the expectations of the role of the teacher may vary.

7.2 An overview of the development of school science curricula

Concomitant with the onset of the new democracy in 1994 were new policy directives in accordance with the vision of a new democratic society. School policy was no exception. Just as two distinct phases were discernible in teacher education policy development as outlined in Chapter 5, the school curriculum documents developed post 1994 followed a similar course.

In phase one, broad and ambitious policy guidelines (DoE, 1997) for schools, based on outcomes-based education and to a large extent imported from countries like New Zealand, presented the teacher as a professional who was able to devise his or her own curricula and teaching and learning materials. Before it could even run its anticipated course for all grades, the ensuing backlash (Jansen, 1998, 1999; Cross, Mungadi & Rouhani, 2002; Chisholm, 2005) left policy makers hurrying back to the drawing board to refine the school curriculum by eliminating the confusing terminology, reducing the integrative approach, and providing teachers with tighter guidelines in terms of content and pedagogy, culminating in the NCS (DoE, 2003). Although still outcomes driven, it nevertheless remained fairly flexible in terms of how teachers chose to apply the curriculum.

Phase two ushered in the third revision known as CAPS (DoE, 2011), developed at the same time as 'MRTEQ' (DHET, 2011) described in Chapter 5. This revision is reminiscent of the content-focused curriculum prior to 1994. Outcomes-based education was now an anathema. The CAPS curriculum in Physical Science focuses on the content and practical work that must be covered and even indicates when this should occur down to the number of hours spent on each topic. This does not leave much room for teachers to be flexible in their own teaching contexts.

7.3 Previous analyses of physical science curriculum documents

Several attempts to compare and analyse the physical science curriculum guidelines serve as a context for my analysis. Erduran and Msimanga (2014:S33–S46) used a mixed-method approach based on their conceptualisations of Nature of Science (NOS), Indigenous Knowledge Systems (IKS) and argumentation, to compare the NCS (DoE, 2003) and CAPS (DoE, 2011). Their intention was to map explicit reference to pedagogies that foreground IKS and NOS with a specific emphasis on argumentation as an appropriate choice for initiating learners into how science works. I have already described these methodologies in the previous chapter as well as outlined their potential for the enhancement of critical thinking. Erduran and Msimanga (2014:S33–S46) found that there was a decline in the coverage of NOS, IKS and argumentation from the previous NCS to the current (CAPS) physical science curriculum in the FET band as well as a lack of contextualisation of these three approaches. The authors concluded that a lack of explicit articulation of these approaches in the latest science curriculum document implies that the responsibility to make this explicit rests with science teacher education programmes, a recommendation well worth considering. Previously, Green and Naidoo (2006:71–80) took a different approach in their comparison of the Interim Physical Science curriculum (DoE, 1995) with the NCS (DoE, 2003). They used a multi-dimensional theoretical approach to compare the two documents. They concluded that the former presents a view of science as a decontextualized academic discipline, while in the latter science is presented as contributing to the achievement of economic utilitarian and social goals, and hence open to multiple interpretations depending on the context. At first glance, the subsequent CAPS document seems to resort to the former view, with some exceptions, as I shall outline in my analysis.

Furthermore, in a more recent analysis, an Umalusi²¹ task team (Grussendorff, Zuma, Stephen, Isaacs & Van der Hoven, 2014:93–134) compared the NCS (DoE, 2003) and CAPS (DoE, 2011) for Physical Science for the FET phase, Grade 10 to 12. They based their analysis on a number of criteria which included aspects such as user-friendliness, language accessibility, breadth and depth of content, and central design principles. I shall address a few aspects which I think have relevance to notions of critical thinking. The task team equated depth of content with what they termed cognitive complexity, to which they allocated four levels, ranging from Level 1, designated as superficial, focusing on aspects

²¹ Umalusi is the registered name for the Council for Quality Assurance in General and Further Education and Training.

such as definitions and descriptions, Level 2, which incorporates making links between concepts and doing simple numerical calculations, Level 3, which entails indications of more detailed relationships between concepts involving complex computations and interpretations, and Level 4, designated as complex with a high level of abstraction requiring demanding mathematical computations and problem-solving abilities. In the summary of content depth (Grussendorff et al., 2014:103), about 80% of the cognitive demands made are presented at Level 2 and 3. Unfortunately, examples from the curriculum are not provided where these levels are identified or clarified specifically, thus much is left to the interpretation of the reader as to what this might comprise. The task team approved the highly prescriptive nature of the CAPS document in terms of content and teacher guidelines, as it was pointed out that this would assist teachers who might be deficient in subject knowledge. I concur with their depiction of the central design principle for the NCS as outcomes based, while for CAPS it is content based. The content advocated in the CAPS physical science curriculum hasn't changed much over the last two decades, despite curriculum changes. An exception is the focus on the lithosphere and the link with mining in Grade 11. The main message implicit in the various documents is the role of the teacher, to which I now turn.

The shift from a learner-centred, constructivist enquiry-based approach in the NCS to a teacher-centred, content-driven approach in the CAPS is acknowledged with the concomitant implication for the role of the teacher as a mediator of the learning process in the former curriculum to a meticulous deliverer of the prescribed content in the current curriculum. Hence, opportunities for the teacher to exercise his or her professional judgement, with due consideration of educational contexts, could be much reduced unless sensitised to these possibilities. A number of anomalies related to content, alignment and sequencing were identified and recommendations made to improve the CAPS document, which I shall not elaborate on as it does not relate to the purpose of my study.

7.4 Considerations of pedagogy

As a prelude, when considering what is important in science education, I refer to Lederman et al. (2014:285–302), who advocate the development of scientific literacy, which emphasises learning about the knowledge, processes and products of science as well being able to apply these insights or make choices when confronted with aspects of a scientific nature in varying contexts.

The teacher imparts or facilitates certain ways of engaging with science. The curriculum to a large extent influences this engagement. For the purposes of this study, I distinguish between two forms of engagement. One is embedded in the rationalist, positivist approach, which focuses on enhancing discipline knowledge in a neutral acontextual manner. I refer to this as the subject-specific domain, which would largely but not exclusively be the focus of a teacher with a conservative perspective as depicted in my extended conceptual framework. The other may have broader parameters and be contextualised within society or the environment. I refer to this as the science and society domain. The latter domain may have many dimensions which could involve considerations of the technological applications of science in industry or the bias and impact of science on society and the environment. This would imply broader considerations of the content and context of science, with the focus on science for public understanding as described by Osborne et al. (2002:37–57), such as attention to ethical dimensions of science and ideas about the nature of science. This demands that teachers are able to facilitate effective discussions in which learners are engaged in thinking about scientific or socio-scientific issues. In both domains there is potential for the enhancement of critical thinking. The science and society domain encompasses all those aspects that reveal broader parameters than merely pure science considerations. Such a focus could very well align with the other perspectives outlined in the conceptual elaboration, such as liberal or radical.

I now present some comments on science practical work in the classroom as this is an integral requirement of both curricula. While Hattingh et al. (2007:75–90) acknowledge the role of teacher-run, structured practical work as a way of consolidating existing science knowledge, they suggest that open-ended, learner-controlled practical work is more likely to provide insights into how new knowledge claims can be generated and validated. The latter approach hence could provide learners with some understanding of the methodological aspect of science. However, it has been reported that this is not the reality in South African science classrooms. Hattingh et al. (2007:75–90) devised a classification framework according to the degrees of complexity in science practical work, where Level 1 consisted of teacher demonstration, Level 2 of structured recipe-type worksheets, Level 3 of learner-run practical work with significant teacher guidance, while Level 4 comprised autonomous, open-ended investigations conducted by the learners, with the teacher in a facilitating role. In their study they found that most teachers tended to operate at Level 1. Significantly, they found no link between the resource provision at the school and the level

at which the practical work was conducted. Similarly, Ramnarain (2010:187–200) developed a three-stage classification framework for practical work which is structured, guided and open. His study concurs that most investigations fall into the structured category. Having provided some contexts on practical work in the South African classroom, I now turn to my exploration.

7.5 An approach

In previous chapters I explored what the literature has to say about critical thinking and considered the implication for notions of critical thinking in education generally and science teacher education specifically. The use of constructivist methodologies, as described in Chapter 4, allows the teacher to engage the learners in ways that inspire them to think for themselves. Techniques that challenge them and encourage them to make appropriate cognitive links that would deepen their understanding of the issue at hand were endorsed as appropriate to enhance critical thinking in the science classroom. Based on these views, I peruse the physical science curriculum document to identify whether such methodologies are prescribed or alluded to, or whether there is potential for the teacher to use approaches that enhance critical thinking in both domains. I thus examine the text in the document to identify aspects that are aligned with the four perspectives described and deliberate on ways in which teachers are expected to exercise their professional judgement when navigating curriculum policy prescriptions. Furthermore, I examine how the methodological and epistemological aspects of science are presented and the way in which this is linked to pedagogical aspects, if at all, as outlined in my conceptual elaboration. First, I present a general overview of the two documents. I then proceed with my analysis by using the elaborated conceptual framework as a guide, that is, the dominant perspective revealed, the pedagogical focus highlighted, features of critical thinking, and the key pedagogical aspects advocated or suggested.

7.6 Overview

As pointed out earlier, just as in the teacher education policy documents, two phases can be distinguished in school curriculum development since the onset of the political democracy in South Africa, post 1994. I elaborate on this next.

7.6.1 Phase one: The National Curriculum Statement for Physical Sciences Grades 10 to 12

I place this document in phase one as it served as the official curriculum document during the same period as the Norms and Standards for Educators (DoE, 2000). It also specifically acknowledges that the kind of teacher envisaged is one who can fulfil those roles described in the Norms and Standards for Educators. The kind of teacher that is envisaged is

'... qualified, competent, dedicated and caring' (DoE, 2003:5).

The dispositional aspect is therefore considered as important as the professional aspect. Furthermore, the reliance on the teacher's professional judgement is a crucial expectation of the role of the teacher as I shall outline shortly.

The NCS is in line with outcomes-based education (DoE, 1997), which emphasises competence in certain learning outcomes. Criteria, known as assessment standards, are aligned with each learning outcome. Assessment standards describe how learners can demonstrate the knowledge, skills or values they have acquired. They can also serve as guidelines for teachers when planning their teaching and learning programme or when assessing their learners' progress. For the subject, Physical Science, there are three learning outcomes which drive the teaching and learning process which I shall elaborate on presently. The three learning outcomes are aligned with the cross-curricular critical outcomes, specifically Critical Outcome 1, which is pertinent to this study:

'Identify and solve problems and make decisions using critical and creative thinking' (DoE, 2003:14).

7.6.2 Phase two: The Curriculum and Assessment Policy Statement for Physical Sciences Grades 10 to 12

The CAPS document features in phase two and can be considered in tandem with 'MRTEQ' (DoE, 2011) and the 'revised MRTEQ' (DoE, 2015). The rationale for the subject is presented as all-encompassing but has a decidedly functionalist purpose which ranges from preparing learners for higher education to professional careers that promote the development of science and technology. In this way it is expected that learners are able to contribute to the economic growth of the country and the social wellbeing of its people further along their career trajectory. The detailed prescriptions to the teacher with respect

to content, practical work, time allocation and assessment reduce the professional choices of the teacher considerably as I shall discuss later in this chapter.

The six knowledge areas that inform the Physical Sciences for both curricula are Matter and Materials; Chemical Systems; Chemical Change; Mechanics; Waves, Sound, and Light; and Electricity and Magnetism.

7.7 Analysis

I now proceed to analyse both documents using the elaborated conceptual framework on notions of critical thinking within the context of science teacher education developed in Chapter 6 as a guide. I analyse, report and reflect on the emerging insights as I work my way through the various components of the elaborated framework.

7.7.1 Perspectives of critical thinking

In its general introduction, the NCS endorses the aims of the South African constitution (Republic of South Africa, 1996a), which is based on social transformation, democracy and social justice for all its citizens, and presents teachers as key contributors to these goals. Similarly, the foreword by the Minister of Basic Education, Mrs Angie Motshekga, to the CAPS document (DoE, 2011:1) advocates a transformative agenda for the national curriculum, of which Physical Science forms part. The emphasis, as in the NCS, is on social justice, equality and human rights, whose purpose is to lay the foundation for a democratic and open society. The principles and discussions in the introduction consolidate this transformative intent.

The rhetoric is the same for both documents, which verge on a social democracy, and thus perspectives manifested can be placed on the liberal/radical end of the continuum. A further analysis of the documents will reveal how the specificities of the physical science curriculum align with this intent.

7.7.2 Pedagogical focus: Science education context

The conceptualisation of the Physical Sciences in both the NCS and the CAPS document emphasises scientific inquiry and presents the subject as an investigation of physical and chemical phenomena, where scientific models, laws and theories are applied to explain, predict and understand events in the physical environment. Although both documents highlight the importance of physical science as an avenue for advancement in science-related careers, the NCS (DoE, 2003:9) also acknowledges the role of the subject in

providing scientific perspectives that will assist participation by citizens in making critical choices when responding to issues of science and technology. Similarly, the CAPS highlights the use of scientific, technological and indigenous knowledge to address challenges facing society (DoE, 2011:8).

In the elaborated conceptual framework of critical thinking within a science teacher education context, I presented the pedagogical focus which is epistemological, that is, scientific knowledge construction, and methodological, that is, scientific inquiry. These two foci manifest in both documents.

In the NCS, the scientific enterprise and scientific knowledge are presented as developmental, tentative, contested and contextually biased.

Some of the aims include initiating learners into the processes and products of science in ways that will stimulate their curiosity, deepen their understanding of scientific conventions, mobilise their understanding of African indigenous scientific knowledge and practices, as well as develop their insights into responsible technological applications of Physical Science (DoE, 2003: 9–10).

The three learning outcomes align quite well with the epistemological and methodological focus of science as depicted in my elaborated conceptual framework developed in Chapter 6. Learning Outcome 1 emphasises practical scientific inquiry and problem solving, Learning Outcome 2 focuses on the construction and application of scientific knowledge, while Learning Outcome 3 expects the learner to make appropriate links with the nature of science and technology, society and the environment (DoE, 2003:13–14).

In the CAPS document, just as in the NSC, there are three similar foci in the Physical Sciences but this time they are presented as specific aims rather than outcomes. The first focuses on scientific inquiry coupled with problem solving. The second presents an epistemological aspect with a particular stance, that is, it emphasises the application of scientific as well as technological knowledge. In the document no distinction between these two forms of knowledge is explained, while the third emphasises an understanding of the nature of science and its link to technology, society and the environment.

The specific aims of the Physical Sciences as presented in the document again emphasise scientific inquiry in which the purpose of the subject is to alert learners to their environment on the one hand (one can assume that this refers to sensitising learners to scientific

phenomena in their environment as it does not mention this specifically), as well as to equip learners with investigating skills on the other hand. Specific examples of science process skills are given such as classifying and measuring, as well as broader abilities such as designing an investigation and all that it entails, including the ability to hypothesise, interpret findings and evaluate conclusions as well as formulating theoretical models. Problem solving and reflective skills are also mentioned as desirable attributes for physical science learners.

Hence, the pedagogical focus for the physical sciences for both documents aligns very well with the elaborated conceptual framework.

7.7.3 Features of critical thinking

I next consider how features of critical thinking as presented in the elaborated conceptual framework manifest in both documents. While context and purpose would be applicable to both documents, I focus more on ways in which rational reasoning skills, a dispositional aspect, and reflexive praxis are presented as these have direct links to the role of the teacher.

In the NCS, rational reasoning skills as highlighted in the literature do feature in the assessment standards. For example, during scientific investigations, learners are expected to analyse as well as interpret data and formulate and defend scientific arguments. However, when examining the assessment standards for Learning Outcome 2, which focuses on scientific knowledge, it seems to be presented in a way that encourages recall rather than active engagement. Words such as ‘define’ and ‘describe’ are used. On the other hand, learners are also expected to discuss and explain scientific principles and processes which could lead to more critical engagement. If the learners are encouraged to justify their positions during such engagement, it may well fall within the realm of critical thinking. This depends on the choices made by the teacher.

The dispositional aspect is highlighted in Learning Outcome 3, where learners are expected to identify and evaluate ethical and moral issues related to science and technological applications with particular reference to the impact of science and technology on human development and the environment. Learners are also expected to interrogate and evaluate various historical and culturally sourced explanations of scientific phenomena.

Although core content guidelines are provided, how and what the teacher does is left to the initiative of the teacher. The teacher is simply required to maintain the balance between physics and chemistry and scaffold concepts within the knowledge area to allow for progression in content and complexity as learners proceed from grade to grade. Broad guidelines in terms of percentage of content covered per topic and time allocation are also provided (DoE, 2003:37–54). However, teachers are free to sequence the learning programme in any way they deem appropriate. Even though there is not specific reference to a reliance on professional judgement, the teacher is affirmed as a professional able to make autonomous decisions. Hence, reflexive praxis would be a key component in implementing the NCS.

On the other hand, even though the CAPS document refers to critical thinking when presenting the principles that the curriculum is based on, it has been quite difficult to delineate features of critical thinking specifically. Once again, this could be inferred in the way curriculum prescriptions are articulated.

However, this principle below makes explicit reference to critical thinking and I present it in full.

'Active and critical learning: encouraging an active and critical approach to learning, rather than rote and uncritical learning of given truths' (DoE, 2011:4).

'Identify and solve problems and make decisions using critical and creative thinking' (DoE 2011:4).

This time critical thinking is coupled with creative thinking, which could possibly involve innovation in a problem-solving scenario. Problem-based learning as described in Chapter 6 may be an approach that resonates with this principle.

In the first instance quoted, the implication is that learners should not unthinkingly accept what they are presented with in the classroom but question and interrogate for themselves the validity of what they encounter. In the second instance quoted, learners are expected to apply their minds to solving problems critically and creatively, albeit in a local context. Both these general principles have expectations of a teacher's operating in a way that would provide opportunities for learners to think for themselves.

Unlike in the NCS, the CAPS document is very prescriptive in terms of content, concepts and skills to be covered, practical activities to be performed, and guidelines for teachers.

These are presented as column headings for each grade per topic, accompanied by specific time allocations. For manifestations of the features of critical thinking as outlined in the elaborated framework, I take a closer look at the guidelines for teachers and the tasks learners are expected to perform, as these might provide some insights as to the expectations of the role of the teacher.

The teacher guidelines mainly provide advice on how to clarify content and concepts; these address the epistemological aspects of science. Practical activities prescribed to a large extent serve to consolidate concepts, in certain cases drawing on learners' everyday environments, for example, the use of household objects to test for conductivity in Grade 10 (DoE, 2011:18). Prescribed experiments for formal assessment are spread throughout the document. In Grade 10 and 11 they tend to be in the structured format as described by Ramnarain (2010:187–200).

The following trends identified in the curriculum prescriptions for Grade 10 to 12 (DoE, 2011:15–142) tend to focus on content recall and procedural fluency, largely within the subject specific domain.

- Content recall and consolidation, for example, where learners are expected to list, define, describe or identify given science content.
- Calculations of the algorithmic kind using given equations.
- An orientation into scientific rules, notations and representations, for example, ways of representing atomic structure using Hund's rule or sp notations (DoE, 2011:22).
- Closed experiments with predictable results which consolidate existing science knowledge such as constructing the cooling curve of water. Hence, an opportunity to engage in all those science process skills, for example, the manipulation of apparatus, observation, data collection, drawing up of tables and graphs is provided (DoE, 2011:19).

There are rare occasions in the document where learners are expected to make predictions, make deductions or offer explanations of scientific concepts. For instance, in Grade 10, learners are expected to predict the chemical properties of unfamiliar elements (DoE, 2011:24) and in Grade 12, they are expected to predict whether reduction or oxidation will take place in a half cell when linked to another half cell (DoE, 2011:137). In Grade 11, learners are expected to deduce the shape of a molecule (DoE, 2011:69) and in Grade 12 deduce the overall cell reaction when combining two half cells (DoE, 2011:137).

Some emphasis on the socio-scientific realm is also revealed when learners in Grade 10 are expected to explain the impact of dams on the lives of people and the ecology. This could very well involve the use of those cognitive skills normally associated with critical thinking, whereby they draw on their science knowledge and understanding of scientific convention. The teacher's ability to reflect on the context and make justifiable choices will involve reflexive praxis. However, the dilemma for a teacher education programme is to assist the student teacher to adapt conventional aspects of science knowledge and procedure as presented in the document to a level where learners are challenged to think critically. This is where those key pedagogical aspects as presented in the literature may be of assistance.

While the dispositional aspect is not mentioned specifically, science links are made with indigenous practices as well as learners' everyday lives which could imply that these are regarded as valuable. In addition, there are some instances where learners are expected to research historical and cultural links with science (DoE, 2011:23–24, 31, 95–98,108).

7.7.4 Key pedagogical aspects

My analytical lens involves looking at the potential in the two documents for teachers to use constructivist methodologies which incorporate key pedagogical aspects as depicted in my elaborated conceptual framework in such a way that they boost critical thinking in both the subject-specific and science and society domains respectively. For consideration of these key pedagogical aspects I look at what teaching and learning approaches the documents recommend or suggest and what implications these may have for the enhancement of critical thinking.

As the NCS is outcomes based, there is hardly any emphasis on the role of the teacher. The focus is largely on how the learner is expected to demonstrate knowledge and understanding. Hence, even though the NCS does not prescribe, recommend or suggest any pedagogical approaches to the teacher specifically, some of these approaches can be inferred.

The role of the teacher is implied based on the way in which the assessment standards are presented. For example – when examining the competence descriptors for learners exiting Grade 10, 11 or 12 (DoE, 2003:64–75), the following can be discerned. In Grade 10 and 11, the teacher is expected to manage science classes in a way that enables learners to evaluate critically scientific procedures and scientific constructs to solve problems using

criteria given by the teacher, while in Grade 12 learners are expected to formulate and develop their own scientific investigations based on their own criteria. In such settings, where the focus is learner centred, the teacher could draw on some or all of those key pedagogical aspects mentioned in the elaborated conceptual framework. It is left to the teacher's discretion to make choices that will encourage an enabling environment where learners are challenged conceptually to engage in scientific reasoning within authentic or simulated contexts.

I examine the CAPS curriculum prescription by looking at the three categories depicted in the document. These are the prescribed and recommended practical work, suggested activities for learners, and guidelines for teachers.

In the CAPS document on the whole, there is a heavy content focus, where many of the experiments, particularly in Grade 8, serve to consolidate and verify existing science knowledge. There has been an attempt at progression from Grade 10 to 12. For example, in Physics, when dealing with motion, it is recommended to do motion along one, two and three planes for each subsequent advance to the next grade. The rationale is building on what has been covered at the lower grade but making it progressively more challenging. While in chemistry, understanding industrial applications clearly draws on conceptual understanding of work learnt in the lower levels. Stott (2008:22) points out the dilemma of balancing procedural fluency with conceptual understanding and application. She notes that procedural fluency frees up working memory to tackle more cognitively demanding tasks. That is, content does matter. One wonders if this is what the curriculum planners had in mind when loading Grade 8 with approaches that favour content recall.

One of the general aims of the South African curriculum emphasises knowledge in local contexts, while acknowledging that sensitivities to global aspects are also important (DoE, 2011:4). The focus thus is on the acquisition of knowledge, skills and values that provide meaning to the learners' own lives. Hence this can be seen as an endorsement of the use of simulated or authentic contexts, as presented in the elaborated conceptual framework, centred on local issues. However, even though learning experiences may be framed in such contexts, for critical thinking, other aspects as indicated in the elaborated conceptual framework should also be present.

Strategies to enhance conceptual understanding such as the use of simulations, building of models and making analogies are also recommended in specific instances in the CAPS

document. Some degree of concretising abstract concepts by using everyday materials such as marbles or play dough for demonstrating behaviour or building models of atoms or molecules is advocated (DoE, 2011:19). In Grade 10 these include simulating the scattering of α -particles using marbles and BB gun pellets (DoE, 2011:21); the use of jelly tots and tooth picks to visually represent atoms and molecules (DoE, 2011:32); or using the analogy of a lawnmower to cut short and long grass to describe the refraction of light (DoE, 2011:27). In most instances where models or analogies are recommended as a representation of abstract concepts, there is no attempt to point out the limitations of the models suggested, except in one instance in Grade 11, term 1 where the teacher is advised to discuss the benefits and shortcomings of using models in science. (DoE, 2011:67). There is some attempt at contextualising the learning experiences in authentic contexts, for example, analysing chemical and physical properties of everyday products in Grade 11 (DoE, 2011:72), or analysing labels of various machine oils or comparing the evaporation of methylated spirits and nail polish remover in Grade 11 (DoE, 2011:89), or the use of limestone in building pit latrines (DoE, 2011:92), while the production of polymers and their impact on the environment make the link with industrial reactions in Grade 12 (DoE, 2011:113).

In Grade 12, links to indigenous knowledge are made (DoE, 2011:108) when learners are expected to explore fermentation processes in the domestic production of beer or sour porridge. Some of the experiments suggested in Grade 12, such as rates of reactions and chemical equilibrium (DoE, 2011:123–125), and experiments to explore the corrosive nature of domestic acid, or the effect of the pH of hair products on hair (DoE, 2011:127), can operate at any of the four levels of science practical work suggested by Hattingh et al. (2007:75–90).

There are very few instances where cooperative learning activities are suggested specifically in which opportunities for dialogical engagement could occur. In Grade 10, a collaborative approach is suggested (DoE, 2011:20) when dealing with the description of the atom. Teachers are advised to encourage learners to do research on scientists who have made a contribution to perspectives on atomic structure, which is purported to give learners insights into the construction of scientific knowledge over time. However, it is noted in bold text that this is not meant for examination purposes.

I now consider pedagogical aspects such as challenging yet attainable conceptual tasks or reflective constructive reasoning as presented in the elaborated conceptual framework. A

detailed interrogation of the periodic table is required in Grade 10 (DoE, 2011:22–24), linking patterns in structure and properties to types of reactions. Here learners are expected to predict the chemical properties of unfamiliar elements based on their understanding of the periodic table. Although no suggestions are made to the teacher, there may be the potential for dialogic enquiry and reflective constructive reasoning. However, the tight timeframes suggested for all the prescribed content to be covered may restrict opportunities for such engagement and the teacher may need to make professional choices on how to proceed.

Even though in the introduction, problem solving is presented as an approach, the practical tasks that are prescribed are standard, conventional procedural ones, for example, standard electrical circuit setups (DoE, 2011:54). Some practical tasks, although conventional, could possibly be adapted to encourage a more ‘minds-on’ focus. For example, when equipped with basic chemical knowledge about halides (DoE, 2011:48), the learners could be encouraged to do tests that would identify an unknown salt. This will depend on how it is introduced by the teacher. There is also potential for open-ended investigations when doing equations of motion in Grade 10 (DoE, 2011:56) and the nature of forces in Grade 11 (DoE, 2011:62).

Opportunities for discussion and critical reasoning exist when learners are expected to discuss the environmental impact of overhead electrical cables in Grade 11 (DoE, 2011:86) or discuss and compare historical and modern mining methods and their impact on the environment (DoE, 2011:97). Open-ended investigation is recommended in Grade 12, which may draw on learners’ application of those cognitive skills associated with critical thinking and encourage a reflective constructive reasoning (DoE, 2011:98).

However, no matter the personal philosophies of teachers and the pedagogical approaches they may favour, they are still bound by the assessment demands of the curriculum as these have implications for the progression of learners to the next level. I shall therefore consider the assessment requirements in both documents next.

7.8 Assessment

The NCS encourages a variety of assessments tasks such as tests, projects, assignments, presentations, and so on, that are criterion based and closely integrated with the learning outcomes and assessment standards formulated. It is also suggested as part of continuous assessment that the different pieces of evidence that learners produce be

included in a portfolio. How all this may be operationalised is left to the discretion of the teacher or cohort of teachers. Guidelines for the design of rubrics linked to outcomes are provided. No specific weighting for the various activities is included. Descriptions of exit-level competencies are provided to gauge learners' achievements in the subject.

In the CAPS document the weighting for the final examination in Grade 10 and 11 is specified as 75%. The remaining 25% is allocated to control tests, experiments and projects. Similarly, in Grade 12, the final external examination is weighted at 75%, while the remaining 25% is for experiments and control tests. There is no project in Grade 12. Despite the rhetoric on practical work, assignments and projects, the heavy weighting for the final examination could compel teachers to teach for the examination. The teacher is expected to exercise judgement on learners' progress at many levels, which to my mind is a crucial aspect of criticality of the teacher's professional role. The document alerts the teacher to where the emphasis in tests and examinations should be. The quotation below does indicate that the teacher is expected to elevate the questions in control tests and examinations so they assess a range of abilities, including critical thinking.

Questions in tests and examinations should assess performance at different cognitive levels with an emphasis on process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts (DoE, 2011:144).

Furthermore, it is specified that the questions in tests and examinations should address an array of cognitive levels based on Bloom's taxonomy (1956). That is, Level 1 emphasises recall, Level 2, comprehension, Level 3, analysis and application, and Level 4, evaluation and synthesis. Appendix 1 (DoE, 2011:152–153) provides a helpful list of verbs which can guide the teacher to formulate questions based on these cognitive levels. For Grade 10 to 12, the suggested weightings of questions for the two upper cognitive levels are 50% for Physics and 45% for Chemistry. Thus, for nearly half of the paper, learners are expected to apply those reasoning skills generally associated with critical thinking. Unfortunately, the verbs used in the actual content component of CAPS (DoE, 2011:15–142) are mostly associated with lower cognitive levels of recall, such as 'list', 'describe', 'define', and 'identify'. Thus, if teachers were to follow these prescriptions unreflectively, they are likely to engage learners mostly at these lower cognitive levels and may find it quite difficult, as well as unfair to their learners, to include more challenging questions in tests and examinations. A teacher education programme needs to alert students to this discrepancy.

7.9 Discussion

Both documents envisage a social democratic society in which citizens contribute meaningfully to the creation of a just and functional system that encompasses democracy and social justice, where the perspective veers towards the liberal/radical part of the continuum. However, despite the rhetorical intent, the way in which teachers' professional judgement manifests is very different. On the one hand, the NCS provides broad parameters where there is the potential and the expectation for teachers to engage in reflexive praxis encompassing all those features of critical thinking as presented in the elaborated conceptual framework. Whether this happens in practice is another matter, and often depends on the biographies of the respective teachers. On the other hand, the CAPS document prescribes the content and practical tasks to be covered in great detail. This leaves little flexibility for teachers to exercise their own discernment in terms of the professional choices they make, although there is an expansion of opportunities for dialogical interaction and critical reasoning from Grade 10 to Grade 12 as pointed out earlier. For instance, in Grade 12, open investigations are recommended. However, this year culminates in a high- status matriculation examination, and if learners are not familiar with constructivist methodologies early on, they may be very difficult to implement at a later stage.

At the classroom level, even if the curriculum is flexible enough to allow teachers to exercise their own judgement when using approaches that engage and challenge their learners, they still need initiation into and guidance on the kinds of techniques that would support such approaches. Osborne, Duschl and Fairbrother (2002:37–57) in their intentionally constructivist science curriculum for public understanding, found that during whole-class discussion, teachers still tried to maintain rigid control over learners' actions, thus providing a strong authoritative framing for the subject. Where teachers in the study attempted other approaches that were meant to engage learners critically, such as small group discussions, analysis of science media reports, or sourcing information from the Internet, they still needed facilitation and scaffolding strategies. For instance, simply getting learners to talk in small groups is not enough. Quite a bit of lesson preparation is needed to alert learners to salient features through the use of appropriate guidelines and prompts.

At the institutional level, systems present powerful leverage for people to conform to entrenched practices at establishments like schools and universities. These practices are

supported by a multitude of structural and monitoring processes as well as policy dictates and assessment demands. For instance, the way in which the desks are arranged in a classroom, or the way in which the timetable is organised, affects what happens throughout the school day. Coupled with that may be the compulsion for teachers' teaching the same grade to pace themselves so that they are at more or less at the same point in the programme. In addition, the pressure to adhere to prescriptive curriculum guidelines coupled with the regular testing regime of the school, which to a large extent is prescribed, leaves teachers with little room to be flexible unless officially sanctioned and supported, where

'... compliance and not autonomy is seen as the benchmark of professionalism'

(Ramatlapana & Makonye, 2012:S22).

Reflective teachers need to take all this into account when preparing for and managing their science teaching and learning programme in both the subject- specific domain and the science and society domain. How much more demanding would this be for beginner teachers straight out of university, equipped with insights into methodologies that have the potential to challenge cognitively the learners they teach? The good intentions to apply those methodologies may quickly evaporate unless they can be sustained through collaborative interaction with like-minded colleagues inside and outside the school. The nascent insights gained at university can take root, albeit in a different form in the cut and thrust of classroom practice if consciously reflected upon and applied, aided by the support of a community of practice. Perhaps one of the responsibilities of a teacher education programme would be to encourage participation in reflective communities of practice.

7.10 Conclusion

In this chapter I used the elaborated conceptual framework as a guide to compare the NCS and CAPS. I did this to discern how critical thinking manifests in each document, and consequently the expectations for the role of the teacher. My focus was especially on the way in which the teacher's professional judgement, as constitutive of critical thinking, is projected, whether explicitly or implied.

For both documents the pedagogical focus comprising the epistemological and methodological aspects aligned very well with the elaborated conceptual framework. However, the role of the teacher in addressing these foci differed, being largely outcomes

driven in the former and content driven in the current document. For the NCS, the professional judgement of the teacher is encouraged within the broad parameters set by the document contextualised within a liberal/radical perspective. In effect, however, the individual perspective of the teacher probably held more sway than the perspective of the document itself. In respect of the CAPS document, despite the liberal/radical perspective manifest in its rationale for the subject, the dominant perspective remains conservative and prescriptive. The potential for reflexive praxis is heightened in the application of the NCS document, where teachers largely are expected to make autonomous decisions based on their own professional judgement, whereas they are expected to adhere to the CAPS document in the ways prescribed. When implementing CAPS, there may be opportunities for constructivist engagement to enhance critical thinking, more so in Grade 11 and 12 than in Grade 10, particularly if learner-controlled open-ended scientific investigations are encouraged. However, this takes quite a lot of time in the school programme, so it is not feasible for all practical work. Student teachers could be sensitised to the need to make strategic choices on when and how to engage learners in this way. The fact that 75% of the weighting for assessment is allocated to the final examination in all grades implies that the teacher may be examination orientated and simply see other forms of assessment as supplementary and not worthy of additional effort.

The lack of contextualisation in many instances, as also noted by Erduran and Msimanga (2014:S33–S46), means that this becomes the teacher's responsibility if socio-constructivist methodologies are to be employed. However, the CAPS curriculum is not wholly content driven and academically neutral as initially assumed when subjected to a cursory examination. There are instances of potential for more contextualised engagement. One of the tasks of a science teacher education programme could be to assist students in creating context. For example, the electrical section as it is presented emphasises knowledge and standard practical work and calculations. Perhaps this lack of contextualisation could be addressed by posing a question to be solved; possibly something like diagnosing why a circuit is not functioning properly or designing a circuit for a particular purpose. This approach could allow learners to interrogate their electrical understanding to solve the problem. In this way they develop a deeper understanding of circuits in their application. Such considerations of context could be dealt with effectively in dialogical settings in the science teacher education programme, where considerations of

key pedagogical aspects as outlined in the elaborated conceptual framework are made explicit.

While the school curriculum provides important guidelines for teachers' conduct in the classroom, it is hoped that a worthwhile teacher education programme would instil in students the confidence in their own professional judgement to make sound educational choices when navigating the content of the curriculum policy document, which very often might be subject to change.

Even though I have contextualised my conceptualisation of critical thinking in the dominant South African education discourses, I feel that I have not given sufficient prominence to the current discourses around the grip of colonialism and the notion of an African university. The current educational climate on science teacher education thus warrants further deliberation. While teachers have had to cope with frequent curriculum changes, higher education has also been confronted with a renewed clamour for change. It is to this call for a decolonised curriculum that I now turn. Hence, in the next chapter I discuss the notion of a decolonised African university and its implication for science teacher education.

CHAPTER 8

A DECOLONISED AFRICAN UNIVERSITY, CRITICAL THINKING AND SCIENCE TEACHER EDUCATION

8.1 Introduction

Historically, universities in South Africa emerged from their status as serving separate populations with distinct trajectories intended for their graduates. Even though, on the surface, much had changed,²² the transition to the new political democracy in 1994 did not fundamentally rock the essence of what universities stood for. Attempts to forge more explicit links with labour and civic society, concomitant with a social justice agenda, hardly made a difference to those to whom it mattered, the disadvantaged and the historically downtrodden. Policies of transformative intent in education depicted in documents like the National Qualifications Framework (DoE & DoL, 2002) failed to be actualised in practice, possibly as a result of their conflicting neo-liberal agenda (Allais, 2003). Recognition of prior learning in lieu of formal qualifications was a key issue ignored when people who had experience and knowledge in their field, but not the ‘piece of paper’, were side-lined in their search for gainful employment. Many black university students in South Africa are first-generation students who may have gained entry at great financial cost to their families. On the one hand, success at university addresses their aspirations for a better life, economically and socially. On the other hand, the call for a decolonised curriculum, in a way, is symptomatic of the failure of transformation in higher education. For these students, additional challenges abound, not least the disjuncture between their own lives and that of the university. The claim is that to a large extent, the kinds of knowledge and skills they are initiated into have colonial roots. While such knowledge and skills could be regarded as highly valued and potentially allow them to function at a level that promises elevated financial security if they succeed, their acquisition also potentially alienates them from their African heritage culturally, socially and economically. Additional challenges impact negatively on the academic performance of poor students, such as difficulties in acquiring suitable accommodation or being unable to afford transport and food, hence the #FeesMustFall movement (Naicker, 2016). Ironically, the group of protesting students have successfully articulated their demands in the ‘colonial’ language and very often, the

²² Such changes may relate to the nature of the student population, to the language policy, to cultural and social backgrounds of those who serve in executive positions in the management of higher education, and to the policy that governs university administration, among other aspects.

parents who have sent them there to study, are confused about this need to protest. Education students form part of that core of students, yet they have a deeper dilemma. They are being prepared to become teachers who need to make professional choices about what and how they teach. Hence, a critical examination of how they engage with educational aspects, including science education at the university, is essential.

While I attempted to interrogate notions of critical thinking and teacher education as concepts relevant to my study in Chapter 3, these conceptualisations simply served as a basis for further development in subsequent chapters. I developed these conceptualisations by attempting to seek constitutive meanings and conceptual gaps related to notions of critical thinking in the terrain of South African education discourse, policy and pedagogy. However, I cannot make appropriate links with science teacher programme development without deliberating more fully on the recent discourses emerging on our educational landscape: the vigorous calls for the decolonisation of the South African university (Heleta, 2016; Naicker, 2016), and by implication, the decolonisation of the science teacher education curriculum. I introduced the discussion on the call for a decolonised African curriculum in Chapter 4 as one of the emerging discourses in recent times in South Africa. Strong sentiments that have emerged at grass-roots level in academia are symptomatic of the will to forge an independent, meaningful pathway. Such occurrences compel us to re-examine our practices, thus notions of decoloniality and the link with science teacher education curricula need to be addressed in greater detail. While conventional science education in South African schools does come from a Western tradition, it would be opportune at this juncture in our history to revisit science education and consider how this could be regarded in the light of the notion of a decolonised African university. We have the responsibility as teacher educators to assist student teachers to navigate their education milieu in a way that allows them to make informed, reflective choices about what and how they teach. Hence, facilitating a critical engagement with science education at the university is essential. This quest is embedded in Research Question 4: How does the conceptual elaboration of critical thinking in science teacher education relate to the notion of a decolonised African university?

In this chapter I therefore provide a brief background to decoloniality and the African university. I then consider the calls for decolonisation of the curriculum and deliberate the implications of such calls for navigating the notion of critical thinking in science teacher education programmes. I highlight notions of rationality, as constitutive to critical thinking, and argue that scientific rationality in the Western modern sense, is not the only type of

rationality. That is, multiple ways of knowing and engaging with nature can have rationality at its core. Finally, I consider what a decolonised science teacher education programme could look like.

8.2 On decoloniality

'Coloniality' is often presented as the continued negative impact of colonisation in post-colonial times. By implication, coloniality contributes to sustaining the inequalities and social injustices pervasive during colonial times. Perhaps then, the 'decolonial' intent in higher education could focus on reducing or eliminating all or some of those aspects of colonialism deemed to entrench and sustain the colonial university model. How this ought to be done is open to debate. Andreotti, Stein, Ahenakew and Hunt (2015:21–40) suggest that the way in which the shiny side of modernity is presented, that is, industrial and technological advances with such concepts as democracy, scientific reasoning and nation states, masks its dark side. Paradoxically they claim that the very existence of modernity's shiny side is dependent on systemic violence on others which can be formulated as coloniality, where *othered ways of knowing and being* (Andreotti et al., 2015:24) are invalidated. As Andreotti et al. (2015:21–40) contend, an awareness of this is possibly worthwhile as a point of departure when deliberating on meanings and practices of decolonisation in higher education. The authors identified four discursive spaces that have implications for higher education's pedagogical responses to the notion of decolonisation. These responses range from an uncritical affirmation of modernity's shine, to perspectives that emphasise soft reform, to radical reform orientations. The former orientation accepts the mainly Westernised view of modernity but is willing to make adaptations and accommodations for other perspectives. The latter orientation actively supports shifting the centre of dominance to empower those groups that are side-lined. The authors argue, however, that both orientations described do not transform the underlying nature of higher education, where one of the main purposes of the university is providing credentials that allow individuals to participate in, benefit from and contribute to those structures that sustain the status quo in society in an essentially market-driven economy. The authors present a fourth discursive space that they term 'beyond reform', which potentially attempts to seek alternatives to the violence of modernity. They claim that such responses can result in attempting to avoid the existing system altogether through creating spaces outside the university on the one hand or using resources within the university to destabilise or hack the harmful effects of modernity on the other hand. 'Beyond reform' is

an attempt to operate outside modernity's framework.²³ However, the authors acknowledge the difficulty in doing this, bearing in mind that we are all framed by modernity, whether from the perspective of its shine or its shadow. Perhaps, when developing curricula, it might be valuable to get a sense of where on the continuum of the four discursive spaces outlined, the dominant pedagogical features of an emerging curriculum could be placed. This would give curriculum developers a sense of their own orientation *vis-à-vis* decoloniality. I now turn to notions of a decolonised African university and make the link with science teacher education.

8.3 A decolonised African university

Van Wyk and Higgs (2007:61–71) deliberate the notion of an African university. They contend that the idea of an African university can be differentiated from a university that is geographically located in Africa. The authors identify several scholars who highlight various ways of what an African university could look like. Some of the roles could include the pursuit and development of knowledge in its various forms through research and development, service to society, and the education of the professional strata, as well as being centres of political and social consciousness and activism, which to my mind is not unlike the role of universities in the West. What then would make it African? Van Wyk and Higgs (2007:61–71) claim that the call for an African university is linked to the idea of an African Renaissance, which highlights an indigenous socio-cultural and epistemological framework (2007:63) in which critical educators with transformative intent should embrace an indigenous worldview. The authors do not elaborate on what they mean by this, so it is open to interpretation. If, as Waghid (2016:12) indicates, the term ‘indigenous’ can be regarded in a relational sense whereby all cultures react in a relational way to others and to their contexts, then such emerging patterns of engagement and practices for a particular culture can be viewed as indigenous. However, cultures are not monolithic, hence generalisations about what constitutes African culture can become problematic.

The term ‘indigenous’ can have different connotations. When we speak about indigenous flora or fauna, there is a definite sense of a geographical or location-bound origin. For instance, the *rooibos*,²⁴ an internationally marketed herbal tea, grows naturally in the

²³ Andreotti et al. (2015:28) refer to ‘hospice’ as another ‘beyond reform’ approach which acknowledges the disintegration of the present system and attempts to facilitate its demise in anticipation of something new.

²⁴ ‘Rooibos’ tea, translated as red bush tea. Its scientific name is *Aspalathus linearis*. (Joubert & de Beer, 2011)

Cederberg region of the Western Cape, South Africa. It could be regarded as indigenous to that area. However, when we speak of indigenous African culture, practices or worldviews, then the meaning becomes much less clear cut. Perhaps then Waghid's (2016:12) allusion to the notion of indigenous as relational to context could be a perspective worth exploring.

In general terms, however, Van Wyk and Higgs (2007:61–71) do mention that one way of highlighting an African perspective is to adopt an 'Afrocentric' worldview as a counter to the 'Eurocentric' worldview. Even then, the authors acknowledge that there is no coherent perspective of what such a worldview may be. They summarise different outlooks on how to view the notion of being 'African'. These perspectives could include geographical, cultural, religious, ethnic and social aspects, among others, to a greater or lesser degree. For instance, if I were to use an example. The notion of *ubuntu*²⁵ has been identified in the literature as an African trait (Nsamenang, 1999; Pityana, 1999; Waghid, 2014b). Would such a notion be considered a hallmark to drive our educational endeavours in higher education? Perhaps. It may be open to discussion and debate. Van Wyk and Higgs (2007:68) highlight aspects of an 'African identity' as presented by Makgoba and Seepe (2004:13–14) which could serve as a driving force to develop a coherent set of ideas in higher education and that takes the African contexts in all its forms into account, but not necessarily discounting other influences. There is thus no definitive answer to what an African university should look like.

8.4 An African worldview

Ndlovu-Gatsheni (2017:54) deplores that even the oldest, precolonial universities in Africa, with their blend of African, Nilotc and Arab traditions, to a large extent have succumbed to westernisation. Ndlovu-Gatshini (2017:58) identifies the University of al-Qarawiyyin, Morocco, founded in AD 859, the University of Al-Azhar, Egypt, founded in AD 972, and the Sankoré University in Mali, founded sometime in the twelfth century. He cites the breakup of the Sudanic empires, the slave trade, and the scramble for Africa by Western powers as possible reasons for this discontinuity of precolonial customs and practices. According to Ndlovu-Gatsheni (2017:56–57), educated Africans in the nineteenth century had already experienced an alienation from their cultural and social roots and were assimilated into colonial norms and practices, such as language and religion, through the

²⁵ *Ubuntu* has been described as a worldview that embraces and affirms people's co-dependence and interconnectedness as part of a common humanity.

mission boarding school system. In a way, maybe this experience, for those who had the opportunity, eased their transition into higher education. Furthermore, the author notes that in post-independence, the anti-colonial African nationalist movements have not succeeded in shifting or eliminating Western colonial models. I would imagine that neoliberalism and market forces probably did a lot more in shifting the way in which universities operate presently. In addition, other than the pre-colonial universities, practically all the universities established in colonial Africa were mediated through imperial power, and according to Ndlovu-Gatsheni, became the sites of coloniality of knowledge, cultural imperialism and purveyors of Eurocentric knowledge (2017:58). These African universities were closely modelled on their European counterparts. So too, the first university in South Africa founded as the South African College in 1829 had close links to the colonial power, Britain. It received formal university status as the University of Cape Town in 1918.

Ironically the public call for decolonisation of the curriculum emerged at the University of Cape Town in 2015 as an aftermath of the #FeesMustFall movement (Naicker, 2016). It was prompted by the action of a student who threw faeces at the statue of Cecil John Rhodes (Naicker, 2016:54) that had pride of place on the Jameson steps at UCT, culminating in the ‘Rhodes must fall movement’. The statue was eventually removed by the university authorities. This movement assumed broader proportions and spread to many universities in the country. Sentiments regarding decolonised universities are not new. However, demands in South Africa have emerged recently, possibly because of the new generation of African students who find themselves in higher education in greater numbers. They thus have a stronger voice to make demands for programmes and curricula relevant to themselves.

Thabede (2008:233–237) posits that an African worldview, which has survived despite suppression or distortion by colonialism, informs the way in which Africans relate to phenomena, and that the origins of such a worldview can be found in traditional African culture prior to the influences of other cultures, such as European or Arabian. Thabede (2008:233–237) asserts that the hegemony of the Eurocentric worldview has side-lined indigenous worldviews. Thabede (2008:235) draws on Van der Walt (1997:89), who claims that ‘modern man’²⁶ separates values, thought and feeling systems in an approach to life which is objectively analytical, whereas African thought does not distinguish between rationality and irrationality. Instead, emotive and intuitive aspects, together with rationality,

²⁶ One can assume that Van der Walt’s (1997, 89) allusion to ‘modern man’ may be linked to those aspects of modernity as highlighted by Andreotti et al. (2015:21–40) as I’ve described previously.

can be drawn on in pursuit of truth. While the focus of this dissertation is not to interrogate such claims, I should like to deliberate on this aspect of rationality raised by the Van der Walt (1997:89) in relation to critical thinking and science education.

8.5 Critical thinking and rationality

Rationality has been highlighted as an important feature of critical thinking by many scholars (Siegel, 1989; Burbules & Berk, 1999; Paul, 2012; Frímannsson, 2015) and it is this conception that I should like to deliberate when considering a decolonised science curriculum. In its general sense, the rational aspect of critical thinking implies that one is *appropriately moved by reasons*,²⁷ in line with Harvey Siegel's position (1989:10), where rationality implies a conscious deliberation that results in logically justifiable choices and actions. However, rational thought is not absolute but is framed by contextual or relational assumptions. Hence someone operating from a different set of assumptions might not see particular ideas or actions as being rational. So too, teachers' conduct may be viewed differently. For instance, teachers may respond to a particular situation in the classroom in different ways. One teacher may send a disruptive learner to the principal to be reprimanded, while another teacher may realise that the learner is bored and give him or her more challenging classwork to do. Both actions are motivated by reason, that is, the intent may be to have a more compliant learner in the classroom. Both actions may have solved the problem and be regarded as rational responses to the situation, but they are operating from totally different premises. The first teacher may be operating within a behaviourist framework, while the second teacher's response may be motivated by deeper considerations of the learner's disruptive behaviour as a barrier to effective learning.

8.6 Rationality: Western modern science and indigenous science

Siegel (1989:9–41) considers two philosophical problems of rationality in relation to the nature of science firstly, and to the aim of science education, secondly. The author (1989:15) argues that the scientific method's claim to rationality is its commitment to evidence. In a conventional sense, the scientific method can normally be regarded as a set of procedures associated with the scientific endeavour. He sees this as erroneous, as many of these procedures are not necessarily unique to science, such as evaluating a

²⁷ Notwithstanding the intricacies of the debate on the kinds of rationality that inform social action as prompted by Weber (1978:24–26), where he introduced distinguishing features of rationality, namely, instrumental, value-laden, affectual and traditional, as this is not the focus of my deliberation.

hypothesis through running tests, for example, and can also be used in other disciplines or scenarios. Similarly, he acknowledges that this commitment to evidence is also discernible in areas other than science. The notion of rationality is therefore not embedded in procedure, which could be wide-ranging, but rather in its obligation to provide evidential substantiation (or reasons) for scientific claims and theories proffered, which may be a consequence of, or a prelude to, a methodological procedure. The scientific enterprise guided by appropriate reason thus could be viewed as being rational. Siegel (1989:15) emphasises that it is this commitment to evidence that makes science rational. This implies rational intent in the scientific enterprise, even though the nature of the evidence tendered may or may not be rational. Siegel (1989:9–41) equates rationality with critical thinking, where he asserts that the pursuance of rationality, or critical thinking, should be a core aim of education. While Siegel(1989:9–41) emphasises this commitment to evidence in all aspects of education, he suggests that it is not sufficient, and that the disposition to be a critical thinker is as important, where the person is motivated to base judgement and action upon reason, thus linking the cognitive with the affective.

Siegel's ideas (1989:9–41) can be placed firmly within the cognitive, rationalist, Western, education tradition. Peters (2007:350–363) problematizes this approach by claiming that the critical thinking movement tends to treat thinking ahistorically and argues for the recognition of different kinds of reasoning. While there may be an accepted style of reasoning dominant in scientific Western circles, this in itself, he suggests, following Hacking²⁸ (2002), may be an outcome of a ‘thought style’ (Peters, 2007, 356) developed through ongoing interactions, norms and practices that have become acceptable over time by groups of people²⁹ interrogating the natural world. The implication is that there may be many other styles of reasoning that have developed historically and contextually in a plurality of different ways, yet still have as their purpose the search for making sense of the natural or social world, and possibly can be regarded as the pursuance of truth. Peters argues that such accounts of thinking shift the emphasis from the ‘pure realms of cognitive science and logic towards views that are *historical, temporal, spatial, cultural, and therefore also empirical* (Peters, 2007:360). If one accepts then, that an African indigenous worldview could have emerged in the way presented by Peters, then it could be regarded as another style of reasoning or rationality that has emerged historically over time. We

²⁸ According to Peters (2007:356), Hacking attributed these ideas to Ludwick Fleck, a polish scholar, whom Thomas Kuhn (1962) also drew on to develop his notion of ‘paradigms’.

²⁹ Scientists.

cannot discount the interplay between differing worldviews, and this is perhaps where the focus on indigenous knowledge systems for science education may be heading. The possibility, as Peters (2007:360) suggests, of the potential for new kinds of thinking and styles of reasoning to emerge over time, may very well arise.

Du Toit (2005:55–73) asserts that rationality is a universal human ability, related to beliefs held or actions chosen based on appropriate reason, and that it is erroneous to present indigenous knowledge processes as simply conforming to convention. For example, Du Toit refers to the hunter-gather's interaction with nature as a sentient ecological rationality, whereby they *feel their way* (Du Toit, 2005:57) in the natural world, learning from it and acting on it in all its evolving forms. The author suggests that conventionally accepted scientific rationality, language and methods have more strict boundaries, and are somewhat artificial in the sense that they do not necessarily conform to everyday life. Perhaps this could be a reason why it may be difficult for some learners to engage successfully with school science. The question is, would this sentient ecological rationality still have value in the modern age? I argue that it would, and that it need not necessarily only be applicable to African contexts. People are not only cognitive. They have emotions, values, ways of living and contexts that inform their ideas and conduct. If a sentient rationality as described by Du Toit (2005:57–58), together with cultural and social influences, mediates how they make sense of the world and their surroundings, this needs not exclude how they rationally make sense of natural phenomena. I contend that the premise on which reasons are based and the criteria by which they are evaluated may appear logical to the person offering those reasons; however, these may not be valid to someone operating from a different perspective. For instance, if a particular belief is defended coherently from a religious perspective, it may not necessarily be considered valid by someone who has an atheist worldview and who may draw on different criteria. Yet, there may be certain moral and ethical aspects which are shared.

Aikenhead and Ogawa (2007:543–544) are in agreement with Du Toit (2005: 57–58), that people in all cultures can engage with nature in a *rational empirically based way of knowing* (2007:544), thus resulting in explanations and descriptions of their natural world.

Biesta and Stams (2001:57–74) considered an approach to criticality which resorts to criteria as a basis of justification for reason and offer ways of conceptions of criticality which they term ‘critical dogmatism’ and ‘transcendental critique’ respectively. The former approach, that is, critical dogmatism, highlights the difficulty of establishing criteria of evaluation on which to base the reasons proffered, which themselves need to be justified,

potentially ad infinitum. The chain or chains of the argument may be quite logical and coherent, but the difficulty is in justifying the basic premise on which all this rests. I imagine that such a premise could possibly be nominally or conventionally based, hypothetically speculative or faith based among others. The latter conception of criticality proffered by the authors, that is, transcendental critique, though still based on criteria, can be considered to be non-dogmatic. It is presented as an internal critique which acknowledges *implicit conditions of possibility* (Biesta & Stams, 2001:65) and therefore is less biased. So, this notion of critical thinking being objective, and possibly unbiased, can be challenged. Biesta and Stams (2001:57–74) suggest a third notion of criticality, which they term ‘deconstruction’, and this is presented as a concern for justice in the Derridean sense (Derrida, 1982). Biesta and Stams (2001, 68) point out that such a notion is an affirmation of the ‘other’ or of that which is excluded, which serves as the condition of possibility for that which is included, thus being open to the unforeseen or to that which is not yet there. I argue that such a notion of criticality is fluid, and while it may be linked to the very system that allowed it to come into being, it provides possibilities for something not yet attained, something in becoming as alluded to by Biesta and Stams (2001, 57–74). It is in this vein that I deliberate on notions of indigenous knowledge systems, decoloniality, and science education next.

8.7 Indigenous knowledge systems, decoloniality, and science education

If the idea of an African Renaissance drives the orientation of science education, with presuppositions of developing Africa in a way that has positive effects on the continent and its people, then an African worldview regarded in this light can only be supported. Even though there may be many perspectives through which to view this notion of an African decolonised university, such as ideological, sociological or philosophical, among others, I choose to take an epistemological stance when framing my discussion. My choice, ultimately, is an attempt to reflect on how a university education programme can provide the space and opportunity for science teacher education students to navigate the epistemic practices of science which, according to Erduran and Garcia-Mila (2015:388–401), refer to those cognitive and discursive activities of science that engage learners in the knowledge construction and evaluation processes of science. I now turn to a discussion of indigenous knowledge and science education.

The indigenous knowledge movement in science education has proposed a consensual model for teaching science in which worldviews are presented as potentially

complementary rather than competing (Chinn, 2007; Ogunniyi, 2007; Ogunniyi & Hewson, 2008; Aikenhead & Elliott, 2010). Ogunniyi (2007:1189–1207) suggests that people are able to quite comfortably straddle different ways of knowing and living, drawing on disparate worldviews separately or together, depending on the circumstances. As pointed out in Chapter 6, studies (Moodie, 1990; Ogunniyi, 2002; Meel, 2007; Loggenberg, 2012; Webb, 2013) have shown how children can comfortably accept the conventional scientific notions as well as the common-sense or indigenous notion of natural phenomena.

Similarly, Aikenhead and Elliott (2010:321–338) recommend cross-cultural science curricula as a way of decolonising school science. They refer to this *as walking in both worlds* and *two-eyed seeing*³⁰ (Aikenhead & Elliott, 2010:326) in which the strengths of both knowledge systems are highlighted. In this way learners are able to affirm and navigate both ways of knowing. The authors (2010:326) suggest that a culturally rich, diverse science education is important in order to avoid the monolithic kind of thinking in future scientists and engineers that continues to endanger the quality of life on this planet.

Le Grange (2004:204–219) asks whether ‘seemingly’ disparate views of the world with regard to science are competing or complementary. He suggests that the representational view of science is depicted by the universalist perspective on one side of a continuum and a multiculturalist perspective on the other side. The extreme universalist perspective accepts the traditions of Western science as a superior approach to understanding the natural world, while the multiculturalist perspective would argue that Western modern science presents a particular understanding of the world but that there are other ways that should be equally acknowledged and explored. However, Le Grange (2004:204–219) suggests that instead of exploring the representational view of science which interrogates what ‘Western science’ and ‘indigenous science’ are, we should explore the performative side of science. The implication is that a representational view could assume formulaic notions of what science is, whereas the performative view of science has the potential to explore ways in which different ways of conducting science can be infused, resulting in a complementary third space (Bhabha, 1994; Turnbull, 1997; Ogunniyi, 2002) of scientific endeavours. While the origin of knowledge, including scientific knowledge, may be located in time and space, it has the potential to move across time and space, and hence a static view of notions of science is not helpful when considering how science educators need to conduct themselves.

³⁰ A term they borrowed from the Elders of the Mi'kmaq nation (First Nation people in the province of Saskatchewan, Canada.) (Aikenhead and Elliot 2007, 326)

While science teachers, like all teachers, have to apply critical judgement in various situations on an ongoing basis, they also have the responsibility of initiating their learners into the processes and products of science. If one regards science as providing explanations for natural phenomena, then scientific inquiry cannot be monolithic as is often projected, with the conventional image of people in white coats conducting experiments. Although the way in which Western science has developed occupies centre stage in school science, I agree with Kawagley, Norris-Tull and Norris-Tull (1998) that knowledge about the natural world developed and embedded in particular contexts and cultures and often referred to as indigenous, can be regarded as legitimate science. The authors posit *that science has a plurality of origins and a plurality of practices* (Kawagley et al., 1998:134). In fact, current notions of the nature of science (Lederman et al. 2014:285–302) do not exclude this perspective, hence the general agreement that the scientific endeavour can be experiential, indecisive and socially and culturally embedded as noted in Chapter 6. Notions of Western science have evolved in a particular way. Aikenhead and Ogawa (2007:542–552) provide a historical account of the term we now call ‘science’, whose origins can be traced to the Renaissance, where the seventeenth-century natural philosophers like Galileo and Kepler, among others, contributed to a knowledge system based on empirical evidence that was contrary to the dictates of the church and royalty at the time.

A second wave of social transformation in the eighteenth century was the industrial revolution, where the ideas of the natural philosophers were used to control the natural environment as well as human productivity. The authors claim that the idea of natural philosophy needed to be ‘professionalised’, and so in 1831 the term ‘science’ was used in its stead at the inception of a new organisation, the British Association for the Advancement of Science (BAAS).

The term has Eurocentric connotations because of its historical trajectory, although the authors make the point that the Eurocentric sciences could very well include knowledge taken from other cultures but amended to adapt to Eurocentric worldviews. Thus, the development of Western science can be regarded as relational to historical and social contexts. In similar vein, scientific inquiry in non-Western settings, that is, an exploration of how the natural world functions and how the knowledge derived from this exploration, can be verified and applied, have possibly followed a different route, but is no less an effort to provide rational reasons for observations and experiences of the natural world. How do

people's contextual and biographical influences relate to their understanding of the physical world and how it works? If we accept the premise that an exploration of that understanding is what science is, then Western concepts of science have emerged in a particular way, socially and historically. Similarly, African concepts of science are socially and historically embedded. An imposition of one on the other is also part of historical influences. However, conventional school science, in the Eurocentric sense, has been entrenched in African school systems as a result of their colonial past. Even the nature of schooling lends itself to the promotion of conventional school science. The San in the Kalahari had a close relationship with their physical environment and an intimate understanding of how this environment related to their everyday lives, whether how to find water in arid conditions, the migration patterns of animals, or the use of medicinal herbs that could cure or alleviate the symptoms of various diseases (Thomas, 2006). If one were to align such practices with the notion of conventional research, then one could view such interrogations of the natural world as longitudinal studies informed by largely qualitative observation and communicated through an oral tradition. Du Toit's *sentient ecological rationality* (2005:57) would be applicable here. Children learned from their elders in a socio-constructivist sense (Vygotsky, 1978). Very few people still have these skills and knowledge, largely because of the way society has changed, violently or otherwise. A structured classroom environment with age-related groupings and fixed curricula in schools as well as separation from the activities of elders is not conducive to pursuing the same kind of social learning.

How then do we as science teacher educators help our students to shift the trajectory of science education to one which is more encompassing of people's lived experiences so that they are able to navigate multiple ways of understanding the world? That is, how do we navigate conceptions of conventional scientific rationality that highlight argumentation and justification with professed commitment to evidence, and rationality as indigenisation, which highlights a more interactive and coherent engagement with the natural world? Ironically, in many science classrooms in South Africa, this notion of scientific rationality through argumentation is hardly a feature of classroom practice, despite curriculum intent. The tendency is still to master the conventional science concepts and procedures as depicted in textbooks rather than to engage with scientific inquiry. On the other hand, ignoring learners' biographies and tacit exposure to other ways of knowing could very well be a missed opportunity for engaging critically with science. In the Western Cape, South African learners and their families often make annual excursions to the rural Eastern Cape, where their interaction with elders and their engagement with nature is a lot more intimate

than in the urban settings, thus presenting opportunities for science teachers to acknowledge and draw on such experiences when teaching science.

In the current South African physical science curriculum document for the senior phase (DoE, 2011:8), indigenous knowledge systems are presented as worthwhile knowledge passed on through generations, and with scientific and technological knowledge could be helpful to address society's challenges. While indigenous knowledge systems have been incorporated as a necessary feature in the current school curriculum with some episodic indicators of how this could be done, where instances of indigenous knowledge processes are suggested as a guide to the teacher,³¹ the dominating emphasis is one of standard school science.

8.8 What of language?

Very often the everyday meanings of language at home may not coincide with meanings at school. The situation is further complicated when the language at school is not the mother tongue. The language of science with its specialised and often abstract terms is already alienating for children in the West (Aikenhead & Elliott, 2010:323–325); how much more alienating for African children in rural areas, especially when they are expected to engage in a spoken and written language other than their mother tongue. In South African schools, from Grade 4, the majority of African children are taught through the medium of English, and not their mother tongue. Moje, Ciechanowski, Kramer, Ellis, Carrillo and Callazo (2004:38–70) claim that academic school texts could act as colonisers, assuming the role of gatekeepers to validating other forms of knowing. The authors discuss funds of knowledge, which refer to social networks or relationships that generate knowledge. These may be engendered in different contexts such as in the home or at school. The authors critique the notion of competing spaces being in binary opposition to each other and suggest an alternative way of viewing what might emerge as a 'third' or 'hybrid' space, similar to what I referred to earlier. While the third space could be a means of mediating indigenous knowledge with the purpose of improving learners' academic performance in academic science, Moje et al. (2004:38–70) indicate the possibilities of an integration of funds of knowledge, in potentially different ways, which could make this third space a

³¹ These include a discussion of legends and folklore about animal behaviour in Grade 10 (DoE, 2011:31), a historical perspective on mining practices in indigenous communities in Grade 11 (DoE, 2011:95–97) and indigenous fermentation processes in Grade 12 (DoE, 2011:108).

meaningful one for learners. With such an emphasis, the articulation of academic and everyday discourse could result in something new.

8.9 Implications for science teacher education

One of the key features of criticality is to ask appropriate questions which could serve as a guide for exploration. Such deliberations around decoloniality and science education may ask questions like: Whose knowledge is it? Whose interests does it serve? How relevant is it to the lives of the learners? How should it be taught? These may have been the kinds of aspects that occupied the minds of the students in their call for a decolonised curriculum. There is no doubt that school science as we largely experience it has its origins in colonial models.

Pillay and Kathard (2015:196) ask '*What is it about science, our practice and education that allows us to be complicit in creating inequities and in reproducing its effects over generations?*' In their research on audiology and speech therapy, which is regarded as an allied health service, they make the point that the individualised service model may never reach the vast majority of those who need it. Here they are engaging concerns of who benefits from the application of science education in the health industry and questioning the way healthcare practitioners are educated. In their profession, they advise a shift to population-based intervention. The authors (2015:212–220) suggest three enablers of decoloniality, namely, a deconstruction of dominant knowledge and texts, a dialogical pedagogical focus, and an emphasis on contextual learning. Pillay and Kathard (2015:212–220) argue that context facilitated learning *demands a critical, social, historical and political reading of the situation* (2015:219). This approach may well have implications for making science education more inclusive.

Winberg and Winberg (2017:248–253), in the engineering context, identified four foci of consideration in the literature for the decolonisation of science, technology, engineering, and mathematics (STEM) curricula. The first is that the *indigenous ways of being, knowing and doing* (Winberg & Winberg, 2017:248) are filtered and accessed via the conventional disciplines, another is a focus on the correction of misunderstandings of the history of the STEM disciplines and an appreciation of their varied origins, a third is a focus on student education that emphasises treating people and the planet with respect, while a fourth looks at innovation that reduces dependency on colonial countries and shifts the emphasis from users of advanced technology to innovators of technology that addresses local needs.

These four themes thus encompass the nature and mediation of STEM knowledge production, that is, the historical trajectory, a moral and ethical development focus with a decidedly social justice agenda, concerns of dependence and interdependence, as well as questioning who the beneficiaries of scientific applications and processes may be. The literature on decolonisation and science education however, has largely looked at indigenous knowledge in science and ways of incorporating these into standard science curricula (Ogunniyi, 2004, 2007; Le Grange, 2007; Aikenhead & Elliott, 2010) as discussed earlier.

However, it is problematic to make assumptions about indigenous science knowledge in our attempts to restructure curricula, as there is a tendency to present science that has emerged in Africa as localised and rudimentary, whereas science from the West is sophisticated and modern. This leaves one with the question of how to view human constructed knowledge. Does human knowledge have cultural and geographical boundaries? Could the various influences on human knowledge be contained and restricted to specific origins in a world where everything, including knowledge movement and development, is intangible and complex? Events in our historical past have influenced our present. There is no definitive answer.

What would a decolonised science teacher education curriculum look like? One of the tasks of a teacher education programme is to assist students to cultivate pedagogies that will assist the learners they teach to develop understandings of the epistemological and methodological aspects of science. Perhaps context-facilitated learning as recommended by Pillay and Kathard (2015:219) earlier in the discussion, together with more worldwide orientations as highlighted by conventional science, may be the way forward. In this way our teacher education students would be able to navigate coinciding orientations.

While it may be an appropriate point of departure to link the idea of an African Renaissance to indigenous knowledge systems as culturally and place based, in a world of constant change we should be open to a plurality of possibilities to something yet to come. For science education, such a renewal should be able to incorporate different ways of engaging with the natural world. Conventional science in the Western world has traversed a particular pathway, culminating mainly in its significance for commercialism and the market intent, which to a large extent has influenced higher education institutions as Blunt (2005:1368–1378) so ably relates. Science has become big business, with its emphasis on patents, the development of commercial commodities, and the potential for lucrative

university grants that address those demands. Science education, no less, has served this intent, where graduates are meant to operate in organisations such as pharmaceutical or engineering companies, among others. Unfortunately, South Africa's record in science education has been dismal if it is viewed along the global competitive lines that underscore a market-driven orientation. On the other hand, indigenous science has been presented as cultural and context specific, holistic and in tune with nature in a way that is sustainable and non-exploitative (Snively & Corsiglia, 2001; Kawagley et al., 1998). We may well draw on such approaches to assist in breaking the downward spiral of the negative effects of scientific practices on our environment and society. Many examples abound where indigenous knowledge has made significant contributions to modern science. Considerations of these contributions raise additional issues such as intellectual property rights and who the beneficiaries of such science applications may be. Deliberation on these matters could very well be part of a science teacher education programme, possibly as an important component of a science and society module or integrated throughout the course content. Popp (2018) believes that both approaches, that is established western science and indigenous science, have their strengths and can in fact complement each other. When viewed in this light, it opens up the potential for Biesta and Stams' (2001:57–74) notion of 'deconstruction', which embraces a fluid criticality that invites possibilities of something yet to come in which we can celebrate our common humanity. Such an orientation, which potentially embraces both rationality as justifiable argument and rationality as indigenisation, implies that we as science educators need to critically re-examine our own understandings of science education and encourage our students do the same. We need to critically reflect and apply a repertoire of pedagogies in our own practice and engage students on the appropriateness of choices made. We need to encourage our students to 'try things out for themselves' and to deliberate on the implications of their own understandings and practice for the learners they teach. We need to seek out the 'quiet ones' and encourage them to articulate their ideas in meaningful ways. We need to familiarise ourselves with our students' biographical contexts so we can make appropriate links with their worldviews and notions of science as well as be sensitive to language aspects that may limit student engagement.

8.10 Modifying the elaborated conceptual framework

How does the conceptual elaboration of critical thinking in science teacher education relate to the notion of a decolonised African university as formulated in research Question 4? I contend that all the dimensions of the framework will still have relevance.

The four perspectives of notions of critical thinking outlined in the elaborated conceptual framework, that is, conservative, liberal, radical, and postmodern, could still inform teachers' conduct. An acknowledgement of different ways of engaging with the natural world could fall into one of the four categories, possibly in line with the continuum of the four discursive spaces of Andreotti et al. (2015:25–37). The conservative perspective would possibly marginalise or ignore other ways of knowing or engaging with the natural world. The liberal and radical perspectives respectively can range from a tentative to an explicit acknowledgement and incorporation of diverse engagements with the natural world. Furthermore, the emphasis on rational reasoning skills and reflexive practice would also be applicable to the enhancement of criticality in the science classroom, whether engaging with conventional school science or with other ways of knowing which may be unfamiliar to some. Scientific rationality in the conventional sense is not the only type of rationality in action (Du Toit, 2005:65–66), as previously discussed. In addition, the key pedagogical aspects as highlighted in the elaborated conceptual framework would be pertinent as well, supporting the creation of an enabling environment where teachers apply their professional judgement to find ways to encourage learners to engage critically with multiple worldviews. The pedagogical focus as depicted in the context of science education in the framework can also be regarded as multiple ways of knowing and multiple ways of engaging with the natural world (Aikenhead & Ogawa, 2007:539–620). So, I shall adapt the elaborated conceptual framework slightly to incorporate multiple worldviews as depicted below.

Table 8.1 An adaptation of the elaborated conceptual framework of notions of critical thinking within the context of multiple worldviews and the role of the teacher

8.11 Conclusion

In this chapter I deliberated on the notion of a decolonised African university and its implications for critical thinking and science education. My contention is that notions of critical thinking as presented in the elaborated conceptual framework could still be relevant. In my search for constitutive meanings related to a decolonised African science curriculum, there seems to be an acknowledgement of an independent pathway that

severs or diminishes those aspects of colonialism that enslave our minds and prevent us from pursuing an authentic path that would benefit Africa and those who dwell in it. Such a path may mean different things to different people, where some meanings could be conflicting in terms of who is African and what can be construed as an African university, while other meanings could be in agreement in terms of the vision for an African university that ethically and morally strives for the common good, whatever that may signify. For many, such a pathway would embrace an African indigenous worldview. Perhaps it is fitting to reflect on what this might mean for science education. Scientific rationality in the conventional sense is not the only type of rationality in action as previously discussed. A decolonised science teacher education curriculum should support the creation of an enabling environment. Such an environment would encourage student teachers to navigate ways that would motivate learners in diverse classroom settings to engage critically with multiple ways of knowing and engaging with the natural world.

CHAPTER 9

IMPLICATIONS OF NOTIONS OF CRITICAL THINKING FOR SCIENCE TEACHER EDUCATION

9.1 Introduction

My initial interest in critical thinking was prompted by my work as a teacher educator, when, with colleagues and curriculum advisers from the WCED, we embarked on a project to introduce science teachers and science teacher education students to methodologies that supported the enhancement of critical thinking. We chose argumentation in science as a way to do this as explained in Chapter 6. However, as this was only one approach of choice, it lacked a comprehensive base and a more serious deliberation on the construct was required. Initially, as mentioned in Chapter 1, my idea was to ascertain how science teacher educators at selected universities viewed critical thinking and to provide insights into how they enacted the enhancement of critical thinking in their own practice. However, I was not convinced that emergent insights from such a study would inform science teacher education programme development in a coherent way, as multiple views on critical thinking could emerge which might be localised and contextually bound. Upon reflection I realised that two types of policy could impact on teacher education nationally: South African teacher education policy and South African school curriculum documents. I then decided to explore how notions of critical thinking manifest in these two documents and what the implication these notions may have for science teacher education programmes specifically, guided by my four research questions as elaborated on previously. Furthermore, as these policies did not emerge in a vacuum, it was necessary to contextualise them in South African educational discourses. This placed my study in the interpretive hermeneutics paradigm, with a conceptual and deconstructive analysis of notions of critical thinking as a logical choice for my research method. The conceptual analysis entailed finding constitutive meanings (following Fay, 1975) of critical thinking in the literature as well as in South African educational discourses. The deconstructive analysis involved reflecting on and imagining conceptual gaps which needed further exploration. Both constitutive meanings and conceptual gaps informed the development of an elaborated conceptual framework on notions of critical thinking. Thus, one of the outcomes of my research was the development of a conceptual elaboration on critical thinking in the context of science teacher education which evolved as I worked my way

through the dominant educational discourses and policies operating in the South African context. In fact, the elaborated conceptual framework encapsulated key dimensions of notions of critical thinking emerging from an analysis of educational discourses in South Africa, general literature on critical thinking, as well as specific literature on critical thinking and science teacher education. Furthermore, appropriate versions of the conceptual framework were used as a basis to analyse teacher education policy and physical science curriculum documents. This chapter thus deliberates on and discusses the implications of the insights gained on notions of critical thinking for science teacher education programmes.

9.2 Addressing the research questions

I started by conceptualising common meanings in notions of critical thinking as they emerged from the literature and developed a tentative conceptual elaboration which comprised features of critical thinking, with the teacher's professional judgement at its core. With this as a basis I proceeded to address methodically the four research questions formulated. Each version of the conceptual framework informed the subsequent phases of analysis. I now turn to a discussion on notions of critical thinking guided by my four research questions. I first deal with each research question separately and then discuss implications of the insights gained from the study for science teacher education programmes generally.

9.2.1 Research Question 1: How do notions of critical thinking prevalent in the dominant educational discourses in South Africa impact on science teachers' conduct?

I drew on the categorisation of Cross et al. (2009:475–503) of the major educational discourses pre-and post-apartheid, namely, conservative, liberal, radical, and postmodern to extrapolate expectations of the professional conduct of teachers. In the apartheid era, Christian National Education, together with the educational philosophy of fundamental pedagogics, was imposed on most educational institutions. The teacher was treated as a functionary expected to deliver the syllabus without questioning its intent or consequences. Professional judgement was limited to the confines of the subject being taught, and the questioning of broader educational contexts was not encouraged. The liberal and radical responses to this attempted to counter the conservative influences. In the democratic era, post 1994, the transformative intent of the new Constitution (Republic of South Africa, 1996a), as well as significant education policy (DoE, 1995) as outlined by Enslin

(1999:175–186), presented notions of critical thinking related to democratic citizenship and social justice, tinged with liberal influences. At the dawn of the new South African democracy the teacher was regarded as a professional capable of exercising autonomous judgement. The neo-liberal economic agenda, however, curtailed liberal intent, and resulted in the reduction of teacher education programmes in the late nineties as well as a downsizing of the teacher core, thus side-lining issues of teaching and learning in an effort to survive as a profession. More recently, sporadic radical voices have called for authentic, decolonised African curricula (Heleta, 2016; Le Grange, 2016). These emanated from institutions of higher learning, and extrapolation into the school system or teacher unions for that matter, has not been evident. However, incidences of learner agency at high schools have emerged sporadically. There were instances where learners asserted their rights to have certain hairstyles and dress codes accepted in schools. In addition, there were instances where learners protested about the poor state of the school buildings. Language was also an issue, where learners claimed that they were not allowed to speak their home language, which was not English, on school premises (*Mail & Guardian*, 2016; Postman, 2018). This is the terrain in which prospective teacher education graduates may ultimately find themselves. So, in a dynamic educational milieu, notions of critical thinking span all four genres, namely, conservative, liberal, radical, and postmodern, with differing perspectives on how teachers are expected to exercise their professional judgement. An inclusion of these perspectives resulted in an expanded conceptual framework on notions of critical thinking. I was now in a position to use this expanded conceptual framework as an analytical tool to address Research Question 2.

9.2.2 Research Question 2: How do notions of critical thinking manifest in South African teacher education policy post 1994?

While studies on alignment of policy and teacher education curricula (Darling-Hammond, 2017; DeLuca & Bellara, 2013), and implementation of policy (Sayed, 2002; Robinson, 2003) have been done, I have not come across studies of how notions of critical thinking manifest in teacher education policy which is the focus of my study. This seems to be a new terrain.

There are two distinct phases of policy prescription for teacher education after the advent of a democratic South Africa as described in Chapter 5. In the first phase, the teacher is regarded as a professional capable of autonomous judgement. Here critical thinking is presented as a key critical cross-field outcome for all programmes, including teacher education. Very broad demands were made on the teacher as a contributor to building the

new, socially just, democratic state. The Norms and Standards for Educators (DoE, 2000) specified seven roles of the teacher which ranged from the teacher as a classroom practitioner, to the teacher as a community activist, scholar and life-long learner. The perspective of critical thinking in phase one verges on the liberal/radical side of the continuum. In the second phase, expectations of the teacher's role are diminished to the context of the classroom. Other loftier aspects such as social justice and transformation are no longer emphasised. The perspective of critical thinking is a conservative one, where the focus is on the preparation of competent, qualified classroom practitioners. In the 'revised MRTEQ' (DoE, 2015), five types of learning with eleven associated competencies serve as the guiding principles for programme design. However, Competency 11 requires teachers to reflect critically on their own practice (DoE, 2015:62). Thus, the allusion to autonomous professional judgement and reflexive praxis does feature, if somewhat hidden. It all depends on the way teacher education programmes navigate these more restricted guidelines.

9.2.3 Research Question 3: How do notions of critical thinking manifest in South African physical science school curriculum documents post 1994?

Even though the expanded conceptual framework was useful to analyse teacher education policy, it was not adequate to analyse notions of critical thinking in physical science curricula *vis-à-vis* expectations of the role of the teacher. In order to extend my conceptual framework, I turned to the literature on critical thinking and science teacher education in search of constitutive meanings. I identified common enablers or key pedagogical aspects for the enhancement of critical thinking. They were the setting of challenging yet attainable conceptual tasks within authentic or simulated contexts, the encouragement of dialogical enquiry, and reflective constructive reasoning. The teacher would provide an enabling environment in which some or all of the features of critical thinking would be supported. However, this still did not put it within the realm of science education. It needed a science education focus. I was guided by Lederman et al. (2014:285–302) who noted that the development of scientific literacy, an acknowledged goal of science education, emphasised the epistemological and methodological aspects of science. These two aspects, as a pedagogical focus in science teaching and learning, provided the science teacher education context and hence, together, became important additions, culminating in an elaborated conceptual framework. I was now able to use it as an analytical tool to analyse the physical science curriculum documents, namely the NCS (DoE, 2003) and the CAPS (DoE, 2011). Just as for teacher education policy, these two documents were

located in phase one and phase two respectively. While the pedagogical focus of both documents emphasised the products and processes of science, the outcomes-driven NCS presented broad parameters where teachers are expected to use their professional judgement to make their own pedagogical choices about what and how to teach. On the other hand, the content-driven, prescribed CAPS curriculum reduces the professional autonomy of the teacher, although advancement from Grade 10 to Grade 12 does progressively provide teachers with more flexible pedagogical options as described in Chapter 7.

9.2.4 Research Question 4: How does the conceptual elaboration of critical thinking in science teacher education relate to the notion of a decolonised African university?

While perspectives differ on what makes an African university, there is consensus as encapsulated in the African Renaissance movement that the colonial university models cannot be wholly applied without taking African contexts and concerns into account.

The conceptual elaboration of critical thinking in science teacher education as depicted in my dissertation aligns well with the notion of a decolonised African university. Particularly pertinent to critical thinking is the idea of rationality and reflexive practice which I have included as part of the dimensions in my conceptualisation. My research has highlighted orientations of rationality as justifiable argument and rationality as indigenisation respectively. In science education these orientations have traversed distinct but possibly complementary trajectories. On the one hand, conventional science has resulted in conceptions of modernity that have contributed to development and innovation of the modern world as we have come to experience it, albeit with a neo-liberal bent as discussed in the previous chapter. On the other hand, perceptions of indigenous science as culturally and contextually embedded support an engagement with the natural world that is non-exploitative and promotes environmental sustainability. A science teacher education programme would thus traverse these orientations to support methodologies that would sensitise our students to multiple ways of knowing.³² Cross et al. (2009:475–503) allude to the postmodern as part of an unfolding historical trajectory of South African educational discourses. In accordance with Lyotard's (1984) rejection of the grand narratives, particularly as they relate to postmodernity, the post-colonial era may very well yield unchartered post-modern possibilities.

³² Conventional Western science education has been the dominant approach in South African schools, with an acknowledgement of the contribution of indigenous knowledge systems as worthwhile knowledge in the latest physical science curriculum.

I now consider the implications of the conceptual elaboration on notions of critical thinking for science teacher education programmes.

9.3 Implications for science teacher education programmes

While my search for constitutive meanings from the literature informed the development of the conceptual elaboration, the conceptual gaps identified through reflection placed the notion of critical thinking in the realm of teacher education. The first conceptual gap identified was reflexive praxis, which was incorporated as part of the features of critical thinking. This aspect can be considered a generic aspect for all teacher education students. The second conceptual gap was the identification of the pedagogical focus, contextualised in science education specifically. This focus incorporated the epistemological and methodological aspects of science education, which could also be viewed as multiple ways of knowing and engaging with the natural world when considering the notion of a decolonised science curriculum.

Implicit in the content of the elaborated conceptual framework are the theoretical underpinnings of notions of critical thinking informed by the literature and depicted as constitutive meanings or conceptual gaps. Together they comprise the dimensions of the elaborated conceptual framework which could possibly serve as practical guidelines for the inclusion of notions of critical thinking in a science teacher education programme. These dimensions are perspectives on notions of critical thinking which influence the teacher's conduct; features of critical thinking which are key concepts related to critical thinking, particularly the notion of a reflexive praxis that highlights the teacher's professional judgement; pedagogical aspects which are likely to promote critical thinking in the classroom; and finally, the pedagogical focus which contextualises the development of critical thinking in science teacher education. I now deal with each of the dimensions in turn.

9.3.1 Perspectives of critical thinking

The science teacher operates from particular perspectives which could possibly influence how he or she attempts to enhance criticality in the classroom. These perspectives could potentially correlate with the parameters of operation in the classroom, from a purely science discipline perspective to ones which attempt to make the links with science and society. A teacher education programme could sensitise students to the different perspectives on notions of critical thinking identified and encourage them to reflect on how

these perspectives could influence their professional conduct. If we try to sensitise students to their own philosophy of learning in relation to the educational theory they encounter in the academy, it might assist them in reflecting on and being able to articulate and justify their own educational perspectives as well as understand the perspectives of others.

9.3.2 Features of critical thinking

Students spend a limited time at the academy, after which they operate as professionals in varying educational contexts. Their various biographies will impact on their conduct once they leave the academy. Teacher education programmes are faced with the classic dilemma of finding the balance between educational theory and educational practice. However, even when introduced to various teaching and learning approaches, backed by theory, the student teacher still needs to make professional choices in a particular educational context. One could address this dilemma by finding ways to endorse and facilitate the development of professional judgement and reflexive praxis. A teacher education programme could possibly scaffold ways for them to develop their professional judgement while at the academy. Despite the rhetoric on active learning and facilitative approaches, many of our students come through systems with strong authoritative framing for subjects taught. For the teacher to give up control is very difficult, especially if faced with prescriptive curriculum requirements. An opportunity for us as teacher educators to consciously role model authentically participative methodologies that challenge our students could potentially shift entrenched perceptions on the role of the teacher. This does not mean that we abdicate our responsibility as teacher educators and leave student teachers to work it out all by themselves. Providing facilitation and scaffolding techniques as suggested by Osborne et al. (2002:37–57) could assist student teachers to enrich their own pedagogy.

Browne and Freeman (2000:301–309) suggest that an aggregate of approaches can provide developmental stimuli to enhance critical thinking in a higher education classroom. They note that the core of critical thinking entails the application of rational criteria to reasoning, whatever form notions of critical thinking may take, including the perspectives I have outlined previously. They claim that one of the attributes of a critical thinking classroom may be that it is '*abuzz with questions*' (Browne & Freeman, 2000:302) posed by the educator or the students. The authors point out that while questions in themselves do not presuppose criticality, they could serve as a stepping stone towards the evaluation

of reasoning. Questions could relate to aspects of ambiguity, assumptions underlying reasoning, the quality of the reasons or evidence provided, alternative views or inferences drawn and so on, conducted in an emotional climate '*consistent with a search for stronger beliefs*' (Browne & Freeman, 2000:303). Encouraging student teachers to ask critical questions that prompt deliberative conversation about their own practice or those of others could assist them in developing their professional judgement.

9.3.3 Pedagogical focus

In science teacher education, both the content and processes of science are important. The exponential growth of scientific knowledge may well complicate where the emphasis should be. Çorlu and Çorlu (2012:514–521) suggest that action research cycles (Stenhouse, 1975) and learning cycles could assist student teachers to improve their ability to facilitate scientific inquiry in the classroom as well as strengthen their own conceptual understanding of scientific concepts. Subsequent cycles of teaching and learning could possibly encourage students to look at multiple ideas and solutions rather than being stuck in a single perspective. This might also ease the transition for them from theoretical content knowledge to practical pedagogical content knowledge. In this approach, the reflective component is at the core of decision making and contributes to enhancing professional judgement on aspects of pedagogy in the science classroom. Prioritising opportunities for reflection linked to practice as an important component of a science teacher programme may mean that other considerations have to be minimised.

9.3.4 Key pedagogical aspects

I now deliberate on the key pedagogical aspects as depicted in the elaborated conceptual framework.

9.3.4.1 Challenging yet attainable conceptual tasks

Kahneman (2012:24–26) presents two systems of thought which could be quite useful when considering how teaching experience could contribute to the level at which the teacher is operating. System One is intuitive and procedural, based on experience and possibly assumptions which may or may not be justified. System Two requires effort and this is where critical thinking could feature. According to Kahneman (2012:24–26), when System One runs into difficulty, it calls on System Two to support more detailed and specific processing that may solve the problem of the moment. The science teacher could draw on either system to make professional judgements. An effective teacher may have a

wide pedagogical repertoire that sits comfortably in System One. This high level of PCK may be as a result of considered reflection or as a consequence of encountering pedagogical episodes through the course of his or her teaching career, which may have required some effort to address at that stage. Once familiar, it becomes an intuitive resource that the teacher can draw on when faced with similar occurrences during the course of normal classroom practice. However, when presented with more challenging aspects that require effort to address, then System Two is activated. On the other hand, if the teacher is ill-prepared to address such challenges, then the pedagogical repertoire remains ineffective. Student teachers do not have the benefit of long experience, and thus much of what they do initially in the classroom is more likely to function on System Two. That is, they may be faced with conflicting ideas on how to proceed and this could be an opportunity for accelerated learning through exercising reflexive praxis. Dialogical spaces in which they are allowed to try things out and are encouraged to articulate their reflections and actions could be a means of supporting reflexive praxis.

9.3.4.2 Dialogical enquiry, reflective constructive reasoning and an enabling environment

Social constructivism has been presented as a convincing teaching and learning approach for enhancing critical thinking in the science classroom. It is argued that dialogical interactions encourage learners to articulate their reasoning, and thus provide opportunities for reflection on and refinement of their ideas. The teacher's job is to channel this process in a way that would stimulate learning. If this is the case, then teacher education programmes should at least equip science pre-service teachers with ways of facilitating such engagements. Perhaps then, one of the key aspects of a teacher education programme may be to encourage conscious dialogue on matters of pedagogy to promote learning, whether that dialogue is with self or with others. Wegerif (2015:428–429) denotes dialogue as being internal and invisible (when referring to individuals who are having an internal dialogue in their own minds) or external and visible (when referring to individuals who are communicating their ideas with one another). Dialogic thinking, according to Wegerif (2015:427–440), drawing on Resnick (1987), implies that more than one voice or perspective contributes to meaning and has the potential to elevate thinking to a higher level than merely being 'monologic' (embracing a single perspective). Thus, even thinking through ideas by oneself can be dialogical. By being involved consciously in a dialogue with self or with others has the potential to enhance metacognition, which is a

key aspect of reflective thinking. Reflective thinking can involve looking back and looking forward, metaphorically speaking. Looking back could involve thinking about the appropriateness of pedagogical choices made and enacted while looking forward could involve thinking about the consequences of choices being considered for future action. However, student teachers need to be introduced to ways in which they can encourage learners to reflect on their own thinking and those of others. Zohar and Barzilai (2015:229–242) identified instructional practices that engage learners in metacognitive thinking. These include the use of metacognitive prompts which could involve scaffolding questions, statements or steps of enquiry for learners to consider; explicit instruction, practice and training; metacognitive discussions; reflective writing; visual representations; metacognitive modelling of ways demonstrated by the teacher; and the use of ICT. The authors (2015:229–242) caution that metacognitive knowledge, that is, awareness of ways to enhance one's thinking, might not necessarily match metacognitive skills, that is, the enactment of the metacognitive knowledge. They acknowledge that simply using the transmissive mode to introduce teachers to instructional practices that enhance metacognition will not work. They suggest that constructivist methodologies, as outlined previously, are a better way of deepening teachers' understanding and pedagogy.

While reflexive praxis can be supported at an individual level, the provision of dialogical spaces within the academy could stimulate articulation of imaginative thought and action for students and teacher educators alike, thus forging dynamic communities of practice consciously. Such communities of practice (Wenger, 1998) are dynamic in that they are subject to forming and reforming depending on the context. They could be generalised, where the focus is on broad educational aspects, or they could be defined where the focus may be on a specific discipline or field. Members of the community could also vary. They could include students, teacher educators, industry participants, teachers at schools, and so on. Such communities should not operate at the cognitive level only. Students can also be encouraged to ask questions in safe, enabling spaces that encourage them to reflect on how their emotions and values impact on their professional conduct. It has been my observation that students who come from different backgrounds tend to remain within their own cultural groupings on campus as well as seek out schools that acknowledge and match their own cultural groupings. Opening up the dialogue not only on what works in terms of success in the classroom, but also opening up the dialogue on what makes one uncomfortable, especially in unfamiliar territory, is key. Placing oneself in someone else's

shoes could be one approach; the other entails reflecting on the shoes you find yourself in and making that explicit.

Sustaining such dialogue, however, needs conscious inputs. As students come and go, the impetus for perpetuating deliberative conversations and sustaining imaginative dynamic communities of practice should reside in the academy, and possibly even be regarded as an integral feature of a teacher education programme. In addition, such dynamic communities should reflect and deliberate on how best to navigate changing teacher education curricula as well as changing school curricula. If our students are encouraged to participate in these deliberations where feasible, then the emphasis would shift from a prescriptive orientation to a collaborative orientation, thus acknowledging the intellectual equality (Rancière, 1991) of our students despite their limited experience in the profession.

9.3.4.3 Authentic or simulated contexts

The internship or professional practice component of a teacher education programme provides opportunities for student teachers to operate in authentic school contexts. While Darling-Hammond (2010:35–47) suggests that a partnership with high-quality professional development schools (PDS)³³ that focus on quality and equity specifically can enhance the teaching practice experience of the student teacher, this is not always possible. Student teachers do not always find themselves in functional schools with effective mentoring support systems. Thus, preparing the students for their school-based experience is a crucial component of the teacher education programme. Imbuing them with the willingness and the ability to reflect on their experiences in a way that will enhance their own professionalism is a way of counteracting possible negative experiences they may endure during their stint at the host schools. Furthermore, the drive on the part of the academy to seek genuine partnerships with the host schools should be ongoing in order to ensure worthwhile learning experiences for our students, where the emphasis is not only on organisational aspects but also on educational aspects. The latter emphasis has the potential to enhance the professionalism of the student teacher. Furthermore Darling-Hammond (2010:35–47) notes that the scripted school curricula, designed with underprepared teachers in mind, fail to improve student learning as they do not meet distinct needs of diverse learners or address the enhancement of higher-order skills. While

³³ These are schools that form partnerships with the universities with the specific purpose of being sites of development for student teachers.

the prevalence of outcomes-based accreditation is what eventually affirms and accredits the graduate, she suggests that it is equally important to focus on important inputs that should serve as essential ingredients or inherent requirements (Sharplin, Peden & Marais, 2016:224–241) of a teacher education programme.

9.4 Inherent requirements of a teacher education programme

When reading literature on what knowledge, understanding and skills students should develop to become effective teachers, one is struck by the enormous array of capabilities presented as ‘must haves’ in initial teacher education. These capabilities include having a broad repertoire of pedagogies appropriate for diverse learners in diverse contexts; a deep knowledge of the subject specialisation, including the way in which knowledge is constructed and mediated in the discipline; appropriate dispositions that will enhance learning ethically and responsibly; knowledge of learning theories and their implications for teaching; a deep knowledge of human growth and development; an in-depth understanding of the learning process; an understanding and application of appropriate assessment practices for learning; and the development of a strong professional identity that will support self-directed professional growth (Hollins, 2011; Sharplin et al., 2016). In addition, teacher education policy provides criteria in the form of standards and minimum requirements for programme development. The student is expected to learn to integrate, synthesise and apply these various aspects in a way that will bring about effective learning in those they teach.

While an array of relevant foci pertaining to teacher education may be aspects for consideration, it does not mean that by including them specifically as part of a programme of requirements, they will automatically become part of the students’ knowledge and skills sets. Rather alert students to what these may be and help them to develop their own way of dealing with emerging educational concerns. While there may be some exemplary cases, the teaching contexts shift for individuals, and assisting students to navigate these shifting contexts by using their professional judgement to inform their practice may be a better way of enhancing their criticality than trying to develop a predetermined set of capabilities.

9.5 Dealing with policy

While general teacher education policy exists, there is no policy that focuses on science teacher education in particular. However, there does seem to be an alignment in terms of the spirit and intent of each document between the teacher education document and the school curriculum document for Physical Science for each phase as outlined previously. Presenting the science curriculum document as tentative guidelines which serve as a basis for negotiating reflexive praxis may be one approach that will encourage criticality.

The nature of the policy comes from a particular time and place in South Africa. There is a particular transformative intent in the new policies, but the realistic situation on the ground militates against its realisation. The shift from a social justice agenda to a more pragmatic agenda is evident in the shift from Phase 1 to Phase 2 in both teacher education policy and school science curriculum policy. Additional emerging discourses around #FeesMustFall and decolonisation of the curriculum may influence further policy prescription. Educational imperatives in our young democracy will always be fluid and complex; hence, even momentary stability in the state of education is likely to be short-lived. Policy is limited in that it can only provide general guidelines for teacher education contextualised in the current educational contexts. We in the academy should be in a state of constant attention and deliberative discussion with one another and with our students as an integrated part of our own practice, especially with regard to education policy.

9.6 The significance of the study: Contributions and limitations

My interest in pursuing this study was to interrogate how notions of critical thinking could be incorporated into science teacher education programmes. I hoped that my findings would provide some insights into how critical thinking could be operationalised in the subject discipline of Physical Science. As the construct ‘critical thinking’ is multifarious, I selected to restrict my exploration to education generally and science teacher education specifically in the context of South African educational discourses and policy. I thought that the four research questions formulated to guide my study contextualised it in the South African educational milieu sufficiently, while still being informed by broader educational considerations. My research method, namely, a conceptual and deconstructive analysis, allowed me to search for constitutive meanings which informed my exploration. In addition, it allowed me to create meaning through identifying and deliberating on conceptual gaps in relation to science teacher education. The latter insight, that is, creating meaning, came

much later in the study. It was my ‘aha’ moment. Together, constitutive meanings and conceptual gaps made up the dimensions of the elaborated conceptual framework developed through successive cycles of literature interrogation as previously described. This approach, I feel, is my methodological contribution to the broader research community.

Furthermore, I argue that an essentialist or fundamental conception of critical thinking is not possible and that notions of critical thinking and their consequent implications for teacher pedagogy can be viewed through the four perspectives I’ve highlighted, namely conservative, liberal, critical, and postmodern. These perspectives are broad categories in which other types could be subsumed, for instance, perspectives such as neo-liberal, pan-Africanist, neo-Marxist, and so forth. While the acknowledgement of perspectives may provide plausible conditions for critique, I should like to imagine how ideas about critical thinking could take a deconstructive turn in the sense of projecting what has not yet been thought of. Such a projection involves imagining reasonable justification of what may be *excluded or forgotten* (Biesta & Stams, 2001:57–74).

Biesta and Stams (2001:57–74) note that the acknowledgement of this play between what manifests or comes into presence and what is not there, which Derrida (1982:5) designates as *différance*, is an affirmation of an otherness that is still to come. Hence, this play of difference identifies the condition for possibility and impossibility and thus hints at the critical potential of deconstruction as a pursuit of justice. Such a pursuit, that is, rationality in pursuit of justice, opens up the possibility for the unforeseeable (Biesta and Stams, 2001:57–74). Considerations of notions of critical thinking thus should not be only in the realm of what is manifest as I have attempted to do in my exploration of the literature and policy documents, but also in the realm of what lingers beneath, what is not yet visible, what has the potential to become. Such considerations of a notion of critical thinking that is not there yet is inextricably bound to what is there in the Derridean sense, would require imagination. Waghid (2014c:34–35) reminds us that this interconnectedness counters the binary dualism of diametrically opposite notions of presence and absence. In this sense, even our imaginings are mutually related to our perception of the world as it is and project the possibilities of what might be. Similarly, Barnett (2013:14–16) juxtaposes Taylor’s (2004) and Kearney’s (2007) ideas of an embedded imaginary which is phenomenologically and hermeneutically driven with Sartre’s (2004) notions of the imaginary as an escape from the world or a leap for freedom in relation to the university re-

imagined. For Barnett (2013:39–40), such a university re-imagined is in pursuit of an improved world and a heightened state of wellbeing. Barnett (2013:39–40) argues that such an orientation is broad enough to enhance the imaginative potential of the university. I imagine that the pursuit of justice as discussed previously could also apply in Barnett's idea of the university re-imagined. I agree with Barnett (2013:16) that this exercising of the imagination is in itself a critical endeavour. To my mind, it implies a critical reflection on *what is*, that is, existing norms and practices, as well as an imaginative yet critical projection of *what might be*. Such a reflection on imaginative possibilities for the university generally or for teacher education specifically could incorporate all those emerging features of critical thinking highlighted in my study.

The study is significant in that it attempts to examine notions of critical thinking from a broad, holistic perspective, comprising the historiography of the South African context, teacher education policy, science curriculum policy, and science teacher pedagogy. The emerging insights are articulated as dimensions of critical thinking in an elaborated conceptual framework. Hence, it is launched from an embeddedness in the South African educational context; however, it also projects a vision of what might be. The adaptation of the conceptual framework to accommodate different ways of knowing and engaging with nature presents imaginative possibilities for science teacher education in pursuit of an improved world as referred to by Barnett (2013:39–40). By implication, this requires an imaginative engagement in the academy that is receptive to different ways of thinking and doing, yet an engagement that emphasises human dignity, ecological sustainability, and justice. Hence the insights from the study present deliberative creative possibilities for operationalising notions of critical thinking not yet present. While the conceptual elaboration on notions of critical thinking that I regard as the theoretical contribution of my study remains tentative and open to further refinement, it could however serve as a basis for imaginative deliberation on the way forward in science teacher education. Thus, the framework should not come across as being definitive. Rather, it should be regarded as my attempt to understand how to approach notions of critical thinking in science teacher education and could serve as a contribution for further reflection and discussions – discussions possibly embedded in imaginative thinking communities about how we as teacher education providers at universities best navigate changing teacher education policy or changing school curriculum requirements. I agree with Waghid and Davids' contention (2016:132) that perpetual reflection ought to be inherent in higher education. If

critical thinking has rationality at its core (Burbules & Berk, 1999:45–65), then the teacher's professional judgement as constitutive of notions of critical thinking would also take a rational turn, in which the student is encouraged to rationally justify educational choices made. Perhaps the university can assist students to articulate those choices in appropriately imaginative dialogical spaces.

When I started on my exploration, I had a particular position on critical thinking which was embedded within the critical rationalist perspective (Higgs & Smith, 2015:26–31) in which ideas and beliefs are challenged through questioning their validity. Hence my involvement in the Critical Thinking Group project which supported rational argumentation as a way of enhancing critical thinking in education students and assisting them with methodologies that supported the development of critical thinking in their own learners. To a large extent, my own position hasn't shifted completely. I still believe that such an approach is vital to support democratic practices, in which students draw on their own abilities to think, question and make informed choices about their own professional conduct and those of others. However, operating at the cognitive domain only is not sufficient for quality learning. Hennissen, Beckers and Moerkerke (2017:315) note that the dominant emphasis in teacher education programmes is rational or cognitive, which does not have much impact on student teachers' preconceptions as it precludes their needs, fears and concerns when dealing with practical situations. The affective, ethical and imaginative domains are also essential aspects of learning as these are often what drive and motivate the direction that learning takes, more so in a recently politically democratised country like South Africa, which still has a long way to go to approximate the vision of an equitable and just society. Hence, further studies on those affective domains which complement the cognitive would advance our insights into improving teacher education generally and science teacher education specifically. The elaborated conceptual framework I developed on notions of critical thinking in the context of science teacher education attempts to highlight teachers' conduct in the science classroom. The focus is thus on the pedagogical aspect of science teaching supported by reflexive praxis. Further research could very well involve the inclusion of other aspects.

9.7 Conclusion

One cannot argue with a social justice agenda which underpins equity and redress to benefit a broad layer of society. However, attempts to effect change in society through educational policy at both higher education and school levels have had questionable

consequences. Even though in South Africa there have been efforts at collaborative and inclusive processes when developing policy, the actual implementation of policy has been problematic. An instrumental view of policy implementation assumes a one-way perspective, where policy provides the template for action. Such a view will probably be associated with a simple systems perspective. Unfortunately, audits of higher education institutions are very often driven by such perspectives of what Gough (2013:1213–1233) terms '*complexity reduction*' where administrators seek '*predictability and control*' (Gough, 2013:1213) over educational value. In this market-driven epoch, compliance means income. We should however be able to interrogate ways of navigating a complex world in which all sorts of crucial issues manifest in the educational arena. Gough (2013:1213–1233) suggests that rather than viewing policy as prescribed text to which our actions and decisions need to be aligned, we should be disposed to interpret its contents. Instead of seeing policy guidelines as a means to an end, they should be viewed as a point of departure. Gough views this as '*deconstructive nonalignment*' as opposed to '*constructive alignment*'. Unquestioning implementation of policy, whether teacher education policy or school curriculum policy, negates any notion of critical thinking.

Teacher education programmes respond reactively when confronted with curriculum policy changes. Extrinsic drivers of curriculum change in teacher education could be changes in higher education policy as was the case in South Africa as previously indicated, as well as changes in curriculum requirements at school level. The recent policy revision (DoE, 2015), as well as the calls for a decolonised curriculum, has again made demands on teacher education programmes to respond. Institutions tend to respond in ways that, at least outwardly, provide some indication that they are reaching the expected requirements. Hence, operational and procedural aspects are emphasised at the cost of educational worth. This is not altogether surprising, as the way in which the policy guidelines are formulated tends to emphasise the former. At least such external factors like changes in national curriculum requirements provide a window of opportunity for management in these higher institutions to consider and reflect on their own norms and practices.

Pogré (2007) notes that, with a few exceptions, the way in which teacher training has accompanied education reforms has been through adding, reorganising or exchanging curricular spaces, or occasionally content within existing programmes. Pogré (2007) states that on analysing different teacher training proposals, the boundaries between academic subjects and departments continue to be strong, while the predominant logic remains intact. So, any intention to integrate critical thinking into a four-year degree

programme will be quite challenging as it requires considerable collaborative effort on the part of the curriculum developers. While faculty in higher education institutions on the one hand need to promote those good practices instituted through the ages, they also need to address imaginatively the challenges and needs of the student body on the other hand. It cannot be business as usual. The last three years in academia have been quite challenging. Interruption of academic programmes by student protests have curtailed the limited time we have with our students. An event or series of events such as the #FeesMustFall movement or the call for decolonisation of the curriculum could serve as impetus for change. A knee-jerk response to such events, with the concomitant desire that it will just go away, is short-sighted, as such disturbances will emerge again and again. Addressing issues like this in academic forums only will render them ineffective from the outset. Critical dialogue for staff and students alike, in not only academic spaces but also in social spaces, is important, as the latter provide opportunities for people to interact at other levels and in informal contexts. In this way notions of critical thinking could serve as an impetus for sustaining ongoing critical conversations and reflexive praxis inside and outside the confines of the academy.

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