

An analysis of National Certificate of Educational
Achievement chemistry courses in terms of curriculum,
pedagogy and assessment: With comparison to the
International Baccalaureate Diploma.

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Abstract

New Zealand has seen significant change in curriculum and qualification frameworks in recent years. The implementation of the National Certificate of Educational Achievement (NCEA) from 2002 and a revised national curriculum in 2007 have underpinned the forces of change. However, preceding its implementation, the NCEA qualification sparked controversy both in the education literature and general media. This controversy around the NCEA continues. Classroom-based evidence on the impact of the NCEA on teaching and learning has a significant role in informing policy, and this work aimed to make such a contribution. As a number of secondary schools in this country offer alternative senior school qualifications, this invited the opportunity to compare the phenomenon of teaching chemistry to Years 12 and 13 students under two structurally different qualification frameworks. The overarching research question investigated in this study was: *In the context of NCEA and International Baccalaureate Diploma (IBD) chemistry courses in New Zealand secondary schools, how do teachers manage the tension between learning, teaching, and assessment?* Teachers' views and practices were explored through inquiry questions relating to the following: Teaching the content and procedural knowledge of chemistry (referring to curriculum and pedagogy); and their approaches to assessment.

Qualitative research was undertaken from a comparative case study within an interpretive paradigm. Two case schools offered both NCEA and IB Diploma qualifications, and one case school NCEA only. A total of ten participants from the three case schools were interviewed, and short sequences of lessons taught by the participant teachers were also observed. Following the coding of the interview data, emergent themes provided direction for the simple statistical analysis of national NCEA results data.

Manageability of courses and their assessment, feeling accountable for high grade outcomes, and the wish for subject specific professional development were areas that teachers of both NCEA and IBDP noted as factors that concerned them. The influence of high-stakes assessment was seen in the teaching methods used in the case schools towards preparing students to attain these qualifications.

It was evident from the interviews that participants had much more to say about their teaching of NCEA than they did for the IB Diploma qualification. The imbalance in the collected data, with more being related to the NCEA, was interpreted as arising from issues related to the achievement standard structure of this qualification. The

impact of the NCEA on teaching and assessment of chemistry in Years 12 and 13 was found to be significant. NCEA achievement standards were seen to be the default curriculum (rather than the *New Zealand Curriculum*), and drove course designs in the three case schools. Extrinsic motivation from NCEA credits and grades were considered by the teachers to be key factors in students' approaches to learning. Courses were designed to maximise grades, and teachers identified the time spent on rehearsal leading up to internal assessment as a concern. When mapped to the *New Zealand Curriculum*, it was evident that curricular holes in NCEA courses existed; in particular with regard to nature of science and investigation learning objectives. In the case schools, coherence of chemistry as a discipline was compromised in NCEA courses, with implications for students understanding. The performance of schools is evidently being judged, by both government and the media through the publication of league tables of NCEA grade data. This seems to be driving chemistry learning in directions that are counter to international directions in curriculum reform.

Based on the findings of this study, several recommendations are made. Attention should be paid to supporting (and resourcing) full implementation of the *New Zealand Curriculum*, with a focus on subject specific professional development for teachers. The relationship between the *New Zealand Curriculum* and the NCEA needs addressing; the achievement structure of the NCEA as it currently exists, is coming at a high cost in terms of compromising pedagogy and subject connectedness. Issues of the reliability and validity of NCEA assessment also exist, suggesting that review of current implementation and assessment policy, including that relating to the conduct of national examinations, need review.

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CHAPTER ONE:

Introduction

1.1 Rationale and context for the study

Internationally, there is evident concern over falling enrolments over the last twenty years in both secondary and university physical science courses, and this is despite apparent political awareness of the future demand for graduates with scientific expertise (Bennett, Lubben, & Hampden-Thompson, 2013; Childs, 2009; Hilton, Nichols, & Gitsaki, 2008; Osborne, Simon, & Collins, 2003). Concern over the *under-preparedness* of new undergraduates has also been raised with regard to courses in science, engineering and mathematics (Reiss & White, 2014; Hong et al., 2009; Osborne et al., 2003).

Sir Peter Gluckman, in his role as the New Zealand Prime Minister's Chief Science Advisor, held the following view:

My belief is that this difference between pre-professional education and the more citizen-focused objectives of science education has grown in importance and will do so even more in the coming decades, such that radical changes in the nature of the science education curriculum will be needed. It is likely, in my view, that there will be, at some time in the not too distant future, a separation of curricula for the citizen-focused objectives from those for pre-professional science education throughout secondary schooling. This is required to enable the majority of students to continue to engage in science education beyond year 11, addressing the challenge of creating a scientifically literate population. (Office of the Prime Minister's Science Advisory Committee, 2011, p. 4)

For those students that do go on to tertiary courses, there is a need to understand the issues they face with regard to the transition from secondary to university study in this subject. This requires an analysis of the current reality of teaching chemistry in secondary schools in this country, in terms of teaching practice, course delivery, assessment, and educational achievement of students.

By the time students reach the penultimate year (Year 12) of secondary school in New Zealand, science is no longer a compulsory subject; students may elect to study chemistry at this level. While it is perhaps probable that only a relatively small number go on to a degree major in chemistry at university, chemistry is a subject that is a prerequisite or recommended subject for many tertiary-level courses.

The last fifteen years has seen much change in terms of policy, curriculum and assessment impacting on the New Zealand secondary school sector. A revised national curriculum document was published in 2007. The New Zealand Curriculum (NZC) is an outcomes-based curriculum and is the basis for three levels of the National Certificate of Educational Achievement (NCEA) qualification. These were progressively implemented from 2002 to 2004. The NCEA qualification is a standards-based assessment system and is typically undertaken by students in Years 11 to 13 (see Section 2.3). Scholarship examinations in individual subjects were introduced in 2004 to recognise top-achieving secondary school students (New Zealand Qualifications Authority, n.d.-a¹). Since its introduction, changes to the NCEA have been ongoing, and between 2011 and 2013 the NCEA was significantly revised, with the aim of improving alignment with the current curriculum (New Zealand Qualifications Authority, 2010). Given the magnitude of these changes to national curriculum and assessment in this country, and now that the NCEA has been in place for over a decade and teachers have gained experience with it, it seems timely to contribute to research into classroom practice in this context. For some of my teaching colleagues, the NCEA is the only qualification pathway they have known, themselves graduates of the system.

There has been uncertainty and controversy surrounding the implementation and subsequent reform of the NCEA, both in the academic literature and in the general media (Hall, 2000; Elley, Hall, & Marsh, 2004; Hall & Irving, 2010; Coddington, 2011). The national media continues to raise questions and promote a range of opinions about the NCEA (such as Downes, 2015; Johnston, 2015, 2016; Morris, 2015).

Since 1991 parents in New Zealand have been entitled to a full choice of state and state-integrated schools for their children, subject to school capacity. State-integrated schools in New Zealand are once private schools that are now state schools that retain their *special character*, and includes many church schools.

When a school reaches its enrolment capacity, as specified by the Ministry of Education, the school is permitted to establish an 'enrolment scheme' that specifies its criteria for selecting students – e.g. geographic, family ties, interviews. (Ladd & Fiske, 2001, p. 44)

¹ In this thesis there are many references made to different pages of the website of the New Zealand Qualifications Authority. Where these pages are not dated, pages are identified in the reference list and in-text citations by letters (here for example n.d.-e).

As parents are empowered to make comparisons between schools, the media discourse and annual publication of league tables of NCEA and University Entrance results may be construed to have implications for schools in terms of enrolments.

After the introduction of the NCEA, some schools began to offer their senior students an alternative academic pathway such as Cambridge International Examinations or the International Baccalaureate Diploma Programme (Shulruf, Hattie, & Tumen, 2008; International Baccalaureate Organisation, 2011). As the introduction of NCEA was imminent, Lee and Lee (2001) held the view that:

As in the past, the success of these current reforms will doubtless be measured in terms of the uptake of the new qualification – in this case the NCEA will be the only qualification available to students in Years 11 to 13 (Forms 5 to 7), even more important still will be the degree to which schools and students actively explore other (overseas) examination options. If the NCEA is judged somehow to be failing, then we can expect to see a significant increase in the number of New Zealand students entering for the English A-level and Cambridge University Entrance examinations, for example. (p. 31)

In 2015 the Post Primary Teachers Association (PPTA) promoted the view that state schools in New Zealand should not be offering international examination boards. The PPTA argued that schools offering the International Baccalaureate Diploma Programme (IBDP) or the Cambridge International Examinations (CIE) were in effect undermining public confidence in the NCEA qualification. The recommendation “that PPTA lobby the government and opposition parties with a view to a future ban on state and integrated schools offering Cambridge or International Baccalaureate qualifications” (Post Primary Teachers Association, 2015, p. 17), drew criticism (Morris, 2015), and was later withdrawn (Johnston, 2015).

At present thirteen New Zealand schools are authorised to deliver the IBDP (International Baccalaureate Organisation, 2016). This includes two large (with a roll of >1000) decile 10 state schools. So, at these schools, students and their parents are faced with making course selections and decisions that require them to compare and contrast the NCEA with the IBDP.

The growth of the IBDP in New Zealand over the last ten years mirrors an international trend in that regard. Bunnell (2010) noted the increasing access of the International Baccalaureate programmes into elite schools in Europe. In Australia, the IBDP is currently offered in 63 schools (International Baccalaureate Organisation, 2016). Doherty (2009) examined the evident appeal of the IBDP in the Australian education market and suggested that the recent growth of the IB

curriculum not only seems incongruent with the push for a national curriculum in that country, but was also linked to the marketing of the IBD as an elite brand:

When choosing curricula, parents are not necessarily dealing with detailed knowledge about how the curriculum might be enacted. Rather they may well be dealing with the affect and connotations associated with the brand – the ‘hot’ reputational knowledge (Ball & Vincent, 1998). There have been previous studies of the IB as such a commodity. Whitehead’s (2005) analysis of 40 advertisements for South Australian schools that mentioned IB programs concluded that ‘these schools are selling social advantage rather than social justice’ and ‘the IB was deployed as a commodity that increased their advantage in the education marketplace’ (p. 1). (Doherty, 2009, p. 83)

Doherty (2009) also asserts that this market positioning and selection of the IBDP by typically middle-class parents as the curriculum of choice (over local curricula), has implications for the local curricula “If the IB is seen to ‘own’ the qualities of ‘academic rigour’, ‘challenge’ ‘well roundedness’, such claims create and promote a perception of their absence in other curricula” (p. 85). The diversity of schools and the pressures on many parents around choice invokes reliance on informal socially differentiated grapevines, with official information given out by schools perceived by parents as a less reliable source in some aspects (Ball & Vincent, 1998).

However, if decision making around curriculum by stakeholders of education in New Zealand is to be informed by evidence based analysis, then there is a need for appropriate studies to be undertaken that are linked to existing educational research in our region. In terms of underlying philosophy and design, the NCEA and IBD qualifications are structurally significantly different from each other, as described in Chapter Two of this thesis, and so invite comparison.

1.2 Background of the researcher

As I write this thesis, my two children are in Year 7 and Year 9, and in making choices for them I have considered the curricula offered at different schools in Wellington. No doubt, being Mum to two school-age children has given me further cause to care deeply about education in this country, and to gain a perspective of teaching and learning through a parental lens.

I was born and grew up in New Zealand and on leaving school went to Otago University. I graduated from there with a BSc (Hons), with a major in Biochemistry. However, after graduation I found myself unable to find work as a scientist in New Zealand, and made the move to Western Australia, where I worked as a research biochemist for around five years. Following that, I was employed as a geochemist by a major mining company, and while in that role was given the opportunity to complete an MSc in Ore Deposit Geology through the University of

Western Australia. The next ten years of work experience saw me work in teams on mining exploration projects in Australia and China. Having returned to New Zealand, and as Mum to two young children, I followed my own Mum's advice and an interest that had always been there, and applied for teacher's training at the Faculty of Education at Victoria University of Wellington in 2006.

This research had its beginnings with a conversation with Dr Moeed, Senior Lecturer in the School of Education at Victoria University of Wellington. I had called her when I was teaching chemistry at a school that was newly authorised to deliver the IBDP from 2010. At the time, I had been teaching for four years, and I was faced with the task of reviewing the senior chemistry courses at my school. This experience, together with that of undertaking the necessary professional development for the new (to our school) IBDP courses, prompted my reflection and comparison between NCEA and IBDP that is central to this project. At the same time, it was with some unease that I realised all my teaching resources for the NCEA courses I was teaching were organised by achievement standard numbers, rather than by chemistry content themes (how did that happen?). My digital resources were in folders labelled 2.5, 3.1 and so on. It made me wonder if assessment, in my laboratory at least, had become the tail that was wagging the teaching canine. Being one of just two chemistry teachers in a small science department at a small secondary school, I was feeling professionally somewhat isolated. I was struggling to reconcile my own experiences of working as a scientist and my pre-service science teacher training, with the culture and practices pervading the science department in which I worked at that time. I chose to undertake this research part-time, while continuing to work full-time. There have been several times over the last ten years of my teaching experience that I have reflected on how teaching practices have changed, and perhaps not changed, since I was first learning about science in primary school.

So, I wanted to hear from my teaching colleagues in other schools about how they were implementing curriculum (or curricula, in alternative qualification schools). What informed their decision-making and practices around curriculum and assessment? What were their views on the qualifications they were teaching towards? How were they dealing with change? What did they see as key learning objectives and outcomes for the students in their laboratories, and how were they going about achieving these? I also wondered how they were developing their practice as chemistry teachers.

As I turned to the literature, and given the enormity of the changes to the education 'ecology' implemented since 2002 in this country, I noted there were few studies offering insights and evidence for how all this change had impacted on students' learning of science in the secondary school classroom. In his review of studies into the experiences of teachers in terms of the impacts of science curriculum reform, Ryder (2015) noted that there is:

significant scholarship and debate around the purposes of school science education. However, there has been noticeably less research focusing on the processes of science education policy – its formation and enactment within schools (Ryder, 2015, p. 88)

1.3 Purpose of the research

This research sets out to examine the relationship between curriculum, pedagogy and assessment in chemistry teaching in New Zealand secondary schools. Chemistry courses in two different qualification regimes are compared: the National Certificate of Educational Achievement (NCEA) and the International Baccalaureate Diploma Programme (IBDP). The focus for inquiry is: *How do teachers manage the tension between learning, teaching and high-stakes assessment?* Teachers' views and practices were explored through inquiry questions relating to the following:

- Teaching the content and procedural knowledge of chemistry (referring to curriculum and pedagogy)
- Approaches to assessment.

The primary focus of this study then, is the exploration of *teachers'* perspectives of chemistry teaching and learning at the classroom level. While it was clear that attention to students' perspectives would also offer rich data, for reasons of manageability, it was decided early on that this study would focus on the teachers' voice.

1.4 Outline of the thesis

The thesis comprises ten chapters. Chapter Two provides the curriculum context for this study, and describes the scope of the science learning area at Levels Seven and Eight from *The New Zealand Curriculum* (Ministry of Education, 2007). The achievement objectives for both Nature of Science and Material World strands together with the principles, values, and key competencies from that curriculum document are considered. Information from the Ministry of Education (MoE) and the New Zealand Qualifications Authority (NZQA) is also given as an overview of the NCEA and its alignment with *The New Zealand Curriculum (NZC)*. An overview of

the IB Diploma Programme as a whole is given in Chapter Two, and the structure of the Chemistry syllabus within that framework is described.

Chapter Three provides a review of selected relevant literature on curriculum, pedagogy and assessment in the context of science learning and teaching.

The research methodology used is described in Chapter Four, with explanations provided for the case-study design decisions made to provide rich descriptions fitting the research focus for this study. The selection of case schools and teacher participants, approaches taken to class observations, instrumentation design, and ethical considerations are described. Also outlined is the approach taken to analysing NZQA results data for chemistry 2010–2014. Limitations and delimitations of the research design are considered.

Results from the three case schools are presented in Chapters Five, Six and Seven. Presented in Chapter Eight are NCEA national data for chemistry achievement standards, extracted and processed from NZQA databases.

The first section of Chapter Nine comprises a synthesis of key findings from the participant teachers in the three case schools and the NZQA data analysis informing this research, together with a discussion of the findings in the context of the relevant literature. Finally, in Chapter Ten, the thesis is concluded with responses to the research questions, implications of the key findings, and my final thoughts as to possible directions for further research.

CHAPTER TWO:

The Policy and Curriculum Contexts of the Study

This chapter provides an outline of the model of education and its administration provided by the New Zealand Government. Responsibility for the development, management and evaluation of curriculum and high-stakes assessment in secondary schools falls to several different government agencies. To provide clarity and sense in the reading of the remainder of the thesis, aspects of the responsibilities of several of these government entities are summarised.

Two curricula form the context for this study: *The New Zealand Curriculum (NZC)* as published by the Ministry of Education in 2007, and the International Baccalaureate Diploma Programme (IBDP).

The revised national curriculum, *NZC* (Ministry of Education, 2007) provides the current framework that directs teaching and learning in the majority of schools in New Zealand, and as such key elements of this mandated curriculum are presented to provide relevant contextual background.

The scope and structure of the science learning area in the *NZC*, and the Nature of Science and Material World strand achievement objectives are described. Background information with regard to the structure of the NCEA qualification, and its alignment with the *NZC* is also synthesised in this chapter.

An overview of the International Baccalaureate Diploma Programme curriculum and structure is then given. As the second curriculum context of this study, the structure and assessment model for the chemistry syllabus as an experimental science subject in the IBDP is described.

Multiple and layered meanings of the term *curriculum* and global trends and tensions apparent in the development of curricula and distinctions between mandated and implemented curricula are reviewed in Chapter Three. The relevant literature underpinning the Nature of Science and Material World strands of *NZC* follows in Chapter Three. A summary of relevant, selected literature and more general media commentary around the implementation and ongoing review of the NCEA is also given in Chapter Three, as is relevant research and commentary around the IBDP as implemented in schools.

2.1 Governance of the education sector in New Zealand

The 1989 Labour Government led the *Tomorrow's Schools* reform package “which emphasized devolution, efficiency and choice, the hallmarks of neo-liberalism” (Codd, 2005, p. 195). *Tomorrow's Schools* resulted in significant administrative restructuring of the education sector (O'Neill, 2015).

The Department of Education was separated into policy, implementation and regulatory agencies under the Education Act 1989, and state schools became self-managing 'enterprises' competing for parent clients under Tomorrow's Schools. Community Boards of Trustees were to be elected to assume responsibility for budget, employment, administration and performance.' (O'Neill, 2015, p. 836)

The education system developed by the New Zealand Government is based on a model known as outcomes-based education (OBE). Intended objectives of the education system; the procedures implemented to achieve the stated objectives; and then the subsequent monitoring of actual versus intended outcomes, are key elements of the OBE model. OBE is founded on the principles of transparency, choice, decentralisation, and accountability (Hall, 2007).

There are ten National Education Goals, set by the New Zealand Government to “establish a common direction for state education” (Ministry of Education, 2015a, p. 1). These goals are one component of the National Education Guidelines (NEGs).

Reflecting the reforms of 1989, several New Zealand Government agencies are tasked with different functions and aspects of policy development and delivery of education services. Four of these agencies, relevant to the administration of secondary schools and this research, are: Ministry of Education; New Zealand Qualifications Authority; Education Review Office; and The Education Council.

Ministry of Education (MoE) – Te Tāhuhu o Te Mātauranga

The MoE develops education policy and provides direction, support and resources (including funding) for education agencies and providers. It is mandated to “raise achievement and reduce disparity by focusing on excellence in teaching, quality providers and engaging families and communities in learning” (Ministry of Education, 2015b, p. 1). It manages state teachers' payroll and school properties. The MoE is the agency that develops curriculum and the NCEA achievement standards and provides professional development programmes for teachers. The MoE also manages *Te Kete Ipurangi* (TKI), which is a bilingual education portal that is a repository of curriculum and assessment resources for use by educators and students.

New Zealand Qualifications Authority (NZQA) – Mana Tohu Mātauranga o Aotearoa

NZQA operates under the Education Act (1989), the Education Amendment Act (2011), and The Industry Training Act (1992). The NZQA administers secondary school assessment systems towards the NCEA qualification. This includes the management of all aspects of external assessments and the moderation of processes and outcomes for internal assessments in schools. The NZQA writes newsletters and *clarifications* for the achievement standard documents developed by the MoE. The NZQA also provide annotated exemplars of student work for specific achievement standards. The NZQA's website has information accessible by all stakeholders of education in New Zealand, as well as log-in secured materials for teachers and school managers. This includes a range of statistical reports on NCEA results. In addition, the NZQA author several publications relating to assessment, including annual reports on NCEA and New Zealand Scholarship data that are publicly available. The NZQA also administers the *New Zealand Qualifications Framework (NZQF) – Te Taura Here Tohu Mātauranga o Aotearoa*. The NZQF lists qualifications by type at levels 1 to 10 from both senior secondary school and tertiary providers and “is structured to be consistent with other mature national qualification frameworks around the world” (New Zealand Qualifications Authority, n.d.-f, p. 1). Level 10 of the NZQF is a doctoral degree.

Education Review Office (ERO) – Te Tari Arotake Mātauranga

The ERO is responsible for undertaking education reviews, typically on a three year cycle, which report on the quality of education in all New Zealand schools. These reports are accessible to the public online. ERO also publishes national reports on specific education topics, and these are available on their website (Education Review Office, n.d.).

Education Council New Zealand – Matatū Aotearoa

The Education Council is a statutory body led by a Governing Council of members appointed by the MoE. The governance function of the Education Council is reported as follows:

We are the professional organisation for teachers. We represent all teachers from early childhood education through to primary and secondary schooling in English and Māori medium schools. We'll promote all that's best about teaching; good practice, new ideas, inspirational leadership.

We will provide leadership and help strengthen the regulatory framework and disciplinary regime for teaching. We aim to boost the status of teaching, strengthening accountability and bringing consistently high standards across the education system. (Education Council, n.d.)

In order to legally teach in New Zealand schools, teachers must hold a practicing certificate with the Education Council, and renew their certification every three years. Renewal of a practicing certificate relies on the teacher providing evidence of meeting the criteria set by the Education Council for practicing teachers. The Education Council maintains the register of New Zealand registered teachers.

School level governance

Under the National Administration Guideline 1, school Boards of Trustees, through the Principal and teachers, are mandated to implement the school curriculum in alignment with *The New Zealand Curriculum*. Within that document, it is stated that: “Teaching programmes for students in Years 11–13 should be based in the first instance, on the appropriate national curriculum statements” (Ministry of Education, 2007, p. 44).

The MoE uses a decile rating system to determine the level of funding provided to state and state-integrated schools. All schools have a decile rating from 1 to 10, with each decile band corresponding to around 10% of schools. “Decile 1 schools are the 10% of schools with the highest proportion of students from low socio-economic communities. Decile 10 schools are the 10% of schools with the lowest proportion of students from these communities” (Ministry of Education, 2015c, p. 1). The 86 private (independent) schools in New Zealand share a government subsidy currently capped at \$41.57 million per annum. The actual per student subsidy therefore depends on total enrolments in the sector, and, they are funded in the main by charging fees to parents. As such, are exempt from having to follow the national curriculum (Ministry of Education, 2016, 2015d). The school year in New Zealand typically starts in early February and ends in early December, and is divided into four terms.

2.2 *The New Zealand Curriculum: Policy and vision*

State and state-integrated schools in New Zealand are required to follow the national curriculum statements: “*The New Zealand Curriculum* is a statement of official policy relating to teaching and learning in English-medium New Zealand schools” (Ministry of Education, 2007, p. 6). There is also a national curriculum for

Kura Kaupapa Māori state schools: *Te Marautanga o Aotearoa*. This curriculum is based on Māori cultural perspectives and students are taught in the Māori language.

The vision for educating the young people of New Zealand as stated in the *NZC* is as follows:

Our vision is for young people:

- Who will be creative, energetic and enterprising;
- Who will seize the opportunities offered by new knowledge and technologies to secure a sustainable social, cultural, economic, and environmental future for our country;
- Who will work to create an Aotearoa New Zealand in which Māori and Pakeha recognise each other as full Treaty partners, and in which all cultures are valued for the contributions they bring;
- Who, in their school years, will continue to develop the values, knowledge, and competencies that will enable them to live full and satisfying lives;
- Who will be confident, connected, actively involved, and lifelong learners.

(Ministry of Education, 2007, p. 8)

Three stages of curriculum design and interpretation are recognised in the *NZC* document. These three stages are the national curriculum, the school curriculum, and the curriculum at work in the classroom. The stated intention for the national curriculum at the school and classroom levels is to:

give schools the scope, flexibility, and authority they need to design and shape their curriculum so that teaching and learning is meaningful and beneficial to their particular communities of students. In turn, the design of each school's curriculum should allow teachers the scope to make interpretations in response to the particular needs, interests, and talents of individuals and groups of students in their classes. (Ministry of Education, 2007, p. 37)

The overall structure of the different elements of *NZC* is shown in Figure 2.1.

2.2.1 Principles, values and competencies.

In the front section of the national curriculum document, and as shown in Figure 2.1, are eight principles that “should underpin all school decision making”: High expectations; Treaty of Waitangi; cultural diversity; inclusion; learning to learn; community engagement; coherence; future focus.

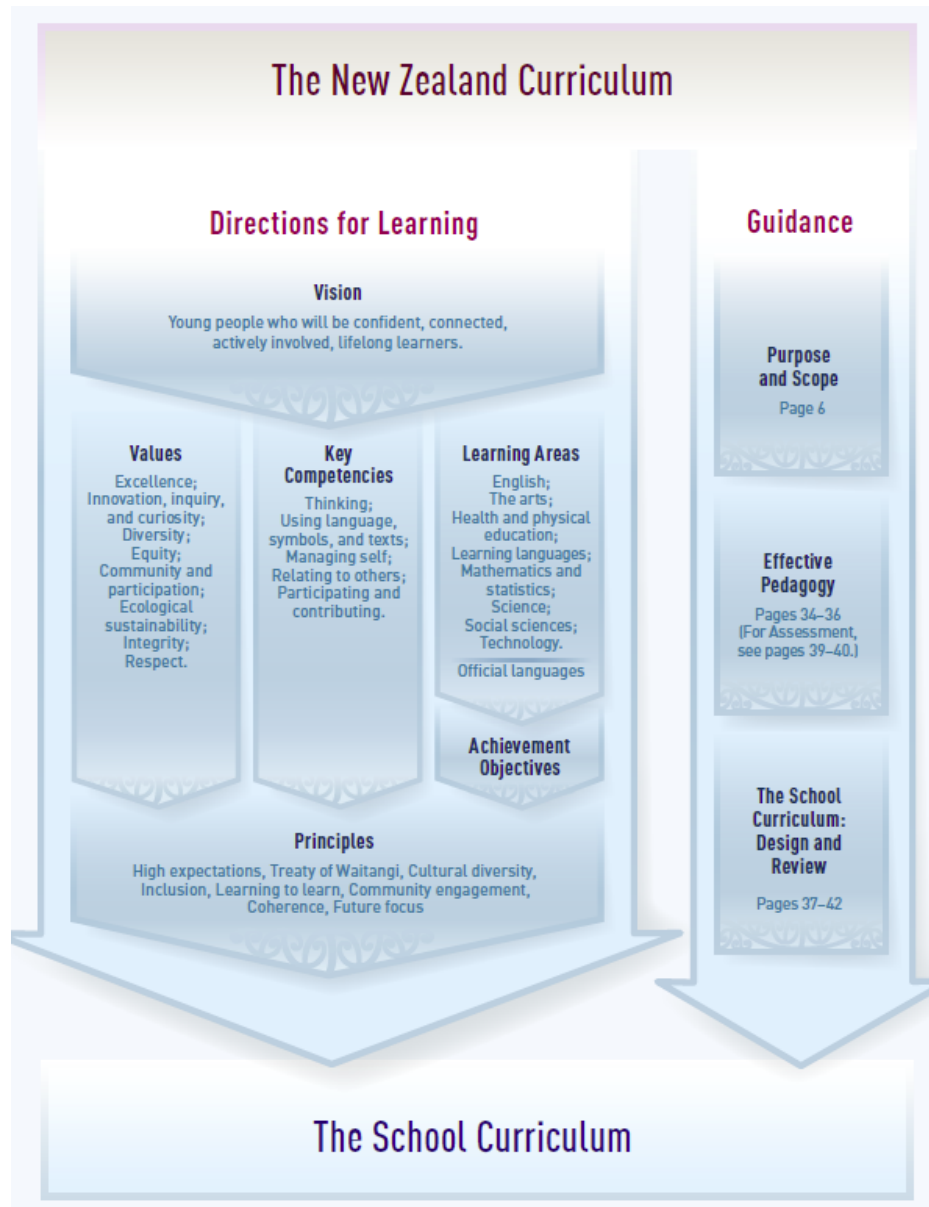


Figure 2.1. An overview of the New Zealand Curriculum (reproduced from Ministry of Education, 2007, p. 43).

Also outlined are seven values that are “to be encouraged, modelled and explored” with students (Ministry of Education, 2007, p. 9–10). In addition, five key competencies are identified that are to be developed in successful learners (thinking; using language, symbols and texts; managing self; relating to others; participating and contributing). Schools are explicitly directed to develop the values

and key competencies in their students, and integrate these within different learning areas as a means of developing the stated vision of “confident, connected, actively involved, and lifelong learners” (p. 8).

While the learning areas are presented as distinct, this should not limit the ways in which schools structure the learning experiences offered to students. All learning should make use of the natural connections that exist between learning areas and that link learning areas to the values and key competencies. (Ministry of Education, 2007, p. 16)

2.2.2 Pedagogy.

NZC lays out seven approaches to teaching that promote effective learning by students.

The evidence tells us that students learn best when teachers:

- create a supportive learning environment;
- encourage reflective thought and action;
- enhance the relevance of new learning;
- facilitate shared learning;
- make connections to prior learning and experience;
- provide sufficient opportunities to learn;
- inquire into the teaching-learning relationship.

(Ministry of Education, 2007, p. 34)

The last of these has been devised as a cyclic *teaching as inquiry* model in NZC, and is based on the premise that effective pedagogy “requires that teachers inquire into the impact of their teaching on their students” (Ministry of Education, 2007, p. 35).

The potential of e-learning and the use of information and communication technologies to support contemporary teaching approaches is also noted in NZC.

2.2.3 Levels of achievement within learning areas.

Eight learning areas are defined in the NZC: English; the arts; health and physical education; learning languages; mathematics and statistics; science; social sciences; and technology. For each of these learning areas, there are specified achievement objectives for eight progressive Curriculum Levels of learning (corresponding to 13 years of schooling) in the back of the curriculum document. Students in Years 12 and 13 of secondary school are typically learning at Level 7 and Level 8 of the curriculum.

2.2.4 The science learning area: Nature of Science and Material World strands.

What Hipkins (2012) refers to as the *Essence Statement*, describing the intent for the science learning area of the *NZC*, reads:

In science, students explore how both the natural physical world and science itself work so that they can participate as critical, informed, and responsible citizens in a society where science plays a significant role. (Ministry of Education, 2007, p. 17)

The science learning area in the *NZC* is structured as a series of learning objectives grouped into five strands: Nature of Science; Living World; Planet Earth and Beyond; Physical World; Material World. Central to this thesis are the Nature of Science and Material World strands of the *NZC*.

Within *NZC* document, the Nature of Science strand is defined as:

...the overarching, unifying strand. Through it, students learn what science is and how scientists work. They develop their skills, attitudes, and values to build a foundation for understanding the world. They come to appreciate that while scientific knowledge is durable, it is also constantly re-evaluated in the light of new evidence. They learn how scientists carry out investigations, and they come to see science as a socially valuable knowledge system. They learn how science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions. (Ministry of Education, 2007, p. 28)

The Material World strand is described in *NZC* as involving:

...the study of matter and the changes it undergoes. In their study of chemistry, students develop understandings of the composition and properties of matter, the changes it undergoes, and the energy involved. They use their understanding of the fundamental properties of chemistry to make sense of the world around them. They learn to interpret observations by considering the properties and behaviour of atoms, molecules and ions. They learn to communicate their understandings, using the knowledge of chemistry. Using their knowledge of chemistry, they are better able to understand science-related challenges, such as environmental sustainability and the development of new materials, pharmaceuticals, and sources of energy. (Ministry of Education, 2007, p. 29)

Relevant to this research are the published achievement objectives for the Nature of Science and Material World strands for Levels 7 and 8 of *NZC*. These are listed below (Ministry of Education, 2007b, p. 26):

Nature of Science

Students will:

Understanding about science

- Understand that scientists have an obligation to connect their new ideas to current and historical knowledge and to present their findings for peer review and debate.

Investigating in science

- Develop and carry out investigations that extend their science knowledge, including developing their understanding of the relationship between investigations and scientific theories and models.

Communicating in science

- Use accepted science knowledge, vocabulary, symbols, and conventions when evaluating accounts of the natural world and consider the wider implications of the methods of communication and/or representation employed.

Participating and contributing

- Use relevant information to develop a coherent understanding of socio-scientific issues that concern them, to identify possible responses at both personal and societal levels

Material World

Students will:

Properties and changes of matter

- Investigate and measure the chemical and physical properties of a range of groups of substances, for example, acids and bases, oxidants and reductants, and selected organic and inorganic compounds.

The structure of matter

- Relate properties of matter to structure and bonding.
- Develop an understanding of and use the fundamental concepts of chemistry (for example, equilibrium, and thermochemical principles) to interpret observations.

Chemistry and society

- Apply knowledge of chemistry to explain aspects of the natural world and how chemistry is used in society to meet needs, resolve issues, and develop new technologies.

2.2.5 Assessment.

The first mention of assessment in *NZC* is that:

The primary purpose of assessment is to improve students' learning and teachers' teaching as both student and teacher respond to the information that it provides. With

this is mind, schools need to consider how they will gather, analyse, and use assessment information so that it is effective in meeting this purpose.

Assessment for the purpose of improving student learning is best understood as an ongoing process that arises out of the interaction between teaching and learning. It involves the focused and timely gathering, analysis, interpretation, and use of information that can provide evidence of student progress. Much of this evidence is “of the moment”. Analysis and interpretation often take place in the mind of the teacher, who then uses the insights gained to shape their actions as they continue to work with their students (Ministry of Education, 2007, p. 39).

The intent regarding assessment for national qualifications in the last few years of secondary schooling, and specifically the National Certificate of Education (NCEA), is stated in *NZC* as follows:

The New Zealand Curriculum provides the basis for the ongoing development of achievement standards and unit standards registered on the National Qualifications Framework, which are designed to lead to the award of qualifications in years 11–13. These include the National Certificate of Educational Achievement and other national certificates that schools may choose to offer.

The New Zealand Curriculum, together with the Qualifications Framework, gives schools the flexibility to design and deliver programmes that will engage all students and offer them appropriate learning pathways. The flexibility of the qualifications system also allows schools to keep assessment to levels that are manageable and reasonable for both students and teachers. Not all aspects of the curriculum need to be formally assessed, and excessive high-stakes assessment in years 11–13 is to be avoided (Ministry of Education, 2007, p. 41).

Several characteristics of effective assessment are listed in *NZC*. Stipulated is that assessment: “Benefits students; involves students; supports teaching and learning goals; is planned and communicated; is suited to the purpose; and is valid and fair” (Ministry of Education, 2007, p. 40).

The curriculum document also specifies that students should be well prepared as they transition through different stages in their education, including from secondary school through to the tertiary sector.

2.3 The National Certificate of Educational Achievement (NCEA)

The NCEA qualification at Levels 1, 2 and 3 was introduced successively into New Zealand secondary schools from 2002 to 2004. The NCEA Levels 1 to 3 replaced the earlier norm-referenced national qualifications of School Certificate, Sixth Form Certificate and Bursary respectively.

There are three years of national testing in New Zealand secondary schools, with the majority of students working towards NCEA Level 1 in Year 11 (Level 6 of

curriculum), NCEA Level 2 of in Year 12 (Level 7 of curriculum), and NCEA Level 3 in Year 13 (Level 8 of curriculum).

The NCEA is a standards-based assessment system, where student skills and understanding are assessed against *achievement standards* or *unit standards*. Phillips (2007) describes standards as having:

...specified learning outcomes and assessment criteria. All standards are assigned a credit value, which represents the extent of learning involved. Credit is awarded in each standard when the required level is achieved. High performance may be recognised in achievement standards through merit and excellence levels. (p. 177)

Together with the credits, students may attain one of four possible grades for each of the achievement standards in which they enrol: Not Achieved; Achieved; Merit; or Excellence. Unit standards are competency based, and students are awarded one of two possible grades: Achieved or Not Achieved. Credits for any single level of the NCEA may be accumulated in more than one year.

There are two types of achievement standards: Those that are internally assessed at school during the course of the year (*internals*); and those that are externally assessed at the end of the year in the format of portfolios of student work or in examinations run by the NZQA (*externals*).

NZQA explains that the rationale for the change to the NCEA:

grew out of a long-term intention to establish standards for national qualifications and recognize a wider range of skills and knowledge. A new set of qualifications was needed to reflect the more flexible learning environments in our schools.

NCEA was designed to challenge all students, including the most able and highly motivated. It was also designed to give schools the flexibility to develop a range of programmes to suit the specific needs of their students. (New Zealand Qualifications Authority, n.d.-k)

Furthermore, Hawke, cited by the NZQA, claimed that the introduction of the NCEA was centered on developing New Zealanders as life-long learners (New Zealand Qualifications Authority, n.d.-d). The discourse in science education between educating future scientists and *science for all*, and the implications for curriculum development is reviewed in Chapter Three (Section 3.1.3).

In science education, Hipkins (2012) noted underlying tensions between science curriculum, learning, and high-stakes assessment, and regarded the “curriculum thinking” (p. 14) undertaken by teachers as important in meeting this challenge:

How they understand their work is framed first and foremost by the purposes for which they think they are teaching science, and the sorts of learning outcomes they see as having value for learners. High-stakes assessments convey compelling messages about valued outcomes. Ensuring a more appropriate alignment between NCEA achievement standards, for example, and the NZC would also help. However, this, too, is unlikely to be sufficient to support and sustain very different ways of thinking about purposes for learning science in the 21st century. (Hipkins, 2012, p. 14).

It is noted that there has been criticism by academic specialists of the impact of NCEA on desired student learning outcomes and a synthesis of this is given in Chapter Three (Section 3.4).

2.3.1 Award of NCEA Certificates.

Under the New Zealand Qualifications Framework, there are three levels of certificate offered in the NCEA: Levels 1, 2, 3, broadly corresponding to Years 11 through 13. The NCEA is a standards based system where students are assessed and earn credits for individual standards, which are counted towards the requirements for the certificates at each level (NZQA, 2015a). Figure 2.2 sets out the credit requirements for each level.

NCEA level	Requirements
Level 1	80 credits are required at any level (level 1, 2 or 3) including literacy and numeracy . Schools can explain the literacy and numeracy standard pathways they are using.
Level 2	60 credits at level 2 or above + 20 credits from any level The Level 1 literacy and numeracy requirements must also be met.
Level 3	60 credits at level 3 or above + 20 credits from level 2 or above From 2014 the Level 1 literacy and numeracy requirements must also be met.

Figure 2.2. Credit Requirements for Levels 1 to 3 of the NCEA (reproduced from NZQA, n.d.-e)

For the award of an NCEA at all three levels, Level 1 numeracy and literacy requirements must be met (Figure 2.2). The requirements for both numeracy and literacy changed from 2013, with now a minimum of 10 credits for both literacy and numeracy from one of the listed *specified achievement standards; literacy unit standards; or numeracy unit standards*. The numeracy and literacy standards correspond to Curriculum Level 6 of the NZC (New Zealand Qualifications Authority, n.d.-g).

2.3.2 Vocational pathways.

As part of the government's Youth Guarantee programme, sector-based vocational pathways were developed in 2012. The six vocational pathways are designed to offer a coordinating framework for students when planning their courses and working towards attaining NCEA Level 2 (New Zealand Qualifications Authority, n.d.-l). They include recommended, and strongly recommended, achievement standards in the sciences designated as being relevant for the different pathways following consultation with New Zealand's Industry Training Organisations.

2.3.3 Course and certificate endorsements.

Since full implementation, the NZQA has effected a series of what Hipkins (2013) called "rolling changes" (p. 2) to the NCEA. It should be noted that change continues. Significant among these changes were the introduction of certificate endorsement (in 2007), and then course endorsement (in 2010). Research into student motivation (Hodis, Meyer, McClure, Weir, & Walkey, 2011; Meyer, McClure, Walkey, Weir, & McKenzie, 2009), underpinned these changes. This is detailed in the literature review in the following chapter (Section 3.4).

A student that attains 14 or more credits (including a minimum of 3 from internal and 3 from external standards) at Merit or Excellence in one year, will be awarded a Merit or Excellence course endorsement, to recognise their high achievement in that individual course (New Zealand Qualifications Authority, n.d.-b).

Furthermore, students who attain 50 credits at Excellence (or Merit) at the level of the certificate or above, will attain a certificate endorsed with Excellence (or Merit) (New Zealand Qualifications Authority, n.d.-b).

2.3.4 Realignment.

"In December 2008 the Minister of Education announced that all curriculum related standards were to be reviewed so that they aligned to *The New Zealand Curriculum*" (Ministry of Education, n.d.). The other stated intentions of the review (or *realignment*), was to resolve issues of duplication of standards and check for credit parity. In terms of parity, one NCEA credit is to correspond to a notional 10 hours of teaching, learning and assessment time (New Zealand Qualifications Authority, n.d.-m).

This realignment of the NCEA was a major undertaking by the MoE and NZQA that involved consultation on draft achievement standards and the new, reviewed

standards were implemented over three years: Level 1 in 2011, Level 2 in 2012, and Level 3 in 2013. It had implications for teachers in that teaching resources, assessment tasks and schedules had to be revised in line with all the achievement standards. The timing of the data collection phase of this research coincided with that of Level 3 realignment and was in the year following the realignment of Level 2 achievement standards.

2.3.5 Chemistry matrix NCEA Levels 2 and 3.

With the achievement standard structure of the NCEA, “schools are able to offer whole 'subjects' in the traditional way – or they can use the standards to develop courses to suit the needs of their students”, and this flexibility in course design afforded to students is cited as one of the key advantages of the NCEA (Ministry of Education, n.d.).

There are six science categories listed on TKI: Agricultural and horticultural science; Biology; Chemistry; Earth and space science; Physics; Science. Each of these groups has a matrix of achievements standards at NCEA Levels 1, 2 and 3. Schools design their senior science courses selecting achievement standards to suit, and comprising a total number of credits at their discretion. So, in the sciences, it would be possible for schools to offer courses in environmental science or biochemistry made up of a combination of achievement standards from Biology and Chemistry subjects. It is also possible for schools to offer a course comprising achievement standards at different levels.

There are a total of seven achievement standards (four internals and three externals) at both Level 2 and Level 3 of the Chemistry Matrix, as shown in Figure 2.3 (Ministry of Education, 2014).

Chemistry Matrix Levels 2 and 3

Level 2	AS91161 2.1 Carry out quantitative analysis.	AS91162 2.2 Carry out procedures to identify ions present in solution.	AS91163 2.3 Demonstrate understanding of the chemistry used in the development of a current technology.	AS91164 2.4 Demonstrate understanding of bonding, structure, properties and energy changes.	AS91165 2.5 Demonstrate understanding of the properties of selected organic compounds.	AS91166 2.6 Demonstrate understanding of chemical reactivity.	AS91167 2.7 Demonstrate understanding of oxidation–reduction.
	4 credits Internal	3 credits Internal	3 credits Internal	5 credits External	4 credits External	4 credits External	3 credits Internal
Level 3	AS91387 3.1 Carry out an investigation in chemistry involving quantitative analysis.	AS91388 3.2 Demonstrate understanding of spectroscopic data in chemistry.	AS91389 3.3 Demonstrate understanding of chemical processes in the world around us.	AS91390 3.4 Demonstrate understanding of thermochemical principles and the properties of particles and substances.	AS91391 3.5 Demonstrate understanding of the properties of organic compounds.	AS91392 3.6 Demonstrate understanding of equilibrium principles in aqueous systems.	AS91393 3.7 Demonstrate understanding of oxidation-reduction processes.
	4 credits Internal	3 credits Internal	3 credits Internal	5 credits External	5 credits External	5 credits External	3 credits Internal

Figure 2.3. The Chemistry NCEA Levels 2 and 3 matrix of achievement standards as published in January 2014. (Ministry of Education, 2014).

2.3.6 NCEA assessment procedures and policies.

NZQA administers NCEA for senior secondary students and ensures that schools follow robust and rigorous assessment processes through oversight of schools' internal assessment, and management of external NCEA examinations and New Zealand Scholarship. (New Zealand Qualifications Authority, 2015, p. 23)

NZQA, with authority under the Education Act (1989), set *Assessment (including Examination) rules for schools with consent to assess* (New Zealand Qualifications Authority, 2016). These rules relate to the assessment requirements for all achievement standards; New Zealand Scholarship examinations; and University Entrance. Within a school, overall responsibility for managing NCEA assessment and compliance with the NZQA Rules rests with the Principal's Nominee. The Principal's Nominee at each school is responsible for assessment practice in that school, including candidate entries, data management, arranging invigilation of the examinations, ensuring the conduct of candidates complies with assessment guidelines, providing appropriate resources and facilities for the proper conduct of the examinations, and processes related to internal assessment.

Through formal *Managing National Assessment* (MNA) reviews, a school's compliance with NZQA procedures and rules relating to assessment is determined. The reviews are carried out once every four years as a minimum. The MNA reviews are administered by the NZQA, and the finalised MNA reports for each school are publicly available on the NZQA website.

2.3.6.1 Managing external assessment.

External NCEA assessment relates to assessment that is not examined by a school's teachers, and includes assessment by examination or portfolios (for example, some Technology and Visual Arts achievement standards are assessed externally through the submission of portfolios of work). NZQA has responsibilities for the preparation and marking of examination scripts, and both are resourced through the short-term contracting of teachers to the NZQA. The agency constructs and publishes (online) the examination timetable. Administrative information relating to the NCEA and New Zealand Scholarship is communicated through electronic bulletins on the NZQA website: *Assessment Matters*.

2.3.6.2 *Managing internal assessment.*

Internal assessments are used to assess skills and knowledge that cannot be tested in an exam, e.g. speeches, research projects and performances. (New Zealand Qualifications Authority, n.d.-i)

The NZQA monitor the consistency of internal assessment tasks and the associated judgements made by teachers through a process of external moderation.

For a specified achievement standard, schools are required to submit to NZQA samples of student work, together with copies of the task and marking schedule, which are reviewed by the external moderator. A moderation report is sent back to the school, recording the suitability of the assessment tasks in terms of meeting the standard, and the level of agreement between the external moderator and the teacher grading.

Teachers may submit a request for further clarification on their interpretation of a standard to the external moderator. Best Practice Workshops (BPW) facilitated by the NZQA and run over the last six years, are subject specific and offer teachers support in their role as assessors. They are especially aimed at meeting the needs of:

- assessors who need to improve their moderation agreement rates
- assessors new to standards based assessment and the NCEA
- beginning assessors

(New Zealand Qualifications Authority, n.d.-j)

In 2016 the BPW were available either as one day face to face, or as an online programme run over five weeks with the time commitment for participants estimated to be 90 minutes per week. The cost of the workshops is NZD 120.00.

Another professional learning initiative aimed at developing teachers' assessment practice was trialled in 2016: Transforming Assessment Praxis (TAP). This was offered as a nine week online programme, with the time commitment for participants estimated at around 90 minutes per week. The stated aims of the TAP programme were:

- To look at ways to re-contextualise existing resources to better meet the needs of your learners
- To provide strategies to enable you to create a variety of new assessment resources
- To explore diverse and valid methods of collecting assessment evidence to meet the varied needs of learners.

(New Zealand Qualifications Authority, n.d.-j)

2.4 New Zealand Scholarship

The New Zealand Scholarship examination offers an opportunity for academically strong students to attain recognition and monetary award in individual subjects. The total number of scholarships awarded in any one subject are set to be around 3% of the total Level 3 candidature in that subject.

Scholarship candidates are expected to demonstrate high-level critical thinking, abstraction and generalisation, and to integrate, synthesise and apply knowledge, skills, understanding and ideas to complex situations. (New Zealand Qualifications Authority, n.d.-a)

2.5 University Entrance (UE)

The minimum requirements for entry into a New Zealand university were reviewed in 2010, and took effect in March 2014. The current University Entrance (UE) requirement in terms of NCEA attainment is:

Three subjects – at **Level 3**, made up of:

14 credits each, in three approved subjects

Literacy – 10 credits at **Level 2 or above**, made up of:

5 credits in reading

5 credits in writing

Numeracy – 10 credits at **Level 1 or above**, made up of:

achievement standards – specified achievement standards available through a range of subjects, or

unit standards – package of three numeracy unit standards (26623, 26626, 26627 – all three required).

(New Zealand Qualifications Authority, n.d.-g)

The *approved subjects* referred to above is a list of subjects (and specified achievement standards) which are accepted towards UE; students must attain a minimum of 14 credits at NCEA Level 3 in three of these subjects. It is important to note the stipulated requirement for UE is based on the definition of a *subject*, whereas NCEA is *course* based. The UE subjects are far stricter in their specification of achievement standards than NCEA allows with regard to school courses.

Other qualifications, including CIE and the IBDP may be “deemed equivalent to the university entrance standard” (Universities New Zealand, n.d.).

2.6 The International Baccalaureate Diploma Programme

The International Baccalaureate (IB) is a not-for-profit educational foundation registered in Geneva, Switzerland.

Schools must be authorised to offer any of the IB programmes, of which there are four. The four programmes offer an *IB continuum* for students aged 3 to 19 years: The Primary Years Programme (PYP); the Middle Years Programme (MYP); the Career-related Programme (CP); and the Diploma Programme (IBDP). Following authorisation, a school's implementation of each programme is evaluated by the IB every five years.

The IB was founded in 1968 at the International School of Geneva and the first IBDP examination was held in 1970. In 2015, 2795 schools in 143 countries offered the Diploma Programme (International Baccalaureate Organisation, n.d.-a).

2.6.1 Policy: Aims and objectives.

Central to all four IB programmes is the philosophy of international-mindedness which is embodied in its mission statement:

The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.

To this end the organization works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.

These programmes encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right. (International Baccalaureate Organisation, 2009, p. 3)

2.6.2 Overview of the structure of the IBDP.

The IBDP is designed as a pre-university curriculum for students aged between 16 and 19 with a view to educating for global citizenship (Davy, 2011). Learners in the IBDP study six subjects concurrently with three curriculum *core* requirements over two years. The IBDP model is shown in Figure 2.4. Breadth and balance in the experienced curriculum is strived for by the design of six subject groups, from which students choose their course (IBO, 2009).

Students specialise by electing to undertake study of three of their six subjects at Higher Level (HL) and the remaining three at Standard Level (SL). Assessment comprises internally and externally assessed components. Examinations run in

accordance with the IB policies and procedures are at the end of the second year of the IBDP.

An overall subject grade of 1 to 7 is awarded per subject. In addition, students must complete the three *core* requirements: *Creativity, Activity and Service*; *Theory of Knowledge*; and an *Extended Essay*, registered in a subject of their choice. A points matrix for combined grades for *Theory of Knowledge* and *Extended Essay* requirements allows for up to 3 additional points. Thus, the maximum possible Diploma points is 45 overall: $(6 \times 7) + 3 = 45$. Award of an IB Diploma requires a student to attain a total score of 24 (International Baccalaureate Organisation, 2004, p. 23).



Figure 2.4. The IB Diploma Programme model, reproduced from (International Baccalaureate Organisation, n.d.-b).

The International Baccalaureate Organisation publishes subject guides which define the curriculum for each IBDP subject. There is a process of subject review on a 7-year cycle and this process includes consultation with teachers. Within an IBDP school, overall responsibility for all aspects of the Diploma implementation within that school rests with the Diploma Coordinator.

Schools authorised to implement the IBDP must ensure that their teachers undertake approved professional development in curriculum implementation, and compliance with this stipulation is part of the school review system conducted every five years. Professional development programmes run by the IB include both online (run over several weeks) and three day face-to-face workshops run by experienced IBDP practitioners in specific subject areas. The workshops are offered in three categories and geared at practitioners of different levels of experience with the programme. Workshops for senior curriculum and administrative leaders are also provided. The registration fee for these workshops in the Asia-Pacific region is currently around SGD 890 per participant. On completion of all aspects of the workshops, participants receive a certificate. IBDP teachers in New Zealand may also attend subject specific *cluster meetings*, which are organised and run by some IB schools.

2.6.3 The IBDP chemistry syllabus.

The data collection phase for this research was conducted under the chemistry subject guide (International Baccalaureate Organisation, 2007), which applied to students completing their IBDP courses up to and including November 2015. Candidates registered for final assessment in 2016 and beyond would be taught from the next edition of the subject guide (International Baccalaureate Organisation, 2014). Chemistry in the IB Diploma Programme is a subject within the *group 4 experimental sciences*.

The IBDP chemistry course

...combines academic study with the acquisition of practical and investigational skills through the experimental approach. Students learn the chemical principles that underpin both the physical environment and biological systems through the study of quantitative chemistry, periodicity, kinetics and other subjects. The chemistry course covers the essential principles of the subject, and through selection of options, allows teachers some flexibility to tailor the course to meet the needs of their students. Throughout this challenging course, students become aware of how scientists work and communicate with each other. Further, students enjoy multiple opportunities for scientific study and creative inquiry within a global context (International Baccalaureate Organisation, 2010, p. 1).

The IBDP chemistry course is available at standard level (SL), corresponding to a recommended 150 hours of teaching time, and at higher level (HL), relating to 240 hours of instruction time. SL students must undertake a total of 40 hours practical work over the two year programme. For HL students this requirement is 60 hours. The use of appropriate information and communication technology (ICT) is

“encouraged in practical work throughout the course” (International Baccalaureate Organisation, 2007, p. 30). Under the 2007 syllabus, a *practical scheme of work* (PSOW) schedule needed to be submitted for each candidate, showing the breakdown of all practical work done and the use of relevant technologies over the two year programme. The required practical hours included 10 hours for completion of a *group 4 project*, a compulsory component of the syllabus:

The group 4 project is a collaborative activity where students from different group 4 subjects work together on a scientific or technological topic, allowing for concepts and perceptions from across the disciplines to be shared in line with aim 10 – that is, to “encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method.” The project can be theoretically based. Collaboration between schools in different regions is encouraged.

The group 4 project allows students to appreciate the environmental, social and ethical implications of science and technology. It may also allow them to understand the limitations of scientific study, for example, the shortage of appropriate data and/or the lack of resources. The emphasis is on interdisciplinary cooperation and the processes involved in scientific investigation, rather than the products of such investigation. (International Baccalaureate Organisation, 2007, p. 33).

Candidates must study all of the core theory topics. In addition, the curriculum includes *options* topics (for both SL and HL courses), which allows for some flexibility in instruction, as two topics are chosen for study from a list of seven. The full list of options are: modern analytical chemistry; human biochemistry; chemistry in industry and technology; medicines and drugs; environmental chemistry; food chemistry; further organic chemistry (International Baccalaureate Organisation, 2007). IBO subject briefs, offering a summary of the HL and SL chemistry courses are appended (Appendices A–B).

2.6.4 Assessment model for IBDP chemistry.

A summary of the assessment model for IB Diploma chemistry is given in Table 2.1 (standard level) and Table 2.2 (higher level). These summary tables show the structure and contribution to an overall grade of the external (examination) components and the internal assessment. The focus of internal assessment is practical skills. Teachers assess student work against the set criteria, and a sample of student work is externally moderated by the IBO.

Table 2.1
 Summary of assessment model for IBD chemistry standard level, first examinations 2009
 (International Baccalaureate Organisation, 2007).

Type of assessment	Format of assessment	Time (hours)	Weighting of final grade (%)
External			76
Paper 1	30 multiple choice questions on the core	0.75	20
Paper 2	Short answer questions on the core, and data analysis. One extended-response question on the core	1.25	32
Paper 3	Short answer questions on each of the two option topics studied	1	24
Internal			24
Practical work	General practical work: short and long-term investigations.		
	Group 4 project		

Table 2.2
 Summary of assessment model for IBD chemistry higher level, first examinations 2009
 (International Baccalaureate Organisation, 2007).

Type of assessment	Format of assessment	Time (hours)	Weighting of final grade (%)
External			76
Paper 1	40 multiple choice questions on the core	1	20
Paper 2	Short answer questions on the core, and data analysis. One extended-response question on the core	2.25	32
Paper 3	Short answer questions on each of the two option topics studied	1.25	24
Internal			24
Practical work	General practical work: short and long-term investigations.		
	Group 4 project		

Following each examination session (May and November), subject reports are published on the IBO *online curriculum centre* (OCC). The subject reports provide teachers with feedback with regard to candidate's performance on each assessment component and makes recommendations for the teaching of future candidates.

2.7 Chapter summary

Following, in Table 2.3, is a summary of the curricular philosophies, structures, and assessment models of chemistry courses designed to fulfil the requirements towards the NCEA (aligned to *NZC*) and IB Diploma qualifications (for the 2007 subject guide).

Table 2.3

Summary of chemistry courses towards the NCEA and IBDP qualifications (International Baccalaureate Organisation, 2007)

	National Certificate of Educational Achievement (NCEA) – Level 2 and 3 Chemistry	International Baccalaureate Diploma – Chemistry
Implementation	<p>The <i>New Zealand Curriculum</i> “provides the basis for the ongoing development of achievement standards and unit standards registered on the National Qualifications Framework, which are designed to lead to the award of qualifications in years 11–13” MoE, 2007, p. 41).</p> <p>The NCEA was introduced over three years, from 2002 to 2004, as the national qualification in New Zealand.</p>	<p>The IB Diploma Programme (IBDP) started in 1968 and the first examinations were in 1970. Currently 2,292 schools offer the DP globally. A total of 11 schools are authorised to deliver the DP in New Zealand.</p>
Curricular philosophy	<p>“Our vision is for young people:</p> <p>Who will be creative, energetic and enterprising;</p> <p>Who will seize the opportunities offered by new knowledge and technologies to secure a sustainable social, cultural, economic and environmental future for our country;</p> <p>Who will work to create an Aotearoa New Zealand in which Māori and Pakeha recognise each other as full Treaty partners, and in which all cultures are valued for the contributions they bring;</p> <p>Who in their school years, will continue to develop the values, knowledge, and competencies that will enable them to live full and satisfying lives;</p> <p>Who will be confident, connected, actively involved, and lifelong learners” (MoE, 2007, p. 8)</p>	<p>“The Diploma is a rigorous pre-university course of study designed for students in the 16–19 age range. It is a broad-based two-year course that aims to encourage students to be knowledgeable and inquiring, but also caring and compassionate. There is a strong emphasis on encouraging students to develop intercultural understanding, open-mindedness, and the attitudes necessary for them to respect and evaluate a range of points of view”. (IBO, 2007, p. 1)</p>

National Certificate of Educational Achievement (NCEA) – Level 2 and 3 Chemistry**International Baccalaureate Diploma – Chemistry**

Chemistry Course Description/ Aims and Objectives

Three contextual strands are identified for *Material World* in *NZC*, and the achievement aims are described for each at Levels 7 and 8 (MoE, 2007):

“Students will

- Properties and Changes of Matter

Investigate and measure the chemical and physical properties of a range of groups of substances, for example, acids and bases, oxidants and reductants, and selected organic and inorganic compounds.

- The Structure of Matter

Relate properties of matter to structure and bonding

Develop an understanding of and use the fundamental concepts of chemistry (for example, equilibrium and thermochemical principles) to interpret observations.

- Chemistry and Society

Apply knowledge of chemistry to explain aspects of the natural world and how chemistry is used in society to meet needs, resolve issues, and develop new technologies.

“The Diploma Programme experimental science courses should aim to:

1. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge students.
2. Provide a body of knowledge, methods and techniques that characterize science and technology.
3. Enable students to apply and use a body of knowledge, methods and techniques that characterize science and technology.
4. Develop an ability to analyse, evaluate and synthesise scientific information.
5. Engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities.
6. Develop experimental and investigative scientific skills.
7. Develop and apply the students' information and communication technology skills in the study of science.
8. Raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology.
9. Develop an appreciation of the possibilities and limitations associated with science and scientists.

Encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method” (IBO, 2007, p. 9).

National Certificate of Educational Achievement (NCEA) – Level 2 and 3 Chemistry **International Baccalaureate Diploma – Chemistry**

In addition to the contextual strands, four learning objectives for the Nature of Science strand are:

- Understanding about science
- Investigating in science
- Communicating in science

Participating and contributing

Course Structure

For NCEA Level 2 Chemistry there is a total of 26 internal achievement standard credits in seven discrete achievement standards offered in the chemistry matrix shown in Figure 2.3 (TKI, 2014). The achievement standards selected to assess the work in a school's course are determined by curriculum managers in those schools. No minimum requirement for practical work is specified.

For NCEA Level 3 Chemistry there are a total of 28 credits from seven achievement standards in the matrix shown in Figure 2.3 (TKI, 2014); a school's course will be assessed by achievement standards selected from the matrix.

Standard Level (SL): 150 hours total of teaching specified, comprising of 110 hours of theory and 40 hours practical work (10 hours Group 4 project + 30 hours investigations). Of the 110 hours of theory, 80 hours is core instruction on 11 topics and the remaining 30 hours comprises *options*. The options are teacher/student selected and students are required to study two topics (from a list of eight).

Higher Level (HL): 240 total teaching hours required. This comprises 80 hours on core theory (as for the standard level course) and an additional 55 hours instruction building on the breadth and depth of core material in SL course. Two additional topics are student/teacher selected from a possible eight topics; 45 hours of instruction on these options. A minimum of 60 hours practical work is required, comprising 10 hours Group 4 project and 50 hours investigation work.

National Certificate of Educational Achievement (NCEA) – Level 2 and 3 Chemistry

International Baccalaureate Diploma – Chemistry

Group 4 Project: This is an inter-disciplinary project that counts for 10 hours of the practical component for both the SL and HL courses. The focus of the project is interpersonal skills.

Extended Essay (EE): Candidates might register to complete their EE in Chemistry.

Assessment – Internal

Refer Chemistry matrix (Figure 2.3): Internally assessed achievement standards at both Level 2 and 3 are:

- AS91161 2.1 Carry out quantitative analysis
- AS91162 2.2 Carry out procedures to identify ions present in solution
- AS91163 2.3 Demonstrate understanding of the chemistry involved in the development of a current technology
- AS91167 2.7 Demonstrate understanding of oxidation-reduction
- AS91387 3.1 Carry out an investigation in chemistry involving quantitative analysis.
- AS91388 3.2 Demonstrate understanding of analytical techniques in chemistry
- AS91389 3.3 Demonstrate understanding of properties of particles and thermochemical principles.
- AS91393 3.7 Demonstrate understanding of oxidation-reduction processes

24% : Comprises practical work (investigations) with five assessment criteria:

- Design – D
 - Data collection and processing – DCP
 - Conclusion and evaluation – CE
 - Manipulative skills – MS (assessed over the whole course)
 - Personal skills – PS (assessed during the collaborative inter-disciplinary Group 4 project)
-

**National Certificate of Educational Achievement (NCEA) – Level 2
and 3 Chemistry**

International Baccalaureate Diploma – Chemistry

**Assessment –
External**

External examinations comprise three papers, each relating to an achievement standard (refer matrix, Figure 2.3):

- *AS91164* 2.4 Demonstrate understanding of bonding, structure, properties and energy changes
- *AS91165* 2.5 Demonstrate understanding of the properties of selected organic compounds
- *AS91166* 2.6 Demonstrate understanding of chemical reactivity
- *AS91390* 3.4 Demonstrate understanding of thermochemical principles and the properties of particles and substances
- *AS91391* 3.5 Demonstrate understanding of the properties of organic compounds
- *AS91392* 3.6 Demonstrate understanding of equilibrium principles in aqueous systems

76%: Three exam papers assess the theoretical component of the course at the end of the second year of the Diploma:

Paper 1 – Multiple choice

Paper 2 – Data analysis

Paper 3 – Short answer and extended response assessing Option component

CHAPTER THREE: **Literature Review**

Presented in this chapter is a review of relevant literature on curriculum, pedagogy and assessment in the context of science learning and teaching.

The meaning of *curriculum* is considered, and tensions evident from the international discourse on the development of contemporary curricula policy are described in the first part of this chapter. The place of knowledge in new curricula appears contested, and there is evidently a distinction too, between mandated curriculum and that implemented in schools.

In terms of learning science, constructivist learning theories appear widely accepted as underpinning contemporary curricula design. Other main theories of learning include cognitivism, behaviourism, and social learning theory. It might reasonably be expected that teachers would be eclectic in their application of learning theories in their practice. However, it was envisaged at the outset that data collected in this research would be viewed in the context of the written curricula and the constructivist learning theories that underpin these. The international trend towards directing the explicit teaching of Nature of Science themes is summarised in this review. The special place of all types of practical work in learning science, including investigation, has been widely studied, and a synthesis of selected, relevant literature is provided as a frame for aspects of this research. Linked to this literature, is that of espoused science teacher beliefs about effective pedagogy, and the extent to which the inclusion of practical work is important in teaching science.

The fundamentals of assessment theory are also considered in this chapter. Different types of assessment, and the key issues of reliability and validity of assessment are described. The literature concerning teacher beliefs on issues of curriculum, pedagogy and assessment, and how such beliefs relate to teacher practices are reviewed.

The chapter concludes with a consideration of claims made in the commentary surrounding the implementation of *NZC* and its assessment (through the *NCEA*), and the *IBDP*.

3.1 Mandated versus implemented curriculum

As an important context for this study, review of relevant literature on mandated versus implemented curriculum follows.

3.1.1 Curriculum: What do we mean?

It should not be assumed that we all attach the same meaning to the term curriculum. As Young (2014) cautioned, despite the level of attention dedicated to it in the literature, it is more likely that what a curriculum actually is, is somewhat ambiguous and interpreted differently by educators. In the same paper, Young paid homage to the work done in the 1930's by the sociologist Emile Durkheim in defining curricula as "social facts". So, curricula act as constraints on all involved with them, including teachers, students, curricula designers and policy writers (Young, 2014). However, aside from constraining, or setting limits on learning, curricula may be enablers of learning and are purposive in design (Young, 2014). He made a distinction between curriculum and pedagogy:

...the concept 'curriculum' refers to the knowledge that it is hoped pupils will acquire by the end of a course. In contrast, pedagogy refers to the activities that teachers devise for their pupils to enable them to acquire the knowledge specified by the curriculum. (Young, 2014, p. 12)

Shay (2015) cited Bernstein in defining curriculum as "what counts as knowledge", and regarded that implicit in this definition are ideas of delimitation and selection of knowledge.

...choices about selection (the content of the curriculum), sequencing (what order/ progression), pacing (how much time/credit), and evaluation (what counts for assessment). Bernstein is clear that these curriculum choices are constituted by a set of underlying principles that legitimate certain curriculum choices and practices and not others. (Shay 2015, p. 433)

In addition to curriculum theory defining what counts as, and is selected as knowledge, Lundgren (2015) added that it also describes the organization of knowledge. The historical development of curriculum sees contemporary curricula typically derived from the organizational structures of earlier subject-based curricula (Lundgren, 2015; Reiss & White, 2014; Young, 2014).

Aside from a narrow sense of curriculum, which may be taken to refer to a specific curriculum document, Bell and Baker (1997) considered that "there is a wider meaning to the word *curriculum* and it can also have multiple layers of meaning" (p. 1). In referring to the New Zealand national curriculum that was published in 1993, and which was the forerunner of the current NZC (Ministry of Education, 2007), Bell

and Baker (1997) described implications of curriculum change for implementation in terms of the layering of curriculum:

Policy-to-practice activities have dominated teacher development programmes in science education in the 1990s. Implementing the latest national curriculum statement (in science) (Ministry of Education, 1993b) involves the planning, teaching and assessing of the new curriculum by teachers and the experiencing and learning of a new curriculum by students. In other words, following the rewriting of a national curriculum statement, each of the other multiple layers of the 'curriculum' (the planned, taught, learned, assessed and hidden curricula) needs to be changed as well. (Bell & Baker, 1997, p. 4)

In elaborating on the idea of the *hidden* curricula, Bell and Baker (1997) explained this as “the implicit and unintended learning which may occur” (p. 2). They remarked that the actual curriculum experienced by students might differ from the mandated one, or that planned by the teacher.

3.1.2 International directions in curriculum reform.

A global trend towards *knowledge-based economies* is driving international discourses about curriculum reform (Priestley & Sinnema, 2014; Shay, 2015). The evident transformation of world markets and economies offer “a challenge to curriculum research to accept broader social, cultural and economic perspectives”, argued Lundgren (2015, p. 788).

Educational systems have expanded and are critical for economic growth. Globalisation leads to the perception that education is a decisive competitive instrument. Non-government organisations like OECD occupy central policy roles. (Lundgren, 2015, p. 798)

Philosophical tensions in curriculum reform are described in the literature, and reflect different stances in terms of underlying principles (Beck, 2013; Lundgren, 2015; Shay, 2015). One such difference in fundamental principles is identified by Shay (2015) who analysed curriculum reform in Hong Kong and South Africa. In this analysis it is noted that policy agendas that “legitimate certain curriculum choices” (p. 433) in the higher education sector in the two countries are different.

...the Hong Kong reform discourse is dominated by a market discourse of competition, the South African reform discourse is dominated by strong political discourse of social justice and the imperatives of redress (Shay, 2015, p. 436).

Several commonalities in recent shifts in western world education policy are referred to in the literature. Claims are made that there is a shift away from prescriptive curriculum statements of content towards active forms of pedagogy and a student-centered approach, “and a view of teachers as facilitators of learning” (Priestley &

Sinnema, 2014, p. 51). Abiss (2014) described the tension between such a student-centered approach and a competing one for more centralised governance as one that:

...can be generally described as a tension between a return to a child and student-centered approach, which tends to emphasise democratic concerns, and the role of teachers as curriculum-designers, and increased centralised control, which tends to emphasise economic concerns, focus on a narrow range of aims and measurable outcomes and give policy makers a tighter grasp on curriculum. (Abiss, 2014, p. 4)

Priestley & Sinnema (2014) asserted that trends in recent international curriculum reform are defined by “assessable outcomes, modular courses and ladders of qualifications (Young, 2008), accompanied by increasingly pervasive regimes of accountability and cultures of performativity” (p. 51). Codd (2005) claimed that such shifts are evident too in educational reforms in New Zealand and “have had largely negative consequences both for teachers and for the overall purposes of public education” (p. 194).

New forms of control and accountability have emerged informed by theories of economic rationalism and based on a culture of mistrust. Strongly influenced by discourses of economics, educational accountability has shifted away from a focus on inputs and process and onto a focus on outcomes and products. Increasingly, schools have been commercialised, functioning more like small business firms and less as institutions with an education mission. (Codd, 2005, p. 194)

That Australian school results were being published in league tables was reported by Klenowski and Wyatt-Smith (2012) as a situation driven largely by the media, and one that had negative impacts on curriculum. The Australian Primary Principals Association (APPA):

...acknowledges the negative impact of high stakes assessment on the quality of teaching and learning when there is a shift to focus only on the results in the evaluation of school performance and when sanctions are imposed. These unintended consequences have been identified in terms of: the narrowing of the curriculum as teachers teach only that which is to be tested; curriculum areas that are not to be tested are neglected; higher order thinking skills that are difficult to assess in such paper and pencil formats are also neglected; time is spent on coaching and practice tests; schools participate in perverse practices designed to improve achievement data; and finally, as stated in the APPA position paper, ‘a testing industry grows which is driven by its own commercial interests. (Klenowski & Wyatt-Smith, 2012, p. 70)

The relationship between *new curriculum* and knowledge has been debated (Beck, 2013). School curriculum addresses “what knowledge?” (Young, 2014, p. 8), and Beck (2013) proposed a taxonomy of knowledge in three categories: Powerful, esoteric, and knowledge of the powerful. Of these, powerful knowledge was described by Young (2014) as the knowledge acquired by learners through

education, which takes them beyond that knowledge derived from their own prior experiences.

A pragmatic approach was proposed by Biesta (2014), employing transactional theory by Dewey to avoid the issue that “we are in danger of being left with a theory of pedagogy, or teaching and learning but with no curriculum” (Young, 2014, p. 9).

Challenges to the traditional organisation of curricula, from a subject based one, to an aims-based model appear in the literature. Reiss and White (2013), proponents of aims-based curriculum, likened the purpose of schools to that of families, noting it is the purpose of both “to equip each child to lead a life that is personally flourishing”; and “to help others to do so too” (p. 1). Reiss and White (2013, 2014) proposed that from these simply expressed two aims, a broad-based national curricular framework might be generated. Then, more specific aims may be developed that are of relevance to the students in a particular school. This approach appears to give primacy to being responsive to the needs of students in a particular school community. They argued that this would necessitate the addition of one further aim for schools, which is “helping every student to form a broad background of understanding” (Reiss & White, 2013, p. 15).

Arguments for science curricular reform have been made whereby the emphasis on substantive knowledge (that is, understanding of factual knowledge, concepts, laws and theories) is reduced, in favour of a greater focus on growing students’ procedural understandings of science and skills in evaluating and asking questions of evidence (Duggan & Gott, 2002; Roberts, Gott & Glaesser, 2010; Tytler, Duggan & Gott, 2001). Learning about the Nature of Science is prioritised in most recent curricula, including NZC where it holds a weighty position as the overarching strand. Lundgren (2015) commented on a shift in semantics in the contemporary curriculum discourse on content knowledge, along with changes to the organisation of content.

In curricula and in public discussions about the curriculum there is now a shift in how content is described. The term ‘knowledge’ is at least partly replaced by terms like ‘competence’ and ‘ability.’ This is motivated as [sic] consequence of new demands for competence and capacity. The ‘curriculum language’ around the selection and organization of content is changing. (Lundgren, 2015, p. 797)

Talanquer and Pollard (2010) suggested that making connections is important, and argued that shifting the ways chemistry undergraduates think is key. However, these researchers claimed the reality is that the majority of current university chemistry courses take a topic-based approach, with many students therefore not having adequate understandings of key concepts, not making connections or able to

transfer knowledge to solve problems (Talanquer & Pollard, 2010). Their stated aims for students engaging with their ambitious new chemistry curriculum (*Chemistry XXI*) were: The development of deeper understandings; making links between core ideas; and contemporary approaches to problem-solving.

The need for assessment reform in chemistry education, to keep pace with curricular reform was put forward by Holme et al. (2010). These researchers argued that when curricular changes targeting aspects of learning drive the development of new assessments, then more effective (data-based) decisions in the classroom should be possible. Taber (2014) reflected on how determining the influence that chemistry education research has on teaching practice is a complex, difficult and often indirect process.

3.1.3 Science curricula: *Science for All* versus science for experts.

The importance of educating all students (both future experts and citizens) in key aspects of scientific literacy has been declared for more than a decade (Hodson, 2014; Lederman et al., 2014; Osborne, 2007, 2012). However, issues of how to best educate students for citizenship as well as those destined to be future scientists have not yet reached a consensus (Smith & Gunstone, 2009; Young, 2014).

In their critique of the *Science for All* curriculum agenda in Australia, Smith and Gunstone (2009) examined the rationale and evident tensions in this initiative. These authors argued for a reconsideration of the vision for secondary school science education, whereby in the education of future scientists, there needs to be the expectation that more than acquiring “knowledge that is narrow and esoteric” (p. 15) is expected.

Science education remains wedded to educating every student to a level from which they could become expert scientists. It is as if science teachers and science curriculum writers believe that the only way a citizen can cope with the requirements of a technological society is to never need to trust the expertise of a professional scientist. At the same time, we do not transmit to our future professional scientists any sense of the complexity and social embeddedness of the work they are about to undertake. (Smith & Gunstone, 2009, p. 13)

Smith and Gunstone (2009) argued that future scientists would be best served by an education system that inculcated the social and cultural aspects of science “in the company of his or her fellows who will not go on to be scientists” (p. 14).

Young (2014) questioned if a “science education for all should be based on an introduction to the concepts and methods of physics, chemistry and biology” (p. 11),

and offered the view that such a science foundation may be best reserved for those students with aspirations to be scientists. However, he acknowledged that such differentiation would have other implications:

The related question, if such a foundation is not appropriate for the majority of pupils who are unlikely to be future specialists, does this not imply that the science curriculum must be differentiated at some relatively early stage of secondary schooling? A differentiated curriculum raises the question as to the basis on which pupils are selected (or allowed to choose) their curriculum and the principles on which the curriculum is differentiated? (p. 11)

In addition to certain core concepts in science, that schools in New Zealand should also be teaching nature of science ideas “is seen as a way to address several persistent challenges in science education” (Hipkins, 2012, p. 5). This idea is further discussed in Section 3.1.4.

Concern about predicted shortages of science, technology, engineering and mathematics (STEM) graduates in many OECD countries has been noted (Beck, 2013; Bennett, Lubben & Hampden-Thompson, 2013; Osborne, 2003; Prinsley & Baranyai, 2015; Reiss & White, 2014).

Educational curricula in contemporary societies cannot escape powerful demands to select and prepare a significant (and growing) fraction of the nation’s children to become specialists of one kind or another. In some ways, such pressures are increasing. They are driven by global competition, especially in subjects related to those sectors of modern economies that really are ‘knowledge-driven’. (Beck, 2013, p. 188)

Twenty years of A-level data in England were analysed by Bennett, Lubben and Hampden-Thompson (2011). Their work showed that the percentage of entries in Chemistry dropped over that twenty year period from 6.8% to 5.2%, and in Physics from 6.2% to 3.6%. It was these data that provided the context for their study into factors within secondary schools that influence students’ subject selection in the STEM (Science, Technology, Engineering and Mathematics) *pipeline* in secondary schools. Bennett et al. (2013) noted several implications in terms of policy and practice to improve uptake of chemistry and physics in the years at school that are post-compulsory science. These suggestions included providing “diversity in the curriculum prior to subject choice, such that it offers a range of choices for students with differing aptitudes for science” (p. 687). Providing authentic opportunities for students to engage with science-related organisations was also considered by these authors a useful strategy for improving the uptake of STEM subjects, and echo the views of Gluckman (2011).

In New Zealand, analysis of NCEA enrolments showed evidence that a significant drop off in enrolments in science subjects from Level 1 (where the study of science is generally compulsory in schools) to Levels 2 and 3 (McKinley, Gan, Buntting & Jones, 2014). The implications of such a drop in senior secondary science enrolments for both filling the STEM pipeline and growing a scientifically literate citizenry has been noted in New Zealand and internationally (Lederman, Antink, & Bartos, 2014; McKinley et al., 2014). Reiss and White (2014) argued that there is an important place for applied science and mathematics learning, even if traditionally such learning “is often considered of lower intellectual worth” (p. 86) than that of the *pure* forms of these disciplines. Applying an aims-based curriculum approach to science education, one of the functions then:

...is seen as enabling students to better appreciate the contribution of science to our cultural milieu, or ‘background’ as we put it here. Big ideas are more important in this than specifics, and accumulating knowledge is in the interests of reflection on and discussion about the bigger picture that is being put together. (Reiss & White, 2013, p. 16)

3.1.4 Curriculum development in New Zealand.

NZC may be seen as a curriculum document in two parts (Section 2.2.1). The *front* end focuses on values and principles, and seems philosophically aligned with the aims-based curriculum vision of Reiss and White (2013) when they wrote that “schools’ main job should be to nurture desirable dispositions in every learner” (p. 99). However, the *back* of the *NZC* follows traditional lines with its subject divisions and stated achievement objectives for each. *NZC* emphasizes inter-relationships, and directs the fundamental nature of the values and competencies for life-long learning.

In 1993, the first outcomes-based national curriculum, *Science in the New Zealand Curriculum*, was published. Hipkins (2012) describes the subsequent publication of separate curricula for Biology, Chemistry and Physics in this country and the omission of Nature of Science (NoS) learning objectives from these:

Although most students continued to study one combined science course at Year 11 (Level 6) the three supplementary curricula allowed for expanded specialist courses at this level as well. In a telling development, all three specialist subject curricula dropped the NoS strand of the full science curriculum. (Hipkins, 2012, p. 8)

Re-writing of the 1993 curriculum led to the 2007 *New Zealand Curriculum*, which was “explicitly designed to enable school-specific curriculum development” (Hipkins, 2012, p. 11). Hipkins (2012) offers insights into the MOE directives and the processes undertaken to achieve these by the developers of the current national

curriculum. Firstly, the *front end* of *NZC* with its vision statement, principles, values and competencies aimed “to reflect wider societal changes within the structure of the national curriculum” (Hipkins, 2012, p. 9). Secondly, the curriculum development team were tasked with *substantially* reducing the number of learning objectives of the 1993 curriculum, with a view to making the curriculum content more manageable for teachers to implement.

The intention was to bring the bare bones of the still recognizable learning areas together into one slim “framework” document. The work of every subject team began with this pressure to reduce and streamline existing content as a frame of reference. (Hipkins, 2012, p. 10)

In line with this intent for streamlining, the science curriculum design team advocated for the integration of the NoS and investigation aspects of the 1993 curriculum. Hipkins (2012) explained how the development of overarching aims for each of the five strands of the science curriculum (Nature of Science, Living World, Planet Earth and Beyond, Physical World, Material World) were intended to clarify the purposes for learning science. These aims were in addition to the *Essence Statement* (see Section 2.2.4), which highlights NoS. However, the aims for the science learning area were published separately from the *NZC* document.

Unanchored from the main *NZC* document, they were arguably easily lost sight of. This could be one reason that teaching the content of the contextual strands continued to be seen as the dominant purpose for the learning science. (Hipkins, 2012, p. 10).

Furthermore, Hipkins (2012) commented that the *NZC* “resulted in the NoS strand carrying a very heavy change burden” (p. 10) through its four substrands: Understanding about science; investigating in science; communication in science; participating and contributing. She went on to refer to “benign neglect of its change intent” (p. 11), with regard to teachers’ enactment of NoS in their implementation of the science learning area of the *NZC*. For example, citing evidence from a 2012 ERO report, Hipkins (2012) noted that in evaluating the implemented science curriculum in 100 primary schools, more than two thirds of the schools did not have effective science programmes.

Bull (2015) described further curriculum development in New Zealand whereby five provisional *science capabilities* have been introduced. The rationale for the development of the science capabilities provided by Bull is the vision for young New Zealanders to become scientifically literate citizens, with a functional knowledge of NoS. The science capabilities were described as being a “*set of ideas for teachers to think with*, in an attempt to support teachers to refocus their thinking” (Bull, 2015, p. 1). The science capabilities were published online (Ministry of

Education, n.d.-b) and comprise five capabilities: Gathering and interpreting data, using evidence, critiquing evidence, interpreting representations of science, and engaging with science. The inter-relationship of these capabilities is represented in Figure 3.1, reproduced from Bull (2015).

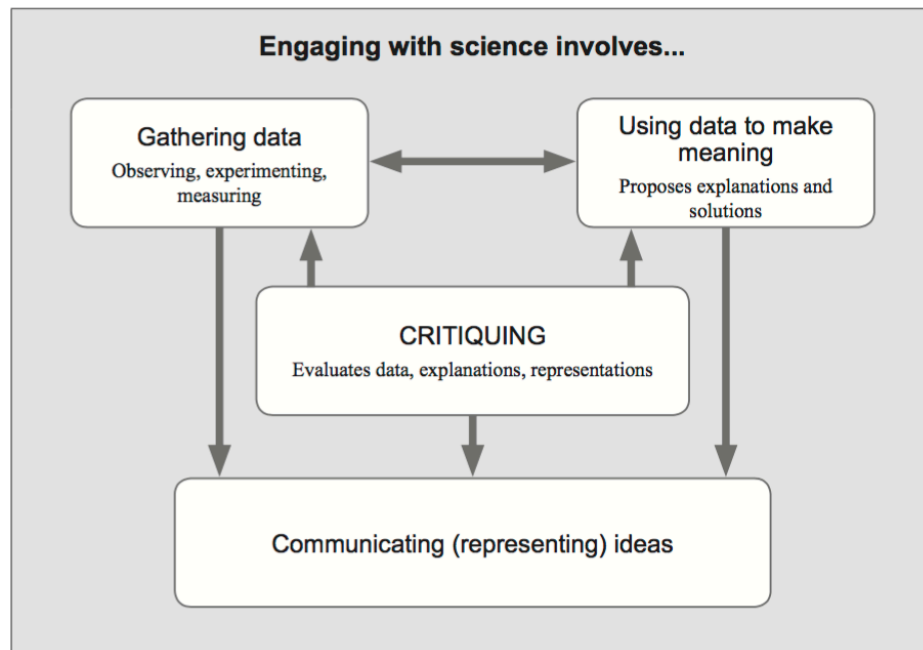


Figure 3.1. Reproduced from Bull (2015): Model of science capabilities.

It is noted that *asking questions* is omitted as one of the five capabilities in the model put forward by Bull (2015), and in that regard differs from the eight scientific practices defined by Osborne (2014), which are described in Section 3.2.2.

Schools were to have fully implemented *NZC* early in 2010. Given that two of the three case schools in this research are independent schools, it should be noted that independent (private) schools in New Zealand are exempt from having to follow the national curriculum; so avoiding possible issues as raised by Reiss and White (2013) in terms of the non-compliance with a national mandated curriculum in England.

Reviews of early progress towards full implementation of *NZC* by schools showed that the extent of progress towards implementation varied (Cowie, Hipkins, Keown & Boyd, 2011; Schagen, 2011). Positive outcomes were recorded in early adopter schools, but new tensions also emerged:

NZC gives schools the freedom to design local curriculum but the sense that content must be “covered” has not gone away: in senior secondary schools, NZC and NCEA requirements must be reconciled... (Cowie et al., 2011, p. 9).

That the NCEA strongly influences teachers in terms of their curriculum thinking was also noted in later work by Hipkins (2015).

The task of implementing NZC is a complex and challenging one, as discussed by Hipkins, Johnston and Sheehan (2016). It requires schools to build their own curricula, integrating the principles, values and key competencies of the front end of NZC with the objectives of the learning areas at the back. Hipkins et al. (2016) asserted the “the two-halves structure of the framework has contributed to the neglect of the more visionary aspects of NZC at the expense of what is assessed” (p. 29).

Teachers’ practice in relation to *learning to learn*, one of the foundational principles of NZC, was explored by Hipkins (2015). That report was based on national survey data collected in 2012. One conclusion from this work was that “enacting aspects of learning to learn requires real changes in what teachers see as the main purpose(s) for teaching and learning in their subject areas” (Hipkins, 2015, p. xii). That *learning to learn* had not been the focus of any “systematic programme of professional learning for NZC implementation” was noted (Hipkins, 2015, p. 23). The extent to which implemented curriculum reflects the NZC principle of *coherence* was also critiqued by Hipkins et al. (2016). This aspect is taken up in Section 3.4 as part of the review of the literature relating to the fragmentation issue and the NCEA.

Science education research in recent times has focused not only on science teacher beliefs, but also on how these beliefs influence teacher practice (Bryan, 2012; Lumpe, Czerniak, Haney, & Beltyukova, 2012). Pajares (1992) offered a distinction between beliefs and knowledge: “Belief is based on evaluation and judgement; knowledge is based on objective fact” (p. 313). Such beliefs may be either espoused beliefs, or inferred from practice. Evidence for espoused beliefs might be gathered through interviews, questionnaires and Likert-style surveys, whereas inferred beliefs are based on observation of practice, and in more recent times through the recording of classroom practice. Bryan (2012) reported studies on science curriculum innovation that “document the critical relationship between teachers’ beliefs and instructional decisions that demonstrate that *teachers’ beliefs mediate the curriculum implementation process*” (p. 483; the emphasis is original). The significant implications for science curriculum reform were put like this by Bryan (2012):

Research on science learning tells us that learning begins with the existing beliefs and knowledge of learners. If gains are to be made in terms of reforming science teaching, then science educators must tailor instruction to address the beliefs and knowledge of

those who are expected to enact the changes. Ignoring or marginalizing the role of teachers' beliefs in the process of improving science education is essentially the same as ignoring the role of students' existing beliefs and knowledge in the process of learning science. (p. 492)

3.1.5 Mandated versus implemented curriculum: Summary.

This section of the literature review has provided relevant background to this research by considering what is meant by *curriculum*; international directions in curriculum reform; the importance of science education for all students; and historical perspectives on curriculum development in New Zealand.

Globally, there is a trend towards the development of student-centered curricula. The literature shows that different perspectives exist in terms of what should be selected by curriculum writers as knowledge that is important for students to know, and how that knowledge might be organised. In science education, there is clear emphasis on developing students' substantive *and* procedural understandings. However, a consensus on how to best educate both citizens and future scientists is yet to be reached. Nature of Science learning is prioritised in contemporary curricula and in *NZC*, Nature of Science is seen as the overarching strand. Experimental science courses in the IBDP also include such NoS aims.

The literature also raises the issue that in reality, the planned and taught curriculum are likely to be significantly and potentially negatively influenced by reporting of students' assessment data. Negative consequences of high stakes assessment on the taught curriculum include the narrowing of curriculum, and a reported emphasis on rehearsal-type teaching strategies aimed at improving achievement statistics. In regards to this aim, it has been suggested that schools may be operating more like small businesses, with a focus on measureable outcomes. In New Zealand, there are reports indicating a need to reconcile the requirements of full implementation of *NZC* within the framework of the NCEA qualification. Selected assessment literature is more fully reviewed in Section 3.3; implementation of the NCEA in Section 3.4; and the IBDP in practice in Section 3.5.

Thus, it is evident from the literature that tensions exist between curriculum policy and implementation, and this provides context to the exploration of enacted curriculum (*NZC* and IBDP) reported in this thesis.

3.2 Pedagogy in science education.

While several definitions of pedagogy exist, that of Dillon and Manning (2010) is given here. They defined pedagogy such that it “implies the whole philosophy and value system that leads teachers to make the choices they do in what and how to teach” (p. 9). The traditional image of science as an area of unproblematic knowledge, comprising right answers underwent a paradigm shift in the 1970’s (Carr et al., 1994). Smith and Gunstone (2009) highlighted how so in referring to the following list as being the necessary knowledge for scientifically literate learners:

...that science has limits – it cannot predict or explain everything and there are other ways of understanding the world; that science is done by people, or by groups and networks of people – it is a human activity and therefore not 100% infallible; that scientific evidence is not always conclusive – decisions are not made on scientific grounds alone but by weighing up benefits, risks, and probabilities; that science does change over time (albeit slowly) and across cultures and nations; and that above all, science proceeds in a social, moral, spiritual, and cultural context. (Smith & Gunstone, 2009, p. 14)

Along with this reconceptualisation of science, the learning theories that guide the teaching of science (and chemistry) have also undergone change, as considered below, with implications for traditional transmission (teacher to student) teaching strategies.

Inquiry into students’ learning of chemistry is outside the scope of this research. However, the inclusion of a brief review of key learning theories is given in the following section of the thesis, on the basis that the influence of such theories are likely to inform the espoused beliefs and observed teaching practices of participants in this study. Constructivist theory is also purported to underpin the written curriculum documents relevant to this research: *NZC* and *IBDP*.

Following the brief consideration of learning theories, teaching strategies considered to be effective in science education are reviewed in Section 3.2.2. This review of effective pedagogies in teaching science provided a frame for the instrument design for this study (see Section 4.5). A synthesis of strategies relevant to science teaching in general is first presented, then approaches specifically relevant to teaching chemistry are reviewed from selected literature in Section 3.2.3.

3.2.1 Learning theories.

Four influential general theories of learning may be discerned and considered as particularly relevant to science education: Cognitive development, constructivism, behaviourism, and social learning theory (Barker, 2005; Driver & Oldham, 1986; Gunstone, Hand, & Prain, 1990; Hall 2003; Hohenstein & Manning, 2010; Taber, 2014). James (2006) posited that science teaching and assessment practice should be congruent with these general learning theory frameworks. While learning theories are reviewed below under separate sub-headings, it has been stated (Hall, 2015, *pers. comm.*) that:

- no single theory of learning has a complete explanation;
- explanations of behaviour in terms of learning are contestable;
- actual learning can usually be explained satisfactorily by more than one theory;
- a teacher is very likely in their teaching practice to be eclectic in their use of learning theories; and
- teachers might often be unaware that they are demonstrating particular facets of different theories.

The IBDP and NZC curricula with regard to cognitivist, constructivist, and behaviourist frames are then considered in the following sections.

Stage theories of cognitive development.

Central to the stage theorist Piaget's work, were epistemological questions into the nature of knowledge and how that knowledge might develop (Sjoberg, 2007). Fundamental to developmental learning theories is that as learners mature, they make progress through different stages of intellectual ability.

Piaget considered there to be four stages of cognitive development: Sensorimotor, preoperational, concrete operational, and formal operational. The last two of these, the concrete and formal operational stages, might be considered most relevant to this work on teaching chemistry in upper secondary school, as these two developmental stages relate to learners in adolescence through to adulthood. At the concrete operational stage learners may solve problems relating to concrete objects, whereas the formal operational stage is characterised by the ability to think in terms of abstract concepts (Santrock, 2008).

Arguments exist in the literature that Piaget's work may have over-estimated the abilities of pupils, and later researchers have further refined them (Childs, 2009; Driver, 1982). Other developmental theorists have also been influential, including Bruner (Barker, 2005).

Piaget's stage theory was influential in science education and curriculum projects in the 1970s. In his historical account of Piaget's work, Sjoberg (2007) wrote that Piaget's scientific and mathematical background, and the language he used in his work, was one reason for his appeal to science educators. Sjoberg (2007) acknowledged Piaget's use of the term constructivism from the 1920s. Newer developments in thinking, based on Piagetian perspectives, emerged in the late 1970s and led to constructivist theory in science education (Sjoberg, 2007).

The work by Piaget has been influential in curricular development in the United Kingdom, where students may pass through four 'key stages' of their education (Osborne & Dillon, 2010b). Barker (2005) has indicated that developmental theory has influenced the structure of the national curriculum in New Zealand, both in and across learning areas, although it is perhaps not exactly clear the way and to what extent developmental theory is linked to NZC.

Constructivism.

As a simple distillation of constructivism, learners are viewed as actively building their understanding, and learning is seen as conceptual change (Bell, 1993; Driver & Bell, 1986; Driver, 1982). Hohenstein and Manning (2010) summarised constructivism as a theory that recognises that "learners create new mental schemas (concepts, ideas, theories) based on previous knowledge (and/or stage of development) and that learning is directly correlated with their motivation to learn" (p. 72). Ultanir (2012), saw common aspects in the pedagogical perspectives of Dewey, Piaget and Montessori in that each agrees on the "acquisition of knowledge and learning is about constructing meaning as opposed to passive reception" (p. 208).

Driver and Bell (1986) listed the characteristics of constructivist learning theory thus:

1. Learning outcomes depend not only on the learning environment but also on the knowledge of the learner
2. Learning involves the construction of meanings. Meanings constructed by students from what they see or hear may or may not be those intended. Construction of a meaning is influenced by our existing knowledge.

3. The construction of meaning is a continuous and active process.
4. Meanings, once constructed are evaluated and can be accepted or rejected.
5. Learners have the final responsibility for their learning.
6. There are patterns in the types of meanings students construct due to shared experiences with the physical world and through natural language. (p. 454)

Constructivism has evolved as an influential learning theory in science since the mid 1980's and it takes several forms with some apparent blurring of the distinctions between these: radical, social and contextual constructivism (Baviskar, Hartle, Whiney, 2008; Cobern, 1993; Driver, 1982; Joldersma, 2011; Windschitl, 2002).

Constructivism as a current leading learning theory in science education has, however, faced some criticism. Wink (2014) reviewed what he termed the “vibrant controversy” (p. 617) in chemistry education over constructivism. He referred to confusion about what constructivism refers to when applied to chemistry education. Wink (2014) distinguished between pedagogical constructivism and philosophical constructivism. In this point of view, Wink echoes the views of Baviskar, Hartle and Whitney (2009), where those authors claimed that “constructivism is often either misused or misunderstood” (p. 541). That constructivism “is a term that should be used with caution” was argued too by Sjoberg (2007, p. 1); he pointed to the low precision in the definition of the term constructivism in the literature. Furthermore, he suggested that the proliferation of qualifiers (such as radical, contextual, sociocultural) used in referring to constructivism added to the potential for misunderstandings to arise (Sjoberg, 2007).

Other criticisms have centered on teaching approaches stemming from constructivist theory. Mayer (2004) noted that active learning, has been inappropriately interpreted by educators as requiring learners to be physically active, and argued strongly that minimal guidance and discovery-based teaching methods are inadequate. Instead, Mayer (2004) argued for teachers to ensure learners are cognitively active and use guided instruction approaches.

In reviewing national curriculum development in New Zealand since the 1990s, Coll, Dahsah and Faikhamta (2010) commented on the learner-centered nature of the national curriculum documents, and therefore their congruence with constructivist theory, even though these researchers stated that “the curriculum developers themselves were curiously reluctant to label them ‘constructivist’ ” (p. 5).

In a summary of approaches to teaching and learning in the IB Diploma Programme, it is stated that:

From its beginnings, the DP has adopted a broadly constructivist and student-centered approach, has emphasized the importance of connectedness and concurrency of learning, and has recognized the importance of students linking their learning to local and global contexts. (International Baccalaureate Organisation, n.d.-c)

So, the two curricula that form the frame for this research (NZC and IBDP) appear informed by constructivist learning theory.

Radical constructivism.

Ernst von Glasersfeld (2013) described radical constructivism as an “unconventional approach to problems of knowledge and knowing” (p. 1). He clarified this by adding that a thinking individual has no choice but to construct what they know based on their own experiences. He argued that experiences are subjective, and even when one believes that their experiences may be the same as those of someone else, one cannot be sure that it is the case. Glasersfeld asserted that it is the learners’ understanding which matters most. Radical constructivism theory “encourages the learner to be an active participant in the learning process” (Joldersma, 2011 p. 277).

Social constructivism.

Social constructivism is a theory that considers knowledge that is shared between the members of a group or culture (Baviskar et al., 2009). Solomon (1989, 1993) argued that doing science is a social activity, which is governed by the rules of any group activity. Solomon went on to make the case that social construction of knowledge starts from the time a student enters the laboratory and affects all learning, including understanding of science concepts, whether the teacher posed the questions or questions were derived from the activity that students engage in. Put simply, McRobbie and Tobin (1997) stated that “social constructivism recognises the importance of social and personal aspects of learning” (p. 194). In the New Zealand classroom both practical work and group work are promoted as preferred pedagogical approaches, which highlights the important position this theory of learning holds in this context.

Contextual constructivism.

Coburn (1993) highlighted the importance of culturally based beliefs held by students and teachers in the construction of new knowledge. This cultural context is “created by, for example, social and economic class, religion, geographical location,

ethnicity, and language” (Cobern, 1993, p. 1). For new knowledge to be constructed such that it is personally meaningful for the learner, Cobern (1993) notes it must be consistent with the learner’s personal and individual knowledge; their “conceptual ecology”.

Behaviourism.

This theory is centered on the idea that cognitive processes in the mind are unobservable and therefore may be disregarded. Instead the focus for the behaviourist is on the observable inputs and outputs to determine possible impacts on learning (Scott, 2016). Various classroom strategies in the form of extrinsic rewards and consequences are derived from this theory.

It may be argued that the OBE model of education in New Zealand (Section 2.1), framed in terms of achievement objectives and learning outcomes, aligns more closely with behaviourist learning theory than other philosophies of learning (Hall, 2005, 2007). Behaviourism recognises operant conditioning as a main form of learning. The central idea is that the consequences (pleasant or unpleasant) of a behaviour will influence whether that behaviour is repeated, or not. So strategies are developed that may encourage certain behaviours and discourage others (Hall, 2003). In the context of the NCEA, credit accumulation and endorsements may be viewed as tools that encourage extrinsic motivation. Furthermore the move to “training” students to pass may be seen as akin to behaviourist philosophy of learning.

Social learning theory.

Two inter-related aspects of social learning theory as an explanation of socially learned behaviour are the significance of learning by modelling (that is by observation and imitation), and self-efficacy (Hall, 2003). Commentary on the extent to which these concepts were evident in the case schools in this study would have relied on the collection of interview data from students, which was beyond the scope of the design of this research.

In summary, while it is clear that different theories might be evoked in developing an understanding of student learning, it is the phenomenon of *teaching* chemistry that is the primary focus of this research. This then leads to the following review of selected literature relating to effective strategies for teaching science, and then more specifically, approaches to teaching chemistry.

3.2.2 Teaching strategies in science education.

There appears some general agreement in the literature about what students need to learn in science. This comprises: Conceptual understanding, procedural understanding, and an understanding about the nature of science. More recently, scientific literacy has been added to this list by some authors (Abd-El-Khalick, 2013; Hodson, 2014; Osborne, 2014). Relevant to this research is review of selected literature concerning strategies that may be used by teachers to help students to construct these understandings in science.

Driver (1982), an early proponent of constructivism in science education, believed that teachers using constructivist approaches in teaching need to be aware of children's pre-existing ideas; use a range of strategies which encourage students to reflect; and construct meanings which lead to conceptual change. Driver (1982) remarked:

If conceptual learning involves such a major restructuring of ideas, then this has implications for instruction; we may need to pay as much attention to the learner's current ideas and how they change as we do to the structure of the knowledge to be taught. (p. 75)

Baviskar, Hartle, and Whitney (2009) proposed four essential features of constructivist pedagogy; "eliciting prior knowledge, creating cognitive dissonance, application of new knowledge with feedback, and reflection on learning" (p. 541). They suggested that these four criteria would be a useful framework for evaluating whether or not a teaching approach is constructivist.

Minner, Levy and Century (2010) argued that the development of inquiry-based instructional approaches in science education arose from constructivist theory. These authors suggested that different levels of teacher direction may apply, so distinctions of *open* and *guided* inquiry may be made. However, beyond investigation, these researchers did not find a correlation between improvements in learning outcomes for students and high saturation levels of inquiry based teaching. Osborne (2003) in his review of attitudes towards science, cited common aspects of effective teaching:

- clear goals for pupil learning;
- clarity of communication of lesson goals and agenda to pupils;
- use of preview and review of lesson content;
- helping students to contextualise content in terms of their own experience and knowledge, as well as in terms of other teaching goals and learning experiences;
- some willingness to allow pupils to have input into goal and agenda setting;

- a supportive social context designed by the teacher to help pupils feel accepted, cared for and valued;
- an ability and willingness to allow for different cognitive styles and ways of engaging with the learning process among pupils, through multiple exemplification, and the use of different types of illustration and mode of presentation, and offering pupils a choice from a menu of possible ways of engaging; and
- a willingness to take into account pupil circumstances and to modify/ pace/ structure learning tasks accordingly. (Osborne, 2003, p. 1067)

The preceding list appears consistent with the views of McRobbie and Tobin (1997) in terms of the stated significance of student involvement, autonomy and the relevance of content to students in social constructivist learning environments. Having fewer goals for any practical activity, and articulating the intended learning, were critical in Abrahams and Millar's view (2008).

That there are problems with an inquiry based approach to science education is noted in the literature (Abd-El-Khalick, 2013; Hodson, 2014; Osborne, 2014); the argument has been made that there is a conflation of the work done in science (*the doing of*), with the *learning of* science. Osborne (2014) explored the rationale for, and implications of, recent changes to science education standards in the United States of America. These comprise a shift from teaching science as a process of inquiry, towards the teaching of explicit scientific practices. Hodson (2014) argued that, whereas inquiry is a tool of the practising scientist and centres on the methods of scientific investigation, the learning of science through an inquiry-based approach is broader than that. Furthermore, that because investigation/inquiry lies at the heart of doing science, there has been the assumption made in written and implemented curriculum, that investigation and inquiry "should be central to science education" (Hodson, 2014, p. 2538).

Osborne (2014) also noted the evident ambiguity of the term 'inquiry' with the implication being that "any activity that is of a hands-on nature can be considered to fulfil the basic requirements of this pedagogic approach" (p. 178). The choice of successful teaching methods in science depends on teachers being clear about the intended learning goals, and sharing these with students (Hodson, 2014; Millar, 2011). Hodson made the distinction between four main types of learning outcomes: Learning science; learning about science; doing science; and addressing socio-scientific issues. Abd-El-Khalick (2013) concurred with Hodson in that careful planning by teachers when selecting appropriate teaching strategies is necessary. He also drew attention to the embedded and persistent linking of the teaching of

NoS with inquiry strategies in the education literature, but argued that improved understandings do not just emerge from engagement with inquiry.

Osborne (2014) put forward the view that eight scientific practices (refer Table 3.1), as defined in the *Framework for K-12 Scientific Education* (Quinn, Schweingruber, & Keller, 2012), offer a significant progression from an inquiry approach.

Table 3.1
Eight scientific practices from the Framework for K-12 Science Education (Osborne, 2014)

Scientific practises
Asking questions and defining problems
Developing and using models
Planning and carrying out investigations
Analysing and interpreting data
Using mathematical and computational thinking
Constructing explanations and designing solutions
Engaging in argument from evidence
Obtaining, evaluating and communicating information

Following is a summary of the pedagogy advocated by von Glasersfeld based on a radical constructivist frame:

- (1) teaching involves creating opportunities for students to trigger their own thinking;
- (2) teachers not only need to be familiar with the curricular content, but they must also have available a repertoire of didactic situations in which such conceptual content can be naturally built up in a way that sparks the students' natural interests;
- (3) teachers need to realise that students' mistakes are not wrong as such, but are predictable solutions on the way to more adequate conceptualisation;
- (4) teachers need to understand that specialised words in academic disciplines do not have the same meaning for a student as they do for the expert, and teachers must have an idea of the students' present concepts, ideas, and theories; and
- (5) teachers must realise that the formation of concepts requires reflection, something accomplished by conversations among students and with the teacher. (Joldersma, 2011, p. 277)

Components describing an effective teaching practice framework that aimed to widen perspectives on pedagogy were developed in 2000–2004 as part of a major initiative (School Innovation in Science – SIS) to improve science teaching and learning in Victoria, Australia (Tytler, 2009). These components are summarised here, and are relevant to this research as this framework provided the basis for lesson observation instrumentation (see Chapter Four, Section 4.5.2). The School

Innovation in Science (SIS) components (from Tytler, 2009, p. 1781) relating to effective teaching and learning in science are:

1. Encouraging active engagement with ideas and evidence
2. Challenging students to develop meaningful understandings
3. Linking science with students' lives and interests
4. Catering for individual students learning needs
5. Embedding assessment within the science learning strategy
6. Representing the nature of science and its different aspects
7. Linking science with the broader community
8. Exploring learning technologies for their learning potentialities

The framework of Tytler (2009) appears to share common ground with the elements of effective pedagogy described in *NZC* (Ministry of Education, 2007):

While there is no formula that will guarantee learning for every student in every context, there is extensive, well-documented evidence about the kinds of teaching approaches that consistently have a positive impact on student learning. This evidence tells us that students learn best when teachers:

- Create a supportive learning environment
- Encourage reflective thought and action
- Enhance the relevance of new learning
- Facilitate shared learning
- Make connections to prior learning and experience
- Provide sufficient opportunities to learn
- Inquire into the teaching-learning relationship (p. 34)

NZC also notes the significance of ICT to enhance the teaching approaches listed above (see Section 2.2.2). An example of an investment in new technologies to support teaching and learning is the *New Zealand Science Learning Hub (SLH)*; an online resource collection that developed from collaboration between “research organisations, industries, science educators and teachers” (Cooper, Cowie & Jones, 2010, p. 97). It is promoted as a means of offering quality, locally-relevant resources through a wide range of contemporary science contexts to support the teaching of typically Years 9–10 students. Bunting (2012) identified several possible ways of using ICTs in innovative science education, including facilitating peer collaboration, and having students working *with* and *as* scientists. The New Zealand government

owned company, *N4L*, provides network management services (fully-funded) for all state and integrated schools. One significant initiative developed and managed by *N4L* is *Pond*, an online platform offering many online communities for educators with specific interests.

Shulman (1987) claimed that an effective teacher will emphasise to students what is “essential about a subject and what is peripheral” (p. 9). However, while there may be science context specific challenges for learners, a counter-claim is that the overall process of developing learners’ understanding in science should be the same as in other subjects (Hohenstein & Manning, 2010).

The inter-relationship of content and pedagogical knowledge has been termed Pedagogical Content Knowledge (PCK) (Aydin & Boz, 2013; Childs, 2009; Shulman, 2002). Shulman (1987) defined PCK as follows:

It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. (Shulman, 1987, p. 8)

Studies into the development of PCK in beginning and experienced teachers have shown that it leads to a better alignment of subject content and pedagogy, which in turn facilitates improved understanding by students (Drechsler & Van Driel, 2008; Loughran, Mulhall & Berry, 2008). There is acknowledgement that PCK is complex, and there is some debate as to the best approaches to developing teachers’ strengths in this aspect (van Driel & Berry, 2012).

This implies that professional development programs aimed at the development of teachers’ PCK should be in ways that closely align to teachers’ professional practice, including opportunities to enact certain (innovative) instructional strategies and materials and to reflect, individually and collectively, on their experiences. (van Driel & Berry, 2012, p. 27)

The significance of reflective practice by teachers’ with regard to improving teaching and learning has been highlighted too; with differences in terms of whether student difficulties or teacher performance was the primary concern (Drechsler & Van Driel, 2008; van Driel & Berry, 2012). Osborne (2014) suggested that teacher educators are required to lay foundations for disciplinary knowledge, together with procedural and epistemic knowledges, with a view to future science teachers being able to further develop and extend their PCK through their careers. This stance is in the context of recent curriculum developments in terms of stipulated scientific practices.

In the United Kingdom, a professional development programme, *Getting Practical*, aimed to support teachers in implementing effective practical work in science (Abrahams, Reiss & Sharpe, 2014). The approach of the *Getting Practical* programme was both “hands-on” and “minds-on” (p. 264), and aimed to support teaching:

The course materials were designed to help teachers reflect on and improve: (1) the clarity of the learning outcomes associated with practical work; (2) the effectiveness and impact of practical work; (3) the sustainability of this approach within their schools, allowing for ongoing improvements; and (4) the quality, rather than the quantity, of practical work used. (Abrahams et al., 2014, p. 264).

Despite the claims by participant teachers, that the *Getting Practical* programme had had positive impacts on their practice, the findings showed the programme had made little headway into effecting change (Abrahams et al., 2014). In New Zealand, Kennedy, Smith and Sexton (2015) reported on the success of the Sir Paul Callaghan Science Academy as a professional learning body tasked with providing support for teachers in the implementation of the science curriculum in New Zealand. The academy aims to help teachers to raise student interest in science.

In summary, the selected literature reviewed in this section of the thesis points to several effective strategies that might be used by teachers to develop students’ understandings in science. It has been reported that teachers should be clear about the intended learning goals, articulate these clearly to their students, and undertake careful planning with regard to the selection of teaching strategies. That teachers should be reflective in their practice with regard to ongoing improvement in teaching and learning is apparent from the literature. Also considered fundamental to good practice, is the development of teachers’ PCK throughout their careers, with opportunities being available to teachers for appropriate professional development in that regard.

3.2.3 Approaches to teaching chemistry.

The preceding section considered what is put forward in the literature in terms of effective strategies for teaching science in general. The literature also raises particular challenges in teaching chemistry, and claims are made that some domain-specific approaches are appropriate. These approaches are considered in this section of the thesis. While it is the phenomenon of teaching chemistry in the upper secondary school context that is central to this research, selected literature reporting on studies undertaken in the tertiary sector was also considered relevant for two reasons. Firstly, in that the issue of student preparedness for tertiary study is one

aspect of this research study (see Section 4.5). Secondly, it seemed reasonable, given the similarities in the scope of undergraduate level (especially first year university) courses and upper secondary chemistry courses, that there would be parallels in the teaching of each.

Why should the teaching of chemistry be different to the teaching of other science disciplines? The answer lies in the nature of matter and how it might be conceptualised by and for learners. In a review of the influential conception of the *chemistry triplet*, Taber (2013) observed that the *paradigmatic* model of chemistry knowledge as originally published by Johnstone in the early 1980's, is now taken for granted by chemistry educators. The model illustrates how students of chemistry must transition between three aspects of the subject: the macroscopic, sub-microscopic and symbolic. While there is a demand for students to be mentally agile between these aspects of the subject, it was pointed out by Taber (2013) that educational psychology gives evidence for the working memory to be limited in capacity. The implications for pedagogy argued by Taber (2013) are that as sub-microscopic models provide explanations for the macroscopic, and that symbolic representations of phenomena are also required, it may be better for the breadth of curriculum to be reduced; for teaching pace to be slowed; and for teachers to offer scaffolded support so that novice learners might better engage with all three inter-related parts of the chemistry triplet. There is a range of topics of chemistry that have raised specific pedagogical challenges for educators. One such topic is organic chemistry. Graulich (2014) called for urgent research into effective instructional strategies to improve students' understanding of organic chemistry concepts, such as the purpose of Lewis structures, and writing reaction mechanisms using curly arrow formalism. Anderson and Bodner (2008) argued that the pace of teaching and the volume of material taught, are leading to an instrumental, rule-based approach to learning of organic chemistry by undergraduate students. Furthermore, they contested that the structures and curved arrow-pushing conventions used in representations of organic mechanisms held no meaning for some students, and were a barrier to students' understanding the big ideas of the topic.

That the teaching of specific chemistry topics demand differences in teaching approaches has been explored from the perspective of teachers' PCK (PCK was defined in Section 3.2.2). Commenting on PCK in chemistry education, Childs (2009) wrote: "PCK is domain-dependent, i.e. it depends on the subject being taught and it also depends on the topic within the subject: thermodynamics, electrochemistry or organic mechanisms each have their own logic and problem

areas” (p. 194). In their qualitative study of teachers’ teaching of reduction-oxidation topics in chemistry, Aydin and Boz (2013) examined the integration of different aspects of PCK, and found that the teachers’ knowledge of learners and instructional strategies had the greatest influence on their practice. Shulman asserted that teachers with strengths in PCK will have expertise that is domain-dependent and may be seen as the primary source of student conceptual understanding of subject content. So, a chemistry teacher has a responsibility to recognise and re-package concepts for students to facilitate their understanding, and how this is done may vary depending on the topic being taught.

One strategy that takes a central place in chemistry teaching, and links to the sub-microscopic aspects of the chemistry triplet of Johnstone, is the utilisation of particle models. Harrison and Treagust (2000) studied the use of analogical models in teaching chemistry to secondary school students. They concluded that students’ understanding of abstract concepts, such as molecular structures and bonding, might be enhanced when teachers give students the opportunity to explore *different* models and their use.

In considering how to improve chemical education, Childs (2009) stated that there is “a great gulf between those who do educational research and their findings written up in research papers in journals, and those who actually do the teaching” (p. 195). Childs (2009) proposed it may be possible to close such a gulf between researcher and practitioner through improved communication by such means as professional development courses for teachers and the dissemination of new teaching materials developed from research-based evidence.

In this research, what participant teachers were using as teaching resources is one aspect of interest. What emerged from review of selected international literature (relevant to the phenomenon of teaching chemistry), was the view that resourcing for teachers had improved over the last few years. For example, The American Chemical Society (ACS) has made a significant decision to fund an American Association of Chemistry Teachers (AACT). Mahaffy (2014) comments on the implications for the development and professional support of chemistry teachers, in that the “AACT, through the ACS, can draw on a massive bank of knowledge about chemistry to enrich the set of reliable content resources for K-12 teachers” (p. 11). In the United Kingdom, Taber (2014) acknowledged the investment over many years of the Royal Society of Chemistry in supporting education in schools through the development of quality teaching resources.

Beyond resources, having sound subject knowledge, understanding the connectedness of the discipline, and the ability to simplify and explain the ideas are essential to be considered a good chemistry teacher (Childs, 2009). However, a study focusing on the subject knowledge of pre-service science teachers in the United Kingdom, led to the conclusion “that possession of a good degree in a science subject does not automatically ensure that graduates entering the teaching profession possess sound content knowledge for teaching chemistry” (Kind & Kind, 2011, p. 2154). Furthermore, these researchers argued that it was likely that the misconceptions held by the studied group of beginning teachers originated from their secondary schooling, and had not been challenged through the tertiary studies undertaken by that group of participants.

Another consideration in this research design was student preparedness for tertiary study of chemistry. Therefore, considered relevant to this study, was the literature that reported on strategies utilized in teaching students enrolling in first year university chemistry courses with diverse backgrounds in terms of prior learning (Allenbaugh & Herrera, 2014; Lawrie et al., 2013; Lewthwaite, 2014; Potgieter & Davidowitz, 2011). One means of supporting students with the demands of foundation courses is through the provision of digital resources. However, implementation of web-based resources as a means of addressing gaps, misconceptions and improving conceptual understanding of chemistry, may not be straightforward. Lawrie et al. (2013) analysed Australian first year tertiary student responses to new digital tools that had been designed to support chemistry learning outside of the lecture theatre. The student participants in this study had been assessed as having “incorrect or naïve mental models” (p. 113). However, it was concluded that these students’ motivation was low when it came to self-regulated web-based learning.

At-risk students enrolled in gateway chemistry courses were the group targeted by remedial peer-tutoring programmes in an investigation by Allenbaugh and Herrera (2014). However, in that study, the poor level of commitment shown by these low-performing (both in terms of chemistry conceptual knowledge and mathematical skills) students was considered to negate the intended outcomes of the intervention. Allenbaugh and Herrera (2014) also referred to the recognition, in both their own work and the literature, of students’ mathematical skills as a strong predictor of success in general chemistry. Investigating secondary school students’ performance of chemical calculations, Scott (2012), concluded that deficiencies in basic mathematical skills “have an obvious knock on effect” (p. 336). That there is disparity between student expectations and level of tertiary mathematics courses

and the preparedness of new undergraduates was identified as a concern by James, Montelle and Williams (2008).

Approaches reported in the literature to be effective in teaching science were reported on in Section 3.2.2. However, despite global developments in education theory and curricula, and the availability of digital technologies, it may be that traditional (transmissive) teaching practises still prevail in our classrooms (Dhindsa & Treagust, 2006; McRobbie & Tobin, 1997; Mansfield, Loughran, & Kidman, 2016). Reasons for this may be a lack of confidence in the teacher and/or disconnection between education research and effective practice (Carr et al., 1994; Childs, 2009). Additional arguments to justify transmissive approaches are a lack of teaching time, and the need to cover content. In contrast, Coll and Taylor (2001) argued for a pragmatic approach to teaching tertiary level chemistry:

In our experience, the teaching of simple factual material *is* effective by conventional transmissive means and we believe there is little to be gained from changing this teaching approach. We see little point in trying to elicit prior knowledge or negotiate understanding of substantial parts of chemistry, like descriptive organic and inorganic chemistry. The effective teaching of challenging concepts such as atomic structure and chemical bonding we believe, however, may be enhanced by a constructivist derived pedagogy. (p. 222).

Furthermore, these authors suggested that little would change in terms of teaching strategies in the absence of any appetite for reform by the stakeholders (teachers, students and parents).

Another aspect of teacher practice that is of research interest in this work, is the place of practical work in teaching secondary school chemistry courses. Teachers' views about what types of practical work to include in their chemistry teaching programmes were explored by Lewthwaite (2014). The inclusion of experiments over other types of practical work predominated, and was based on pragmatic, philosophical and psychological reasons. However, it may be that these 'experiments' were set practical tasks carried out by students with expected outcomes in mind, and so not in a true sense to be considered experiments. Concerns with carrying out investigations were in the main pragmatic ones, which included difficulties in terms of time, manageability and resource availability. However, teachers in the study were mindful about the value chemistry investigations offered to students in terms of authentic learning experiences (Leithwaite, 2014). A comparative study by Wolf and Fraser (2008) of the impact of small-scale investigation versus non-investigative laboratory work found that investigation promoted class cohesiveness. However, Osborne (2014) warned of

problems with teaching of science through inquiry, and how practical *inquiry* could be taken by teachers to mean any activity with a hands-on approach, and so result in “cookbook exercises where students simply follow a series of instruction to replicate the phenomenon”, rather than developing students’ understandings of “knowing that or knowing why” (p. 178).

Links are made in the literature between the scope of practical work, student attitudes to practical tasks, and assessment. Braund and Driver (2005) considered the perceptions of students about science as they were on the cusp of transitioning into secondary school. They reported that some of the participant Year 7 students were already aware of the connection between doing practical work in science and formal assessment in the years to come. Research in the United Kingdom (Donnelly, 2000; Jenkins, 2000) explored teachers’ views on the National Curriculum for science, and how it influenced their use of practical work. Findings of that research suggested “that some science teachers regarded curriculum requirements for practical work as a straightjacket, focused mainly on practical work (fair-test type investigations) whose main purpose is to help pupils gain good grades in examinations” (Braund & Driver, 2005, p. 86). Similar experiences have been reported in New Zealand (Hume & Coll, 2010; Moeed, 2010; Moeed & Hall 2011). Findings from these New Zealand studies are considered with the commentary on the NCEA in Section 3.4.

3.2.4 Pedagogy in science education: Summary

The literature points to the influence of general learning theories, and in particular constructivism, in science education. The written curricula that are the subject of research in this study; *NZC* and *IBDP* appear informed by constructivist theory. Characteristics of constructivist teaching approaches were reported by Baviskar et al. (2009) to include “eliciting prior knowledge, creating cognitive dissonance, application of new knowledge with feedback, and reflection on learning” (p. 541). Furthermore, for teachers to be clear about their intended learning objectives and to communicate these clearly to students, is seen as important in effective teaching approaches to science. Difficulty with the term *inquiry based learning* is noted in the literature, with confusion relating to the doing of science with the learning of science. What constitutes ‘inquiry’ is also ambiguous and questioned in the literature, as is the relationship of inquiry to improved student understanding.

Chemistry teaching evokes the *chemistry triplet*, whereby learners of the discipline are required to move between observation, sub-microscopic, and symbolic representation of changes in matter. Chemistry teachers need to develop topic

specific teaching strategies in order to best develop students' understanding. Types of practical work utilised by teachers have been broadly categorised as experiments or investigations; while investigation is seen as having merit in being more open-ended in intent, the negative influence of assessment on investigation in terms of narrowing the scope of practical investigations has been reported in several studies.

The literature reviewed here provides a basis for evaluating data collected from participant teachers in this study in terms of espoused and observed teacher beliefs and practices. Aspects of assessment and the reported impacts on implemented curriculum are explored more deeply in the following section of the literature review.

3.3 Assessment

The function and different forms of assessment are summarised in this section. Then what follows is a synthesis from selected, relevant literature of issues related to reliability, validity and manageability of assessment. According to Harlen (2005): "All assessment in the context of education involves making decisions about what is relevant evidence for a particular purpose, how to collect the evidence, how to interpret it and how to communicate it to intended users" (p. 207). As assessment is a way of communicating between an institution and the wider community, trustworthiness of results is critical (Broadfoot & Black, 2004). Hall (2006) defined assessment as the "process of judging student performance in order to assign marks and grades on formal assessment tasks or to provide information for further teaching and learning" (p. 2). Crooks (1988) pointed to the significance of assessment in that assessment can influence student motivation, their confidence and perceptions of personal competence, as well as the approaches students may take to learning.

3.3.1 Purposes of assessment.

Three accepted general purposes of assessment are:

- **Diagnostic** – assessment that takes place *before* learning. Based on the constructivist premise that students' prior learning significantly affects learning, it follows that the teacher has a role as a diagnostician (Osborne & Freyberg, 1985). Treagust (2012) highlighted the role of diagnostic assessment in improving teaching and learning in science. The importance of ascertaining students' misconception through diagnostic assessment is an essential element in a constructivist approach to science learning (Scott, Asoko, Driver, & Emberton, 2012).

- **Formative** – assessment that is *for* learning and is concurrent with learning. Assessment for learning is intended to be student centered and has been defined by Gardner (2006):

The process of seeking and interpreting evidence for use by learners and their teachers, to identify where the learners are in their learning, where they need to go and how best to get there. (p. 2)

An implication of authentic assessment for learning (AfL) is that it necessitates a change in the role of practitioners, away from primarily one of responsibility for curriculum coverage, and more towards planning of how best to actively engage and assess student understanding *in the moment* of their learning and determine the next steps (Black & Wiliam, 2006; Cowie & Penney, 2016; Klenowski, 2007). Swaffield (2011) emphasised the conception of AfL as a process (rather than as discrete tasks), and noted the apparent distortion of the underlying principles of AfL in national policy in England. In New Zealand, Cowie and Moreland (2015) highlighted the effectiveness of teaching practices that are beneficial for student participation in formative assessment.

Moeed (2015b) suggested why theorising formative assessment has proven difficult; arguing that formative assessment is actually about learning. Therefore, any theory that underpins formative assessment would have to be a theory of learning. Further elaboration on this does not add to how formative assessment was seen in this thesis, which was for preparing students for summative assessment.

- **Summative** – assessment *of* learning that characteristically takes place at the end of the learning cycle. Summative is distinct from formative assessment in its *purpose*, which could include reporting on progress to parents, certification, and as a basis for selection into higher education. Summative data of students may also be utilised to appraise relative performance of teachers and schools (Harlen, 2005; International Baccalaureate Organisation, 2004; Broadfoot, 2007).

3.3.2 Norm-referenced and standards-based assessment.

The concepts of norm- and standards-based assessment are relevant to this research, and are defined by Hall (1997, p. 1) as follows:

Norm-referenced assessment (NRA): a system of assessment whereby students are marked or graded according to their ranking or relative standing. Thus a grade A might be awarded to the top 5% of students, a grade B to the next 15% of students, and so on.

Standards-based assessment (SBA): this term is often used synonymously with 'criterion-referenced assessment', but is best seen as a subset of the broader concept. Under SBA, the focus is on educational or vocational achievement where performance is judged against preset written standards. NZQA distinguishes between two forms of SBA:

- (i) **Competency-based assessment (CBA):** students are judged to have met the standard or not (a pass/fail assessment);
- (ii) **Achievement-based assessment (ABA):** students are judged according to the level of their performance (e.g. pass, merit, distinction).

3.3.3 Assessment validity and reliability.

Validity issues are related to the extent to which assessment data should be utilised and interpreted for a given purpose (Messick, 1989, p. 5). Zumbo in Hublely and Zumbo (2011) put it neatly: "It is rare that anyone measures for the sheer delight one experiences from the act itself. Instead, all measurement is, in essence, something you do so that you can use the outcomes" (p. 219). Validity is a concept that focuses in essence on *fitness for purpose* and depends on several inter-related factors:

what balance of evidence supports the interpretation or meaning of the scores; what evidence undergirds not only score meaning, but also the relevance of the scores to the particular applied purpose and the utility of the scores in the applied setting; what rationales make credible the value implications for action; and what evidence and arguments signify the functional worth of the testing in terms of its intended and unintended consequences. (Messick, 1989, p. 5)

In evaluating the validity of assessment, a range of qualitative information may be drawn together. Construct validity relates to how well an assessment instrument measures the underlying intellectual construct that it is designed to assess. In relation to the assessment of a student's knowledge of a subject, the domain of knowledge and skills that have been studied represent the *construct* concerned. Construct validity is usually gauged through gathering various forms of evidence and drawing this evidence together (Hall, 2007b). An important component of this is the sampling of content and learning objectives (content validity). Content validity also considers "the extent to which assessment criteria have been clearly communicated to students" (Hall, 2008, p. 6). Predictive validity describes the extent that an assessment task predicts future performance in similar tasks.

The issues around the impact of assessment on individuals and education systems recognise both intended and unintended social consequences (consequential validity), and has implications for consideration of backwash effects on teachers and learners (Harlen, 2005; Hublely & Zumbo, 2011). Harlen (2005) noted that research

into the implications of high-stakes testing for teaching points to: content-focused teaching; rehearsal of model answers with students; and a transmissive teaching style. Such impacts are reviewed in Section 3.3.4.

Arguments have been made that attention in contemporary definitions of validity should comprise test interpretation *and* the utilisation of the resulting test scores (Shepard, 2016; Sireci, 2016). Sireci (2016) warned that “to ignore test use in defining validity is tantamount to defining validity for “useless’ tests” (p. 1). Kane (2016) acknowledged differing perspectives exist, such as those of Koretz (2015), who argued for a simpler definition of validity in the interests of improving *usefulness*. Specifically, what reads as significant in the ongoing debate, is whether or not to include the consequences of test score usage in considerations of validity.

There is less agreement about the role of the consequences of test use in validity. Score uses involve decisions or actions and go beyond interpretations as such. Score uses are similar to score interpretations in that both involve score-based claims that need to be justified, but they differ from interpretations in the kinds of evidence required to justify the claims being made. A score use involves a sequence of claims that culminates in a decision, and decisions are justified in terms of their expected consequences (Kane, 2016, p. 198).

Kane went on to point out that test scores might have positive or negative consequences, depending on their use:

For example, a state mandated testing programme that is used to hold schools accountable for student learning as measured by the test might help to focus attention on particularly valued parts of the curriculum and encourage higher standards of performance (positive consequences), but they might also encourage teaching to the test and contribute to a narrowing of the curriculum (negative consequences). (Kane, 2016, p. 203).

Reliability of an assessment relates to accuracy of the measurements. The reliability of an assessment depends on three different factors (Black & William, 2006; IBO, 2004): The questions that comprise the test (i.e. issues of sampling of content); any day-to-day changes in students who are sitting the assessment; and consistency (or lack thereof) of marking.

Hall (2008) listed several aspects associated with the manageability of assessment:

...the workloads of teachers and students; the amount of time needed to conduct assessments; the degree of intrusion of assessment on teaching time; the amount of supervision needed for supporting practical or workplace assessment; the extent of record-keeping required; the availability of basic resources to support the assessment (e.g., library facilities and access to computers); timetable commitments such as institution deadlines for the registering of grades; and overall costs associated with the conduct of assessments. The important point is that the assessment framework for a

programme, along with the associated frameworks for courses, should be affordable and manageable for all involved. (p. 8)

What needs noting is that most, if not all, of the above factors impact on the validity and/or reliability of assessment data.

3.3.4 Impacts of high-stakes assessment.

That tensions exist in schools between assessment (including as an accountability and/or governance measure) and implemented curriculum has been discussed by many (Harlen, 2005; Isaacs, 2014; Klenowski, 2011; O'Neill, 2015; Polesel, Rice & Dulfer, 2014; Ryder, 2015).

Negative backwash effects of high-stakes testing put pressure on students and teachers, and may include demotivation of students and, to some extent, the compromise of good teaching practice that is intended to impact on the depth of learning (Harlen, 2005; International Baccalaureate Organisation, 2004; Klenowski, 2007, 2009; Moeed & Hall, 2011). Positive backwash effects may also exist. The possible interactions between formative and summative assessment are noted in the literature (International Baccalaureate Organisation, 2004; Harlen, 2005).

Berliner (2011) asserted that a body of evidence from the United States and Great Britain documents the influence of high stakes assessment on teachers' practices.

The inevitable responses to high stakes testing, wherein students' test scores are highly consequential for teachers and administrators, include cheating, excessive test preparation, changes in test scoring and other forms of gaming to ensure that test scores appear high....Yet the most pernicious response to high stakes testing is perhaps the most rational, namely, curriculum narrowing. (Berliner, 2011, p. 287).

Studies by Chen and Brown (2013), and Gioka (2009), explored teachers' beliefs on assessment and teaching approaches, pointing to tensions between teachers' roles (as both teacher and examiner) in the classroom. That validity issues arise when teachers respond to testing pressures by undertaking extensive pre-test preparation and practice testing has been put forth too (Berliner, 2011; Shepard, 2016). Isaacs (2014) wrote about the Regents examinations in New York State, citing these examinations as "an example of the tensions that can be created when one set of measures sets out to satisfy many purposes" (p. 345).

The impact of assessment on students has also received research attention. In the tertiary sector in New Zealand, that students exhibit operant conditioning behaviours towards grading has been reported:

We found that students were assessed so frequently that all their learning was done for a grade and if there was no grade involved, then they would not study...This state of affairs resulted in an assessment arms race between lecturers who controlled student study behaviour with grading. (Wass, Harland, McLean, Miller & Nui Sim, 2015, p. 1324)

Harlen (2005) reported on the negative effect of summative assessment on student motivation. Beyond learning behaviours, however, the adverse impact of internal assessment on student wellbeing has also been a finding of empirical research (Wass et al., 2015; Education Review Office, 2015).

The connections between *NZC* and assessment through the NCEA are central to this thesis. Hipkins et al. (2016) remarked on the intent of the NCEA to allow schools flexibility in course design. They elaborated:

NZC was also designed as a flexible, minimal framework – in effect a conceptual backbone on which a more detailed local curriculum could be built by each school. Again, the intention was to encourage schools to build varied learning programmes to meet the specific needs of all their students.

There were costs and drawbacks to this flexibility. A modular assessment system, in combination with a flexible minimum curriculum framework, can result in a highly fragmented approach to course design. Teachers could and often did create courses that were simply loose aggregations of standards approached as separate curriculum topics. (Hipkins et al., p. 153)

Priestley and Sinnema (2014) posited that *NZC* provides *professional space* for teachers to make decisions about the content to be covered. However, they pointed out the risk “of content being specified for the wrong reasons: purely to meet the demands of assessment, to fit with existing resources, or simply to follow tradition, rather than through a process of thoughtful decisions about content that fits curricular purposes” (p. 70). Furthermore, they argued, high-stakes *and* low-stakes assessment leads to narrowing of curriculum.

3.3.5 Assessment: Summary.

That assessment of learning is a significant aspect of teacher practice seems well accepted. Impacts of high-stakes assessment on teachers’ practice, curriculum implementation, and changes in the learning behaviours of students has received research attention in a range of different educational settings internationally. Several tensions emerge from this assessment literature: teachers may be compromised in terms of their relationships with students by being both teacher and examiner; assessment measures may aim to serve many purposes; and that the intended and

unintended consequences of assessment have implications for teachers and learners.

It is the assessment of *NZC* through the NCEA qualification that is central to this thesis; review of the implementation of the NCEA follows.

3.4 The implementation of the NCEA in New Zealand: Research and commentary

This section begins with a summary of the rationale for changes to national assessment in this country that led to the implementation of the NCEA; puts forth the debate around the NCEA; presents the findings of relevant empirical research; and summarises the commentary around ongoing issues.

The staged implementation of the NCEA began in New Zealand in 2002 (as described in Section 2.3). The argument for the change in national qualifications was in part to move away from norm-referenced assessment (NRA), where the learners “performance is compared to others in the group. The new qualification would apply standards-based assessment (SBA), where standards-based assessment does not assume how many students are able to achieve the defined goals” (Ministry of Education, 2007 p. 9). Shulruf, Hattie and Tumen (2010) summarised the ideological perspective on the shift from NRA to SBA, whereby the norm-based School Certificate and Bursary qualifications (the antecedents to the NCEA), were considered disadvantageous to students of Māori and Pasifika ethnicity and students of low-income backgrounds. However, Elley et al. (2005a) argued that “if SBA is to play a useful role in educational assessment, it must be referenced with NR information to ensure the stability of results between teachers, between schools, between years, and between subjects” and called attempts to polarise distinctions between SBA and NRA “a false dichotomy” (p. 3).

Hipkins et al. (2016) put their views on the rationale for the introduction of the NCEA, which they identified as “one of the most complicated school systems in the world” (p. 6):

NCEA was set up as a flexible standards-based model that aimed to be inclusive of all students. This included those who have previously been excluded from gaining qualifications simply on the basis of their position in a rank-ordering of assessment results, and for whom the schooling process was typically an alienating, negative experience. (Hipkins et al., 2016, p. 5)

A publication by the NZQA (New Zealand Qualification Authority, 2011) aimed at informing the general public about the NCEA, cited the transparency and flexibility in

course structure afforded to students as one of the key design features of the qualification. NZQA highlighted other advantages of the NCEA, including the scope for schools to innovate in terms of offering multi-level courses; and more students leaving school with qualifications.

Although the assessment framework changed, what did not change was adherence to tradition in this country, with three consecutive years of assessment for national qualifications at the senior secondary level (Strachan, 2002). This regime has been questioned, especially around the contemporary relevance of a Year 11 qualification system as the majority of students in New Zealand are now leaving school having at least completed Year 12 (Elley et al., 2005b).

Philips (2003) reviewed some of what he termed *enduring issues* in the reform of secondary school qualifications. He referred to *significant tensions* existing between the NZQA and the MoE at that time. Philips (2003) commented too on the view held in many schools, that the NCEA allowed for flexibility in provision of programmes that aimed to better meet the needs of increasingly diverse student bodies, and that this would see students attending school for longer. However, Philips (2007) raised concern that the curriculum may have suffered a *dumbing-down* in the drive to keep more students at school for longer. Hattie (2011) advanced the case that the implementation of the NCEA had led to increased rates of student retention at school, and labelled this trend a major success of the qualification (p. 288). However, Hall (2015) argues that this claim for the NCEA is a simplistic one. Rather, Hall noted the probable influence of a range of government policies impacting on student retention, including raising the school leaving age, and the provision of vocational pathways in schools. In addition, Hall (2015) points to the “paucity of employment opportunities for students who leave school early is likely to be a significant contributor in students staying on at school” (p. 1).

Lee & Lee (2001) argued that “reforms in education succeed when, and only when, they are viewed as not threatening the opportunities of ambitious youth and when they enjoy strong support from schools, teachers, parents and employers” (p. 10). As with any systemic policy change, there was widespread debate and concern about the introduction of the NCEA, in both the community and also amongst scholars of education and assessment. The implications for senior secondary school assessment are relevant to this study and the debate on this follows.

Prior to implementation of the NCEA, Hall (1997) raised pedagogical and educational concern about unit standards and the potential for fragmentation of

course content. A later paper (Hall, 2000), laid out his profound concerns with regard to issues of reliability, validity and manageability of the, then imminent, new system that was to be based on the assessment of separate standards. Reliability, he argued, was likely to be problematic for two reasons; firstly because the interpretation of a standard might vary between markers, and secondly because student behaviours would be inconsistent in assessments. In that same paper, Hall evoked a bricks and mortar metaphor in his forecast about issues of course coherence in the NCEA:

...a subject can be analysed in many ways depending on the focus that is to be taken. This does not mean that each standard is separate from others in any pedagogical sense. The standards can be thought of as providing the “bricks” – a particular combination of bricks may be the basis for designing the assessment for a particular course – but the “mortar” for the course, the particular knowledge and skills which connect standards and provide the integration and transfer of knowledge from one part of the course to another, is likely to be de-emphasised or de-contextualised in any scheme which treats standards as separate entities. (Hall, 2000, p. 190)

He went on to say:

Teachers are likely to design their teaching differently if the focus is only on the parts. The impetus for inappropriate modularisation is strong – the simplest approach to take is to teach each standard separately even if this is not the intention of the designers of the NCEA. (Hall, 2000, p. 191).

As implementation of the NCEA began, Locke (2002), wrote on the reforms in the context of teaching English. He argued that because the reforms had been highly centralised and state managed, “they have posed a huge challenge to teacher professionalism and identity” (p. 39). Rueing the loss of English as a *subject*, with the establishment of NCEA *courses* comprising *packages* of achievement standards, he put his thoughts down:

Looked at positively, it appears to empower students and teachers to negotiate programmes of study commensurate with the needs and aspirations of students. The downside, however, is its potential to allow students to avoid more demanding achievement standards, or achievement standards that are assessed by external examination. Because the discrete achievement standards are linked to high-stakes summative assessment, a consumer-driven discourse of credentialism might tempt schools to encourage students to enter only for unit or achievement standards where they are more likely to succeed, not for the good of the student but for the reputation of the school as a quality provider. (Locke, 2002, P. 49)

Based on the evidence of the first two years of national NCEA Level 1 together with Scholarship examination data for 2004, Elley et al. (2005) as academic experts in the area of assessment, prepared a submission to the State Services Commissioner, raising their deep concerns about “failures in NCEA, the

Scholarships examinations, and NZQA as the administrators” (p. 1). Their concerns related to the apparent significant variability in results (unreliability); marking moderation issues; and wider issues including fragmentation of assessment, protocols around assessment, and “that of the backwash effect of the SB model on teaching practices” (p. 9).

Hipkins et al. (2016) reflected on the early years of NCEA implementation and what they termed “the variability crisis”:

As it was, NZQA had no plan, and seemingly no intention, to manage variability under the new system.

Exactly why that was so can only be guessed at. It seems probable, however, that NZQA held the view that the description of the criteria for Achieved, Merit and Excellence grades, and the accompanying explanatory notes in the standards specifications, would be sufficient to calibrate teachers’ and markers’ judgements on their own. It may also be that NZQA did not understand the extent to which variability would prove as politically damaging as it was. This seems naive, especially given that assessment experts had warned about both possibilities.

(Hipkins et al., 2016, p. 84)

Changes were effected through the NZQA, including:

undertaking closer scrutiny of examination-setting processes; the adoption of statistical analysis of examination results to inform future examination rounds; and eventually, a new marking system for NCEA examinations, implemented progressively from 2011 and 2013. (Hipkins et al., 2016, p. 88)

One of the significant changes that is referred to in the quotation above, was the development of *profiles of expected performance* (PEPs), whereby the percentage of results in each grade band (Not Achieved, Achieved, Merit and Excellence) were set.

In the decade post implementation of the NCEA, the MoE funded several evaluation projects. In the first of these, Hipkins and Neill (2006) reported on the experiences of a small group of mathematics and science teachers just one year after implementation of the NCEA Level 1. Many positive effects on teaching practice and student outcomes were identified by the participant teachers, including the view that Māori, Pasifika, and low-achieving students had benefitted; and that high-achieving students were motivated to attain excellence grades (but see the research referred to below by Meyer, McClure, Walkey, Weir & McKenzie, 2009). The same study also noted teachers’ comments about the large amount of time they spent on assessment; the compartmentalisation of subjects; narrowing of the experienced

curriculum; teaching to the assessment; and a significantly increased teacher workload, following the introduction of the NCEA.

System reform of the NCEA was ongoing. Since 2007 NCEA certificates could be awarded with Merit or Excellence endorsements (see Section 2.3.3). This development was prompted by research that identified the need to provide students with greater challenge, so as to foster motivation (Hodis, Meyer, McClure, Weir, & Walkey, 2011; Meyer, McClure, Walkey, Weir & McKenzie, 2009). The *realignment* of the NCEA to NZC has been described in Section 2.3.4.

The impact of the NCEA a decade after implementation was evaluated through the analysis of data from a national survey of secondary schools conducted in 2012 (Hipkins, 2013). The statistical analysis and interpretation of responses from teachers and principals included: Support for the NCEA (69% of teachers were supportive); perspectives on what she termed the “rolling changes” (p. 2) to the qualification; workload; professional learning opportunities; and Level 2 NCEA achievement targets. Hipkins noted that “mathematics and science teachers are over-represented among those who see NCEA requirements as a barrier to change” (Hipkins, 2013, p. 48). Furthermore, Hipkins speculated that tertiary science institutions were more likely to have an impact on decile 9 and 10 schools, and so could explain why teachers in these high decile schools “are reporting greater pressure to get their NCEA choices and changes right, with associated workload pressures” (Hipkins, 2013, p. 48). Mizutani, Rubie-Davis, Hattie and Philp (2011) inquired into teachers’ beliefs on the NCEA. They concluded

...that subject played a role in influencing the nature of perceived washback effects of NCEA and beliefs about the assessment. NCEA was influencing teachers and students differently, depending on whether their subject was verbal or predominantly numeric. (Mizutani et al., 2011, p. 55)

In science education, few studies to date have explored the impact of NCEA assessment on the actual curriculum experienced by students (the operational curriculum). Empirical research into internal assessment of science investigation by Hume and Coll (2010), found that what “students came to perceive and experience as scientific investigation was the single, linear and unproblematic methodology of fair testing” (p. 56). These authors concluded that an over-emphasis on fair testing and the use of planning templates were barriers to students engaging in authentic open-ended investigations, and furthermore the students’ understanding of experimental design was shallow although they were competent in meeting the assessment criteria. Hume and Coll (2010) found that significant guidance given by

teachers, enabled students to make links between their data and relevant science ideas. They concluded that observed teacher practice was strongly driven by the demands of the NCEA qualification.

Moeed (2010) conducted a case study of science investigation work undertaken by Year 11 students towards a Level 1 NCEA achievement standard, and her findings were congruent with Hume and Coll's findings in terms of students developing a very narrow understanding of science investigation as "fair testing". Moeed regarded the negative side-effects for students of the observed teaching practices towards this standard, included encouraging a surface approach to learning and teachers' limited use of formative assessment and feedback. These negative side effects highlighted issues of consequential validity. Issues of content validity were also evident, as the relationship between *NZC* and the assessed standard were questionable. The overall findings were that learning was limited, motivation to learn was for credits and grades, and assessment was the driver for learning to investigate in Year 11 (Moeed, 2010; Moeed & Hall, 2011).

The situation in secondary schools may be similarly compromised in terms of implementation of the nature of science strand in *NZC*:

A recent audit of curriculum support resources also found a lack of meaningful alignment between the intent of the NoS strand and the assessment focus of National Certificate of Educational Achievement (NCEA) achievement standards for Years 11-13. Since high-stakes assessment provides a powerful "message system" about the intent of a curriculum, this finding provides indirect evidence that the NoS strand is not being effectively integrated into the senior science subjects. However, it should be noted that the Senior Subject Guides for science do include some specific, if generic, ideas about how to build a NoS component into teaching and learning. (Hipkins, 2012, p. 12).

James, Montelle and Williams (2008) claimed to have conducted the first study into possible impacts of the NCEA on student preparedness for tertiary studies in mathematics. They reported a correlation between the quality of NCEA credits (corresponding to Merit and Excellence), and students' success in foundation mathematics papers at university. Students that had undertaken a *full* Level 3 NCEA course of 24 credits (comprising all available mathematics achievement standards), had greater success in their first-year mathematics courses, while those with less than 15 Level 3 credits in mathematics were judged to be "highly unprepared for university study" (James et al., 2008, p. 1040).

Agnew (2010) studied the NCEA in the context of accounting, and concluded that the NCEA had not improved academic outcomes for Māori and Pasifika students,

noting that “Pasific Island students have experienced a significant decrease in achievement” (p. 87), which was a finding that was incongruent with those presented in the earlier NZCER (2003) report. The implications for students undertaking fewer achievement standards at school in transitioning to tertiary study of accounting were put forward:

There are several potential flow-on effects for tertiary study. Although more students are now studying accounting at secondary school, they are doing fewer standards. This may have repercussions for the tertiary sector, if students are arriving at tertiary institutions with a narrower range of accounting content coverage and skills. Given that the decrease in the number of Not Achieved grades received is not falling as rapidly as the number of accounting standards entered, it would appear that students who have studied accounting at school now have a weaker grasp of content than when NCEA was fully introduced in 2004. (Agnew, 2010, p. 100)

Student wellbeing was the focus of a study that collected data from 68 New Zealand secondary schools (Education Review Office, 2015). The causal relationship between assessment and student anxiety was noted:

In many schools, the only people who understand the overall curriculum and the competing demands on them were the students. What they experienced was very assessment driven and caused anxiety for many students (p. 2)

The findings cited in the report included the following, outlining the extent of the internal assessment load in one study school:

A leader in one school responded to students who said they were stressed by exploring the number of NCEA assessments in each learning area across the year. They found that most students had two assessments every three days. After a discussion, leaders responded to this assessment overload by setting an expectation that subjects offered no more than 21 NCEA credits per course – even so, this could still lead to an unnecessary workload for students participating in six courses (126 credits when only 80 are needed).

Included in the recommendations in the Education Review Office (2015) report were:

...that the New Zealand Qualifications Authority (NZQA) continues to work with school leaders and teachers to promote meaningful and innovative assessment practice that will deliver more manageable assessment programmes and a consequent reduction in teacher and student assessment workload.

ERO recommends schools...review their assessment programme, in particular the number of credits available for each year, using the intent of NCEA. (Education Review Office, 2015, p. 3).

Issues with the structure of the NCEA and its implications for teaching and learning are still being raised. Hall (2016) recently presented his concerns to the MoE around

the fragmentation of curriculum under the NCEA. Hipkins et al. (2016) acknowledged the fragmentation issue, commenting that courses might simply be “loose aggregations of standards” (p. 153).

Hipkins et al. (2016) commented on the challenges facing teachers in bringing NZC and NCEA together in designing coherent courses. They asked: “Could it be that long-established but tacitly held assumptions about the nature of subject coherence are also acting as a barrier to change?” (p. 154).

Beyond the literature, in the public arena, debates and controversy around the NCEA have also been published, and at times may have had an impact on educational institutions. One such example was Coddington’s article in North and South magazine (July, 2011) entitled “*Blowing the whistle on NCEA: “Scaling, fudging figures, manipulating marks – and that is just the administrators. Is NCEA corrupting everyone it touches?”*” That article became the subject of two complaints brought to the New Zealand Press Council by the Post Primary Teachers Council (PPTA) and NZQA. The complaints were upheld in part, on the grounds of fairness and balance. The rulings noted that given the potentially damaging content of the article, the magazine should have sought and presented balancing views from the PPTA and NZQA respectively (New Zealand Press Council, 2011a, 2011b).

As is the case in Australia (outlined in Section 3.1.2), the media in New Zealand have in recent years published league tables of secondary school results (for example, Johnston, 2016; Wilson, 2013). Hipkins (2012) argued that such league tables of NCEA results “can create winners and losers” (p. 16), and from national survey data, she reported that over half of principals believed that league tables had some impact (either a positive or negative one) on their school roll. Furthermore, there was a reported decile effect in this finding, in that trustees of high decile schools were most sensitive to the potential impact of NCEA statistics on their school roll (Hipkins, 2012).

What of those New Zealand schools that offer alternative international qualifications? The number of schools offering CIE has increased dramatically, from one school in 2002 to 55 in 2015 (ACSNZ, 2016). In 2015 the Post Primary Teachers Association (PPTA) mooted that schools should not be able to offer the CIE and IBDP as alternative curricula as were undermining the NCEA, although this stance was criticised (Morris, 2015).

While the Honourable Hekia Parata, the Minister for Education has set specific pass rate targets for NCEA, specifically that “85% of 18-year-olds will have achieved

NCEA Level 2 or an equivalent qualification in 2017” (New Zealand Qualifications Authority, 2014, p. 1), there are those that question this agenda. That debate has also played in the general media. For example, the *New Zealand Listener* (Woulfe, 2014) ran a lengthy article questioning whether continuing rises in NCEA pass rates correspond to real gains in learning, or rather, a lowering of standards. The issue of grade inflation in all three levels of the NCEA was again raised just over a year later, citing reputable academics, and questioning how this trend could be consistent with downward trends in New Zealand students’ performance in PISA assessments over the last ten years (Downes, 2015). While the Ministry of Education denied the issue raised in the media of grade inflation (Hughes, 2015), it is likely that schools, their boards, principals, teachers, students and families are not immune to the arguments made in such articles. The Honourable Hekia Parata has recently applauded students’ success and the attainment, two years ahead of time, of the government target of an 85% Level 2 NCEA pass-rate (Parata, 2016).

3.5 The IBDP in practice: Research and commentary

Little evaluative research appears to have been published on the implementation of the IBDP in the Asia-Pacific region; adding to the justification for the present study. As described in Chapter Two of this thesis, the IBD chemistry curriculum is structurally different to the NCEA, both in terms of scope and its assessment.

It seems probable that there would be differences in how students are directed to take the IBDP at different schools offering a choice of senior qualification. Students might be given the choice of self-selection of qualification (IBD or local/national). Alternatively, the IBD may be reserved for the academically elite in some schools, and this might have implications for classroom dynamics. The IBO policy around access, states that the “Diploma programme provides an excellent educational framework for students of a wide range of abilities and backgrounds and should be made available as widely as possible” (International Baccalaureate Organisation, 2009). The extent to which the intent of this policy was being enacted in schools would need to be understood in order to evaluate teachers’ perceptions of IBD versus non-IBD students.

Doherty and Shield (2012) studied three Australian schools where the IBD curriculum was being offered in conjunction with a local state curriculum. These researchers noted that the IBDP requires a school to host the curriculum, and that implementation is expensive. They pointed to the paucity of empirical studies into the work of teachers at schools that have implemented the IBDP. When surveyed, IBDP teachers described teaching the coursework as being professionally

stimulating. Doherty and Shield (2012) suggested that might explain the reported willingness of teachers to commit to the increased teaching demand of the IBDP, both in the difficulty of material and significant amount of extra hours of teaching required to deliver the syllabus, compared to the local curricula. They suggested that the question of “who gets to teach in which curriculum?” was an interesting one (Doherty & Shield, 2012, p. 421). A perception of *winner and losers* arose in their IBDP study schools; winners being the professionally confident, and losers were beginning teachers, contract staff and non-IBDP students, who were perceived as being ill-served in terms of the equitable sharing of resources in schools (Doherty & Shield, 2012).

Researchers from Deakin University conducted a mixed-methods study of the IBDP and its alignment with the Australian Curriculum (Dixon, Charles, Moss, Hubber & Pitt, 2014). Among the findings of that study, were the reported teachers’ perspectives in the case study schools, that the Diploma was a good fit for their students; encouraged a global perspective; and offered a rigorous academic programme. In the United States, research has pointed to teachers’ views that the IBDP is challenging; required extensive time on their part for planning and implementation; and that it promoted collaboration between teachers (Beckwitt, Van Camp, & Carter, 2015).

All students of the IBDP must complete the Theory of Knowledge (TOK) course, one of three core components of the programme model (see Figure 2.4). The TOK course requires students to critically examine knowledge across disciplines. Exploring perceptions around the implementation of the TOK syllabus in an Australian context, Cole, Gannon, Ullman, and Rooney (2014) found differences in the study schools with regard to teachers’ beliefs about teaching TOK. More experienced TOK teachers held higher self-beliefs in terms of teaching the syllabus, and some thought a challenge in their schools was to improve the integration of the TOK analytical framework into subject teaching, with a lack of support from non-TOK teachers a concern. Some non-TOK teachers were reported as feeling a sense of *mystery* about the course.

At the tertiary level, an Australasian study concluded that “senior university representatives have a very high level of regard for the IB Diploma” (Australian Council for Educational Research, 2007, p. 6). It is important to consider the recent growth of the IB Diploma in both Australia and New Zealand, with the number of schools authorised to deliver the programme increasing significantly over recent years. It may be that university staff now have a greater understanding, compared to

2007, of the Diploma programme and the implications for students transitioning into tertiary study. It would be timely to undertake further research into the perceptions held within New Zealand universities of the IBDP.

The significant growth in uptake of the IBD programme in the Asia-Pacific region in the last decade has led to questions being asked about the implications for the reliability and manageability of the assessments and therefore the potential adverse impact on the IBD's strong reputation in that regard (Bunnell, 2011). The processes around assessment, such as the preparation of examination papers and setting of grade boundaries, are described in a document available online to IBD teachers (IBO, 2004). The same document also outlines policy around the moderation of both externally and internally assessed components. Unlike the situation for the NCEA, teachers' marks will be altered if higher or lower than the judgement of the external moderator. It is also the case in the IBDP that a sample for external moderation is taken of every internally assessed component in every subject.

To date no published research examines teachers' experiences of IBDP implementation in this country. As schools in New Zealand only offer the IBDP in addition to the national curriculum, this raises questions as to how both are managed at the classroom level.

3.6 Chapter summary

The literature drawn on in this chapter has been reviewed in three sections, reflecting what is conceived as a triplet central to teacher practice: that is curriculum, pedagogy and assessment.

Internationally, curricular reform in science education points to a trend towards constructivist frames and student centeredness; value placed on both substantive and procedural knowledge; and explicit objectives relating to learning about the Nature of Science. All of these elements are evident in the written curriculum documents of NZC and IBDP.

However, there are evidently aspects of curriculum design in science education where agreement is yet to be reached. *Science for All* versus science education for future experts is one such tension. In New Zealand, full implementation of NZC appears yet to be realized. The curriculum document itself is a document of two halves, whereby teachers are in the position of having to marry the principles, values and key competencies of the front end with the objectives of the learning areas at the back. The complexity for teachers is thus one of enacting the curriculum

intent, and is occurring in an environment where there is a dearth of government funded professional development opportunities available designed to support the mandated changes in teaching and learning. The literature also raises the significance of acknowledging teacher beliefs in science teaching reform; it prompts questions about the beliefs and practices of chemistry teachers' in this country: What do they think about the curricula they are tasked with teaching?

What comprises effective teaching strategies in science education has been documented by several authors, and that literature provides a useful reference point for the data collection and interpretation in this thesis. The literature showed that central to teaching chemistry was the *chemistry triplet* of Johnstone, acknowledging the abstract nature of the discipline and the accepted symbolism and models used to explain observations of chemical change. That teaching different topics in chemistry might require different pedagogical approaches by teachers is another complexity. From this literature on pedagogy, the question was asked: What are teachers' views and practices in terms of teaching the content and procedural knowledge of chemistry (linking curriculum and pedagogy)?

The final part of the literature review presented in this chapter dealt with assessment, both theoretical aspects and structural issues and commentary related to the NCEA and IBDP. Given the large scale changes in national assessment since the implementation of the NCEA, relatively little practice-based evidence has emerged from classrooms and school science laboratories in this country over the last fifteen years. What has been published to date shows some similarities with findings related to adverse impacts of high-stakes assessment in other countries. Such negative impacts include the narrowing of curriculum to focus on what is being assessed, and a favouring of rehearsal type teaching strategies. The unique structure of NCEA assessment (with its modular achievement standard design) might also have an effect on the operational curriculum. These ideas led to another central consideration of this research, which was to inquire into chemistry teachers' approaches to assessment in the NCEA, with comparison to the IBDP. The views of chemistry teachers' in terms of their experience with implementation of the NCEA in their schools, and in relation to the IBDP, needs to be better understood; this research includes such a focus. The research design and methodology for this research follows in Chapter Four.

CHAPTER FOUR:

Methodology

The purpose of this chapter is to describe the research design for this study, which was dictated by the nature of the research question. The content is presented under the following section headings:

- 4.1 Restatement of the major research question
- 4.2 Selection of the research paradigm
- 4.3 Case study methodology
- 4.4 Selection of schools and teachers
- 4.5 Sources of data and data collection strategies
- 4.6 Data analysis
- 4.7 Validity/trustworthiness of research design and data collection
- 4.8 Ethical considerations
- 4.9 Limitations and delimitations

4.1 Restatement of the major research question

The major research question for this thesis is restated here for the convenience of the reader. A refinement of this, and further questions generated to explore the major research question, are given in Section 4.5.

The overarching research question investigated in this study was: In the context of NCEA and IBD chemistry courses in New Zealand secondary schools, how do teachers manage the tension between learning, teaching and assessment? Teachers' views and practices were explored through inquiry questions relating to the following:

- Teaching the content and procedural knowledge of chemistry (referring to curriculum and pedagogy)
- Approaches to assessment

4.2 Selection of the research paradigm

This inquiry sought to attain an in-depth understanding of the context in which the participant chemistry teachers worked, their rationale for how and what they taught, and their espoused beliefs about their own practice. As the focus for this research was teachers' experiences and behaviours within their schools, the emergent findings then rest within an *interpretive* paradigm (Cohen, Manion, & Morrison, 2000; Merriam, 2009).

Creswell (2009) noted that the selection of a suitable research design is to be derived from a consideration of research philosophy, specific methodology and selected "strategies of inquiry" (p. 11). Furthermore, Charmaz (2014) put forward the principle that data collection methods must "flow from the research question" (p. 27); so that research design cannot precede the research question.

Although chemistry may traditionally be thought of as a quantitative discipline, this research relates to chemistry education, and the framed inquiry questions were designed to capture qualitative data in a naturalistic setting. While some data have enabled a limited range of statistical analyses to be undertaken, the larger part of this research involved qualitative data collection and analysis, as decided by consideration of the research question (Strauss & Corbin, 1998). I aimed to use a "wide- and deep-angle lens" (Johnson & Christensen, 2012, p. 35) to explore in detail the multiple dimensions of teachers' experiences in the context of senior chemistry courses.

There are three accepted design approaches to undertaking research: quantitative, qualitative, and mixed methods approaches. However, it was also asserted by Creswell (2009) that quantitative and qualitative designs are not discrete methodologies, but rather may be thought of as labels describing the predominant approach. So, a qualitative research allows for the use of multiple methods (Denzin & Lincoln, 1994; Mertens, 2014), and a mixed-method study may be considered as being somewhat mid-way on a continuum between qualitative and quantitative research. Defining qualitative research, Creswell (2009) put it like this:

Qualitative research is a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particular's to general themes, and the researcher making interpretations of the data. The final written report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honours an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation. (Creswell, 2009, p. 4).

Charmaz (2014) noted the significance in undertaking qualitative research of collecting rich data: “Gathering rich data will give you solid material for building a significant analysis. Rich data are detailed, focused and full” (p. 23). The detailed qualitative exploration of an aspect of social reality is derived from a small number of participants or examples and relies heavily on words (Basit, 2010; Lichtman, 2010). Research findings in qualitative studies are “richly descriptive” (p. 16), and rely on inductive reasoning, that is, understandings, meanings and theories that may be built from observations (Merriam, 2009). Research findings may be transferable but not generalisable (Basit, 2010).

Philosophically, this study is underpinned by a subjectivist framework and the ontological nominalist assumption that “objects of thought are merely words and that there is no independently accessible thing constituting the meaning of a word” (Cohen et al., 2000, p. 6).

As described in the first chapter, this research had its origins in my reflections and questioning of my own teaching experiences. In terms of epistemology then, my approach is anti-positivist, and as described in Cohen et al. (2000):

... individuals’ behaviour can only be understood by the researcher sharing their frame of reference: understanding of individuals’ interpretations of the world around them has to come from the inside, not the outside. (p. 20).

Qualitative methodology in education research may take several forms, including case study, grounded theory, phenomenology, and participatory action research (Basit, 2010; Creswell, 2009; Creswell, Hanson, Clark, & Morales, 2007). This research investigates teachers’ views of the chemistry courses undertaken towards the NCEA qualification, with comparison to the IBDP. A multiple case study approach was taken, and in addition a small quantitative analysis of NCEA data was included. The case study design is explained more fully in the following section.

4.3 Case study methodology

A multiple case study approach was judged to be appropriate for exploring the open-ended research question, as I sought to collect rich data relating to a contemporary phenomenon (that of teaching chemistry in the context of the NCEA/IBD qualifications). The case schools shared common characteristics (described in Section 4.4 below), allowing for comparisons to be made (Stake, 2013). The researcher had “little or no control over behavioural events” (Yin, 2013, p. 2). Case study research focuses on a phenomenon occurring in a bounded system (Heck, 2006; Johnson & Christensen, 2012). Merriam (2009) stated: “The unit of analysis,

not the topic of investigation characterises a case study” (p. 41). For research to be characterised as a case study, the phenomenon being studied must be intrinsically bounded.

Yin (2013) points to other characteristics of case studies, whereby case studies are distinctive in that they lead to “more variables of interest than data points” (p. 2), and that data triangulation may be a feature of robust design. Multiple sources of data build contextual understanding (Creswell, Hanson, Clark, & Morales 2007). Case studies offer insights that would not always yield to a numerical analysis, and may allow conclusions to be made about cause and effect (Cohen, Manion & Morrison, 2000). However, Merriam (2009) pointed to qualitative researchers being more interested in “uncovering the meaning of a phenomenon for those involved” (p. 5). Furthermore, the imperative in qualitative research “is understanding the phenomenon of interest from the participants’ perspectives, not the researcher’s” (Merriam, 2009, p. 14).

The following are characteristics of case study put forward by Cohen et al. (2000):

- It is concerned with a rich and vivid description of events relevant to the case
- It provides a chronological narrative of events related to the case
- It blends a description of events with the analysis of them
- It focuses on individual actors or groups of actors, and seeks to understand their perceptions of events
- It highlights specific events that are relevant to the case
- The researcher is integrally involved in the case
- An attempt is made to portray the richness of the case in writing up the report

(p. 182)

As indicated above, the phenomenon that is the focus here is teachers’ perspectives on their teaching in the context of NCEA and/or the IBDP. In this study, three cases are analysed, where the evident bounds of each are the selected schools in which the primary data collection was undertaken (two schools offering NCEA and IBDP, and one school NCEA only). The case schools were the intrinsic bounds in which the participants taught. This allowed a comparative case study approach to the two assessment regimes (NCEA and IBDP). A diagrammatic summary of key elements of the multiple case study design is given in Figure 4.1. A description of the characteristics of the case schools follows (Section 4.4).

Stake (2013) noted the tension for the researcher in a multi-case study, between understanding the single case and giving attention to all of the cases. This was a consideration in the approach taken to coding and the synthesis of findings across the cases.

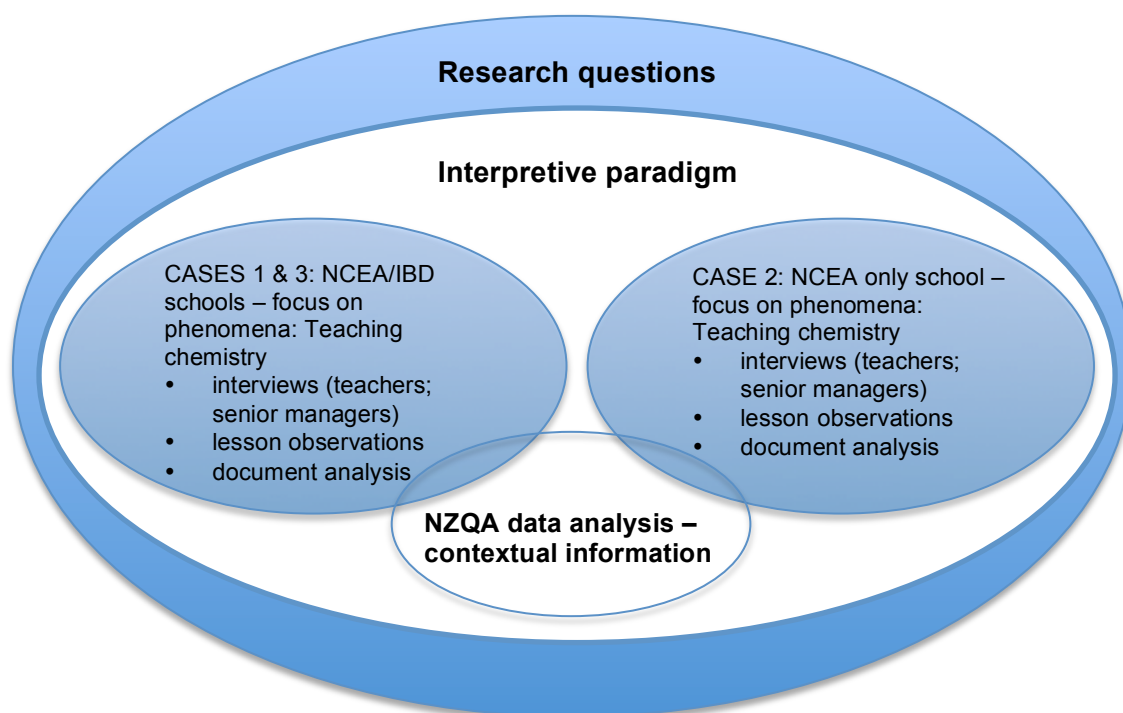


Figure 4.1. Overview of the multiple case study design.

Elaboration of the process by which case schools and participant teachers were selected is described in the following section (Section 4.4).

4.4 Selection of schools and participant teachers

The selection of schools and teachers was through non-random, purposive sampling. Purposive sampling relies on the researchers' situated knowledge of the field and their relationships with those they are researching. It is understood that results cannot be generalized beyond the sample itself (Barratt, Ferris, & Lenton, 2015; Bryman, 2015). That said, the much smaller number of schools offering the IBD qualification and the constraints of time and access for the research, led to the selection of this sampling strategy.

This sampling technique allowed for schools and teachers to be included that would best address the foci of this research (i.e., a comparison of teaching towards the NCEA/IBD qualifications). Only thirteen schools in New Zealand are currently authorised to deliver the IBDP (International Baccalaureate Organisation, 2015), and all are decile 10 schools (for an explanation of the decile classification of schools in

New Zealand, see Section 2.1). These factors constrain the setting of this study. However, the selected schools are considered to be representative cases within this decile, based on the ERO school profiles. Within the selected schools, snowball sampling (Guetterman, 2015) was relied on, so that chemistry teachers of these curricula could be invited to participate and be interviewed on a voluntary basis.

All case schools in this research were urban, and in the upper North Island; with the aim of maintaining some geographic consistency in the setting of the research. Two co-educational, decile 10, private (independent) IBDP/NCEA schools were identified for study and the Principals of each were invited in writing to participate (Appendix C). Such “dual pathway” schools offered scope to interview teachers and curriculum managers who had experience of both the NCEA and IBD qualifications. In addition, one co-educational, decile 10, state NCEA only school was also selected as a third case school. The rationale for selecting a comparable (co-educational, decile 10) school that offers *only* NCEA, was to allow for the collection of teachers’ perspectives in a context that was not potentially influenced by alternative curricula.

Within each case school, interviews were sought with staff (through the Principal) with different levels of curriculum responsibilities. Interviews with a senior manager of the case schools were conducted with the aim of gaining contextual information of how curriculum was operationalised in the school. This typically included seeking information as to how students selected alternative qualification pathways in the school; the numbers of current candidate entries for chemistry in Years 12 and 13; student outcomes in senior secondary qualifications including chemistry; course planning drivers; and priorities for staff professional development. Not all of this information has been reported in the interests of preserving confidentiality, but provided the researcher with valuable insights into the strategic direction and curriculum issues as seen by the senior manager participants.

Table 4.1
The number and role of research participants in each case study school.

	CASE 1	CASE 2	CASE 3
	NCEA & IBD	NCEA	NCEA & IBD
Senior Manager – Curriculum	0	1*	1*
Head of Faculty – Science (and chemistry teacher)	1	0	1
Teacher in Charge – Chemistry	1	1	1
Teacher – Chemistry	1	1	1
Total participants:	3	3	4

** All participants except the two Senior Managers (at Case 2 and Case 3 schools) were teaching Year 12 and/or 13 chemistry classes at the time of data collection.*

To capture the perspectives of middle curriculum leaders, Teachers in Charge of Chemistry or the Head of Faculty (Science) were interviewed in each of the case schools. Each of these participants were themselves teaching senior chemistry courses (NCEA or IBDP), and their departmental responsibilities included senior course design, managing assessment issues, review of departmental results, and managing staff. In total, up to four experienced chemistry teachers of Years 12 and 13 classes in each case school were interviewed. A summary of the participants interviewed in each school is given in Table 4.1.

Further details outlining the experience and teaching load of each interviewee is given in the presentation of the results in this thesis (Chapters Five, Six and Seven; Tables 5.1, 6.1 and 7.1). Following the interviews, participant teachers were observed teaching in a short sequence of four to five lessons over the course of about a week. Consistency between interview responses and salient observed practices have been analysed and commented on with the results from the interviews (Chapters Five, Six and Seven).

No direction from the researcher was given to contacts within case schools with regard to teacher selection, other than to request that up to four teachers of senior chemistry courses from each school be invited to participate; it was left to the Principal (or by delegation the Deputy Principal or Head of Faculty) of each case school to forward the researcher's information sheet and invitations to the teachers. Copies of information sheets and consent forms are appended (Appendices C–F).

4.5 Sources of data and data collection strategies

In the design of this research, it was evident that the major research question, as restated below, required breaking down into sub-questions that would allow for appropriately focused data collection and construction of instrumentation.

The breakdown of the overarching research question into specific research foci is outlined in two separate matrices (one for each aspect). These matrices follow (Tables 4.2 and 4.3). The research design allowed for the collection of data from multiple sources across the case studies, with the aim of achieving coherence and congruence in the findings.

In the context of NCEA and IBD chemistry courses in New Zealand secondary schools, how do teachers manage the tension between learning, teaching and assessment?

Teacher beliefs and practices were explored through inquiry questions relating to:

- Teaching the content and procedural knowledge of chemistry (referring to curriculum and pedagogy)
- Approaches to assessment.

Table 4.2

Research foci and data sources relating to inquiry into teaching the content and procedural knowledge of chemistry

Research foci	Data sources				
	MOE/ NZQA/IBO sources*	Principal/or Senior Manager	Analysis of school documents	HOD Science/TIC Chemistry	Chemistry Teachers
Contextual description of qualification pathway/s offered in case school.	Document analysis	Interview			
What are teachers' experience of other qualification systems?					Interview
What are the drivers for course planning?	NZQA data	Interview	Course outlines	Interview	Interview
What is the (operational) curriculum framework for chemistry teaching?			Course outlines	Interview	Interview
What are the perceived issues in terms of course delivery facing teachers (IBD and NCEA)?		Interview		Interview	Interview
What range of pedagogies are planned for/evident in chemistry classrooms? What influences teaching approaches?			Unit plans		Interview and observations
What do teachers regard as key learning outcomes for Years 12 and 13 chemistry students?				Interview	Interview
To what extent is practical work part of the coursework? How much is open-ended investigation (NCEA and IBD)?	Document analysis		Unit plans	Interview	Interview and observations

Research foci	Data sources				
	MOE/ NZQA/IBO sources*	Principal/or Senior Manager	Analysis of school documents	HOD Science/TIC Chemistry	Chemistry Teachers
Teacher professional development: what is available/undertaken with regard to subject development; course delivery; curriculum implementation/ review?		Interview		Interview	Interview
NCEA: What has been the impact to date of realignment and the new chemistry matrix?	NZQA data analysis	Interview		Interview	Interview

* Sources included achievement standard documentation; chemistry matrix

Table 4.3

Research foci and data sources related to inquiry into teachers' approaches to assessment.

Research foci	NZQA & MOE sources*	Document analysis	HOD Science/ TIC Chemistry	Chemistry Teachers
What is being taught; how is it being assessed?	Data analysis	Course outlines	Interview	Interview
NCEA: What is the level of connectedness between aspects of curriculum covered by different achievement standards?	Document analysis		Interview	Interview
How are teaching units organised? What proportion of the course comprises assessment? How do teachers manage the tension between being a teacher and an examiner? (NCEA and IBD)		Course outlines	Interview	Interview; Classroom observations
What chemistry skills/concepts are teachers teaching that is not intended to be assessed? What is the scope for learning that is beyond the achievement standard/syllabus specifications? What are the affordances and constraints that influence the taught curriculum? (NCEA and IBD)		Course outlines	Interview	Interview; Classroom observations
How are assessment data used to inform teaching and learning?			Interview	Interview; Classroom observations
What are teachers' views of moderation of internal assessment (NCEA and IBD)?	Document analysis		Interview	Interview
What are teachers' views on outcomes for students in external examinations?	NZQA national data analysis		Interview	Interview
How well aligned are Year 13 versus 1st year university chemistry courses?			Interview	Interview

**Includes achievement standard documents; clarification statements; moderation clarification reports; national NZQA data*

In developing the research design, a fundamental consideration was which data sources would be most suited to exploring the over-arching research question. It was decided that the emphasis on conducting semi-structured interviews with teachers would lead to richer data than by alternatives such as written surveys.

The considerations in design of interview and lesson observation instruments are described in Sections 4.5.1 and 4.5.2 below. The types and approaches to analysing documents sought from the case schools as well as documents from NZQA and MoE are detailed in Section 4.5.3. Section 4.5.4 describes the piloting and refinement of the instruments and Section 4.5.5 details the analysis done of selected NCEA data sourced from NZQA.

4.5.1 Semi-structured interviews with teachers.

Charmaz (2014) defined intensive interviewing as: “It typically means a gently-guided, one-sided conversation that explores research participants’ perspective on their personal experience with the research topic” (p. 56). This definition fitted the frame of this research, and so interview instruments were designed as an information gathering tool. Merriam emphasised the importance of open-ended questioning techniques (2009, p. 17):

Interviewing is often the primary data collection strategy in qualitative studies. Getting good data in an interview is dependent on your asking well-chosen open-ended questions that can be followed up with probes and requests for more detail.

Merriam (2009) recommended the inclusion of “neutral, descriptive information at the start of an interview” (p. 103) as a foundation for asking more probing questions of the interviewee. Other advice from Merriam was (2009, p. 104):

Having fewer broader questions unhooks you from the interview guide and enables you to really listen to what your participant has to share, which in turn enables you to better follow avenues of inquiry that will yield potentially rich contributions.

Patton (2002) made the distinction between the researcher maintaining neutrality and establishing rapport with participants in interviews. Consistent procedures when conducting interviews; clarity of language; and interview duration have also been noted as considerations in interview design (Wiersma & Jurs, 2009). Mutch (2013) recommended conducting interviews in quiet and comfortable spaces.

With the above factors in mind, instruments were prepared for conducting semi-structured interviews with the participants. “Semi-structured interviews are guided by a set of questions and prompts for discussion, but have in-built flexibility to adapt to particular respondents and situations” (Punch & Oancea, 2014, p. 184). The semi-

structured design allowed for some consistency in format and scope between participants, but also allowed the researcher the flexibility to probe further, to seek clarification or to adjust lines of questioning if needed. Information and consent documentation were all provided and discussed with the participants prior to agreeing on time and place for the interviews to be conducted. The interviews all began with several simple questions relating to the teaching background of the participants and these worked as an ice-breaker at the start of the interview. Then more open-ended banks of questions followed, designed to probe the questions outlined in Tables 4.2 and 4.3. Copies of the interview instrumentation are appended (Appendices G–H). Different instruments were prepared for teachers and senior managers, as the emphasis of the information sought was different for each of these groups of participants.

Interviews were conducted in the schools in quiet spaces, with a view to avoiding interruptions, and at times that were convenient to the participants. The aim was to have the interviews of around one hour duration, to limit fatigue in the participants. The longest interview was an hour and 15 minutes, and the shortest 52 minutes. All interviews were digitally recorded and conducted by the researcher, for later transcription.

4.5.2 Lesson observations.

Stake (2005) referred to “different ways of seeing as new ways of knowing” (p. 378), and on this basis the research design included observing a short sequence of senior chemistry lessons taught by each of the teacher participants. It was felt that the opportunity to observe the participants’ teaching would provide the researcher with a more informed perspective in terms of understanding the phenomenon in question, that of teaching chemistry.

A lesson observation instrument was prepared in advance of the school visits. The observation sheet allowed for the recording of time and place data (case school; date; teaching period; class; teacher; number of students etc.). A running record of the lesson was also made, and later annotated (see for example, Appendices I–J). Where relevant, comments were also made using the framework of Tytler (2009, see Section 3.2.2). These comments were added to the observation sheets either during or as soon as practicable after the conclusion of the lesson, while the observed phenomenon was fresh in the researcher’s mind. Student consent relating to the lesson observations was also sought, and information sheets and consent forms are appended (Appendices K–L).

4.5.3 Document analysis.

Review of course materials and documentation used by teachers (including course outlines issued to students; copies of assessment tasks; unit planning) provided context to the interviews and further depth to the data collected in this study. It was envisaged that these documents would provide additional evidence of the relationships between curriculum planning and assessment within the chemistry departments of the case schools. NZQA and MOE documents were also reviewed where considered relevant and utilised by the participants. This approach aimed to improve the thick description and reliability of the collected data.

4.5.4 Piloting of the instrumentation.

Once ethics approval for the research was received, a school with broadly similar characteristics to those of the target case schools was approached to allow piloting of the research instruments. The pilot school offered both NCEA and IBDP qualifications to the students. Both the draft semi-structured interview schedule and observation instrument were trialled at this school with two chemistry teachers. These two teachers were teaching both NCEA and IBDP courses at the time. Following the piloting of the semi-structured interview format, some modifications to the lines of inquiry were made. For example, it was found that when asking teachers to describe their approach to planning a unit of work, this was made easier for teachers when a specific topic was referred to by the researcher. So, the interviews then referred to a unit of work in organic chemistry. Conducting the pilot interviews also assisted with planning the length of interviews and technical issues around the digital recording of these. Merriam (2009, p. 95):

The key to getting good data from interviewing is to ask good questions; asking good questions takes practice. Pilot interviews are crucial for trying out your questions. Not only do you get some practice interviewing, but you also quickly learn which questions are confusing and need rewording, which questions yield useless data, and which questions, suggested by your respondents, you should have thought to include in the first place.

Several class observations were also conducted in the pilot school. Through this process procedures around managing the consent from students, working with the observation instrument, and suitable positioning of myself in a laboratory as an observer were refined.

4.6 Data analysis

As described in the matrices above (Tables 4.2 and 4.3), data were collected from different sources in order to enhance the credibility of the results (Cohen et al., 2000).

The research includes the use of *method triangulation* as a way of confirming data and increasing confidence in the findings (Heck, 2006; Moeed, 2015a; Stake, 2010; Yin, 2013). Stake (2013) notes that triangulation is the means by which the researcher reports findings as free from personal bias and as meaningfully as possible. Thus triangulation processes occur through data collection, analysis and synthesis. For this research, the main elements of corroborative triangulation relied on: a comparison of findings between case schools; and utilisation of multiple sources of information including semi-structured interviews, classroom observations, document analysis and statistical review of NZQA data. Commentary from different perspectives within each case school were investigated (e.g., Head of Faculty; Teachers; Deputy Principal), with a view to determining the extent to which data could be corroborated. Interviews were conducted with participants in a semi-structured format. This allowed the researcher to have some broad commonality in the scope of the interviews, but also allowed some freedom to pursue with further questioning of comments made by the participants. In addition to the interviews and observations, relevant documentation and resource materials relating to classroom practices were reviewed by the researcher, and discussed with the participants. These included unit plans, course outlines, and assessment materials as used by the case-school teachers.

The aforementioned aspects of data collection focus on different sources of relevant data. Semi-structured interviews allowed the researcher to probe teachers' perceptions on the foci of this research, and provided insights into the phenomenon of teaching chemistry.

The interviews were transcribed as soon as possible after the collection of data. Transcripts were sent to participants for checking. Formatting of the transcripts was as advised by Merriam (2009, p. 110):

The format of the interview transcript should be set up to enable analysis. At the top of the first page, list identifying information as to when and where and with whom the interview was conducted. A crucial factor to enable analysis is to add line numbering down the left-hand side of the page....Finally, leave a wide enough margin on the right-hand side of the pages for you to add notes or codes as you analyse the transcript.

Following transcription of interviews, the coding process followed an iterative process, leading ultimately to refinement and synthesis of the themes reported across the three case schools (Chapters Five to Seven). In all, the transcripts were read several times over by the researcher in the process of coding. The interviews were first parsed into *units of meaning* (Morehouse, 2012). Initially interviews from one case school were worked on at a time, in line with the process described by Stake (2013). The transcripts were initially coded by means of a “line by line” approach, leading to identification of teacher actions and views, as put forward by Charmaz (2014):

Line-by-line coding, the initial grounded theory coding with gerunds, is a heuristic device to bring the researcher into the data, interact with them, and study each fragment of them. This type of coding helps to define implicit meanings and actions, gives researchers directions to explore, spurs making comparisons between data, and suggests emergent links between processes in the data to pursue and check (p. 121).

From that initial coding and analysis, codes and sub-codes were then identified, compared and refined through an iterative process. I endeavoured to capture as accurately as possible the voice of each of the research participants through the coding of the interview transcripts; and was mindful of my own experiences possibly affecting interpretation. During this phase of focused coding, I was critiquing my coding, questioning possible assumptions, and asking questions of the emerging data. It also became clear at this stage where questions remain, and these would allow for further lines of research (Chapter Nine).

Once all interviews had been coded for each case school, I then proceeded to cluster and provisionally categorise the codes, while making notes about emergent data. The developed code categories are appended (Appendix M). At that stage lengthy discussions between the researcher and supervisors allowed for detailed review of the coded data in terms of key findings.

As described earlier, classroom observations enabled the researcher to describe and analyse the actual practice of the participant chemistry teachers. Classroom observations were made using a framework by Tytler (Section 3.2.2), and a running record of the lessons also allowed for the description of actual practices that occurred in each of the observed lesson. Salient data collected from the lesson observations were considered in conjunction with the coded data from the interviews.

Participants provided copies of relevant course-related documents to the researcher (see for example, course outline for School 2, Appendix N), and these were reviewed for meaning once coding of the interviews had been completed.

4.6.1 Analysis of NCEA data.

Following the analysis of the qualitative data collected from the case schools, covering the research foci outlined in Section 4.5 (Tables 4.2 and 4.3), recurrent themes referring to internal and external assessment and grade outcomes emerged.

Hence, the emergent findings from the case school data led to the inclusion of a simple statistical analysis of selected national data for NCEA Level 2 and Level 3 Chemistry from NZQA. Such analysis offered a contextual national perspective to the data collected from the three case schools. It provided the opportunity for the researcher to integrate findings from both qualitative and relevant quantitative sources, and thus attain overall coherence derived from the evidence (Hall, 2007b).

The period of data collection in this study (2013–2014) was coincident with the final phase of *realignment* of the NCEA with the *New Zealand Curriculum* (MoE, 2007). In this realignment process all achievement standards for chemistry were amended, as was described in Section 2.3.4 (Appendix O). Arguably, the biggest change for Chemistry in this realignment process involved the change in assessment mode relating to the topic of reduction-oxidation reactions. Prior to the realignment, this achievement standard was externally assessed through a paper in the November NZQA examination (Appendix P). Following realignment, this topic was to be internally assessed during the school year and with the classroom teacher (Appendix Q). This shift from an *external* to an *internal* was an intriguing aspect of the assessment theme of this study, and was an extension of the emergent themes of the semi-structured interviews.

Hence, the emergent findings from the case school data led to a simple analysis of NCEA Levels 2 and 3 Chemistry data, exploring these additional questions:

- *How do results for Internal and External achievement standards compare for NCEA Levels 2 and 3 Chemistry?*
- *What was the effect on result distributions when, as a result of realignment, reduction-oxidation chemistry was assessed internally rather than externally?*

Finally, the data (comprising NZQA information for Levels 2 and 3 Chemistry, the interviews of participants, and the classroom observations), were synthesised and

compared. This allowed for reporting of emergent data by three themes: Curriculum, assessment and pedagogy, in a comparison across the three case schools.

4.7 Validity/trustworthiness of research design and data collection

Following are aspects of validity and reliability considered in the design of this research, with the aim of ensuring the quality and integrity of the data collected.

4.7.1 Validity/trustworthiness.

The concept of validity originated from psychometric testing and became part of quantitative research design. A research design may be judged as being “fit for purpose” if it allows the research questions to be answered (Hall, 2007b). In writing on approaches to evaluation as a method for educational enquiry, Hall (2010) elaborated: “In other words, the evaluation asks the right questions, uses appropriate tools and strategies for data collection, and draws together the different data to reach conclusions that give a true picture of what is happening” (p. 4). The qualitative equivalent of validity – trustworthiness – may be appraised from the level of detail provided about the research approach, methods, analysis and interpretation.

Two key concepts that apply to the concept of validity/trustworthiness with regard to the interpretive research approach are credibility and transferability.

Hall (2007b) considered inferences about the credibility of results rely on a *thick* description of the research process, to include: methodological triangulation; and negative case analysis. Methodological triangulation involves the collection of data through different methods to allow the researcher to corroborate data and build coherence (for this research, the triangulation approaches undertaken are described in Section 4.6). Negative, or counter findings were also noted during coding because “real life is composed of different perspectives that do not always coalesce, discussing contrary information adds to the credibility of an account” (Creswell, 2009, p. 192). This study was designed and conducted with the principle of validity in mind, for example, participants were provided with transcripts of interview data to check for accuracy, and at the coding stage researcher’s supervisors were asked to confirm coding and interpretations.

Sampling in this project was purposive and therefore non-randomised, and as such the findings are not by design generalisable. However, the *thick* description referred to above may allow the audience to see the fit of the data to other contexts; hence

the focus here is on the process of “transference” (Cohen, Manion & Morrison, 2000).

4.7.2 Reliability and dependability.

In order to be able to establish research reliability, and the concept of “accuracy”, then again “thick” description of processes are given. In the analysis of qualitative data, the extent to which results can be *depended* on in terms of accuracy may be determined from the procedural detail for all stages of the research, including observations, interpretations and reporting. A detailed record of good practice provides a basis for readers to be able to judge the dependability of research results (Hall, 2010).

The key idea is that consistency of approach leads to accurate interpretations of data; in other words, the margin of error associated with the data is low. There are two main aspects to the reliability of an evaluation: consistency – evaluation procedures and instruments provide stable judgements; dependability – well established or well justified evaluation procedures are used and are open to audit through a clearly documented paper trail (Hall, 2010, p. 4).

The researcher was concerned about maintaining consistency in the coding, given that the transcripts of each interview were long, and that the coding took significant time to complete. One approach used to avoid drifting in the meaning of the codes was to write short notes about the code definitions (Creswell, 2009). The coding was also undertaken as an iterative process, whereby recorded data were reviewed several times before being considered final. A sample of a coded interview transcript is appended (Appendix R).

4.8 Ethical considerations

This research design pays attention to fundamental ethical considerations, and steps taken to protect the welfare of participants are detailed here. This research was approved by the Human Ethics Committee of Victoria University of Wellington (SEPI/2013/43 RM 19895; SEPI/2013/53, Appendices S, T). Once Ethics Committee approval was granted, then pilot interviews and observations as well as the formal process of obtaining access to schools and participant consent began in the second half of 2013.

Firstly, participation in the study was voluntary. Initial contact with the Principal (or in one school, the Deputy Principal) of prospective schools was made by the researcher through a phone call, and consent and information forms were then sent via email as permission was sought to conduct the research in that school. One

school originally contacted declined to participate. On agreement to support the research, the Principal of each participatory school was asked to pass on the appropriate information sheets and consent forms to chemistry teachers, requesting their participation. All prospective participants (Senior and Middle Curriculum Managers; Teachers) in this research were provided with details of the research aims and procedures. Written consent was obtained from each participant. On arrival at each school, the researcher met with the participants to discuss the parameters of the study and offer participants the opportunity to ask further questions. Participants were also provided with my contact details on the information sheets and so had the opportunity to contact me prior to, or during, the data collection phase of the research.

For reasons of manageability, I did not include more than the planned number of chemistry teachers in the study. In one school there were more offers of participation than were required, and the selection of participants was then made through random selection of participants from a coded list

The data collection in each of the case schools was carried out towards the end of Term 3; a busy time of year for senior secondary school teachers and curriculum managers. It was important to the researcher that consideration be given to teachers, and so interviews and observations were carried out at times that were convenient to the participants. One teacher in one instance asked for a particular lesson to not be observed, as she considered the lesson to be “just revision” and so, in her opinion, not worthy of observation. This request was respected.

Following transcription from the digital recordings (carried out by the researcher), the interview transcripts were returned to participants for verification. No requests were received from the participants for changes to be made to the transcripts.

If requested by participants, a summary of the research findings is to be emailed to them at the conclusion of the study. All written and electronic material relating to the research were kept securely, with access restricted to the researcher. These will be destroyed five years after the completion of this research.

It is intended that data analysis and reporting in this thesis be confidential. However, one issue that is difficult to resolve is that of maintaining the anonymity of the case schools in reporting the research. Given that so few schools in New Zealand offer the IBDP as well as the NCEA, it is possible that a knowledgeable reader of the research findings might infer the identity of participant schools even from just

general descriptors. This possibility was considered in the application for ethical approval for this study.

4.9 Limitations and delimitations

A summary of the strengths and weaknesses of case study methodology is provided by Nisbet and Watt (1984), and cited in Cohen et al. (2000, p. 184):

Strengths:

1. The results are more easily understood by a wide audience (including non-academics) as they are frequently written in everyday, non-professional language.
2. They are immediately intelligible; they speak for themselves.
3. They catch unique features that may otherwise be lost in larger scale data (e.g. surveys); these unique features might hold the key to understanding the situation.
4. They are strong on reality.
5. They provide insights into other, similar situations and cases, thereby assisting interpretation of other similar cases.
6. They can be undertaken by a single researcher without needing a full research team.
7. They can embrace and build in unanticipated events and uncontrolled variables.

Weaknesses:

1. The results may not be generalizable except where other readers/researchers see their application.
2. They are not easily open to cross-checking, hence they may be selective, biased, personal and subjective.
3. They are prone to problems of observer bias, despite attempts made to address reflexivity.

So, in this research design it follows that the case study approach lent a real lens through which to view the phenomenon of chemistry teaching. It was intended to allow the teachers' views *speak for themselves*, and it was considered likely that the key findings emergent from the data would not have been so evident from large-scale survey type data. It was a manageable project for a single researcher.

The case studies are limited by:

- The qualitative design components, which means that results will not be generalisable. However, through processes as discussed in earlier sections, readers may be able to transfer findings to other contexts;
- The inclusion of only three case schools in the analysis;

- The number of participants in each case school was limited for reasons of manageability;
- The relatively short teaching sequences observed for each teacher; they could not be representative of all strategies utilised by a teacher in a given year.

Several delimitations apply:

- The curriculum area under study comprises Years 12 and 13 Chemistry courses (towards the NCEA/IBDP qualifications);
- Selected schools are all decile 10 co-educational schools;
- Only teachers' perspectives have been sought.

This chapter has described the research approach, methods, and data analysis utilised in this study. Results from data collected in each of the case schools follows in Chapters Five, Six and Seven. The results of analysis of selected, relevant statistical data relating to NCEA Levels 2 and 3 are presented in Chapter Eight. Chapter Nine provides a cross-case analysis of emergent findings by theme and a discussion of these, together with integration of findings evident from the statistical data analysis.

CHAPTER FIVE:

Results Case Study 1

This chapter presents data collected from the first case school: School 1 is a decile 10, urban, co-educational and independent school in the upper North Island. It offers senior students the choice of undertaking courses towards either the NCEA or the IBD as qualifications in Years 12 and 13. The interviews were semi-structured, were carried out in teacher non-contact periods or lunchtimes and around an hour long in duration. Results from the coded interview data are presented here. Data from a short sequence of classroom observations (3–4) of each participant teacher's practices, and reference to departmental documentation are also included where relevant. This case study was carried out in late Term 3 of 2013. Care has been taken to remove details that would lead to the identification of the school and the participants. Pseudonyms are used to protect the identity of those interviewed.

The researcher endeavoured to capture teachers' voices in a naturalistic setting. Background information on the character of the school, Science Faculty and Chemistry Department is given as a relevant context to the findings. The approach taken to data collection in School 1 is described in the following sections and research findings are reported under the themes of curriculum, pedagogy and assessment.

5.1 School 1

School 1 has been authorised by the International Baccalaureate Organisation (IBO) to deliver the IBD Programme for more than five years, and over that five year period has had an average IBD cohort of almost 60 percent of the total number of Year 12 students at the school. The Year 12 and 13 students undertaking the NCEA Levels 2 and 3 were therefore around 40% of students in the upper secondary school. This mid-sized (in terms of senior student roll), independent school has modern facilities of an exceptional standard, and occupies a spacious campus. Senior management and teachers appeared conscious of the importance for their own job security of maintaining and growing the school roll. The high academic achievements of the senior students were promoted as a significant aspect for attracting new enrolments (as evident from the school website and observation). Published results for the NCEA showed a high percentage of students' certificates at Levels 1, 2 and 3 were endorsed with Excellence. In the IBD programme, the very high overall pass rate as well as the success of students scoring 40+ points was lauded. The school also emphasised its strengths in preparing students for tertiary

studies, and one aspect of that was its stated aims (on the school website) to facilitate student applications for tertiary scholarships. Of the international students at the school, the majority are Korean or Chinese.

The teaching staff appeared to feel valued and enjoyed sharing morning teas together in a large staffroom, which also provided a forum for the Principal to address the staff. Classes were 50 minutes in duration and the school ran a 6 period day. It was observed that the school culture was such that it was expected that students be in class; extra-curricular activities, assemblies, and house events were not intrusive on lesson time. According to the Science Head of Faculty (HoF), Alison, the school had a policy whereby there was an upper class size limit of around 20 students.

5.2 School 1: The Science Faculty and Chemistry Department

The Science Faculty was well resourced, and staff and students worked in modern and spacious laboratories. In the main, each teacher was timetabled to one dedicated laboratory. The HoF was relatively new to the position and the school. She was welcoming to the researcher and acknowledged the strengths of the faculty staff under her direction, including the laboratory technicians, who she appreciated for being supportive and flexible in meeting the needs of the teaching staff. There is a tearoom for the Science Faculty and this was observed to be a place where most staff chose to eat their lunch and conversations included ones around workflow and aspects relating to the running and marking of assessments. The general atmosphere was collegial. All faculty teachers had spacious workstations with shelving for their hardcopy resources in a large communal workroom flooded with natural light. The HoF's office was nearby. The researcher was generously accommodated in the staff workroom, and at the time of the data collection teachers were observed working in a purposeful way in that space.

In 2013 there were four teachers of senior chemistry classes, and two of these teachers had taught at the school for more than 10 years. The HoF was keen to develop learning communities within the faculty staff, and while taking into account teaching preferences of the chemistry teachers, ensured that each teacher of a senior science subject was teaching across both NCEA and IBD curricula. For the chemistry teachers this represented an organisational change from that established by the previous HoF, where there had been a separation of Diploma and NCEA teaching responsibilities, and teachers saw themselves as *either* an NCEA *or* an IBDP teacher.

The faculty appeared to be an efficient one, and documentation, both hardcopy and electronic, were filed in a systematic way. Each teacher had a pigeon-hole in the workroom for the distribution of hard copy materials. The electronic repository of departmental documentation was held on a shared H drive. There were well-established processes around the internal moderation of assessments, as evidenced by the conversations overheard in the workroom and tearoom and from how processes were described in the interviews. However, when the researcher first met the Teacher in Charge of Chemistry, Robert, he commented that arranging meeting times that suited all teachers in the department was difficult because of the demands of extra-curricular activities on staff. This was clearly an on-going frustration for him. Faculty meetings were conducted regularly. In general conversation, teachers commented to the researcher that they were required to attend a number of school events that were scheduled for evenings. Therefore, they found that the logistics of undertaking professional development outside of the school, in addition to the school based demands on their time, to be prohibitive. However, all Science Faculty staff participated in the professional development programme run within the school.

The NCEA chemistry courses in Year 12 (Level 2) and 13 (Level 3), as outlined in the departmental schemes of work, comprised a selection of both internally and externally assessed achievement standards from the NZQA chemistry matrix. In this department the NCEA students did not use a workbook, rather there were teacher written worksheets available for every unit, and these were issued to students to complete for homework. There were copies of commercially produced workbooks for Level 2 and Level 3 chemistry courses available for teacher use.

The IBDP students sat their final examinations in the November session. Higher Level and Standard Level Chemistry courses were taught as a combined class over two years for each cohort. The courses were planned so that the practical and theoretical components stipulated in the IBO subject guide were completed in that timeframe. The IBDP classes used purchased workbooks and both the NCEA and IBDP classes used licenced digital resources.

5.3 School 1: The approach taken to teacher interviews and lesson observations

It was the HoF, Alison, at School 1 who selected the three participant chemistry teachers and introduced them to the researcher. The interviews were semi-structured in design and took place at a time in the school day convenient to the individual teacher in the weeks beginning the 1st of July 2013 or the 29th July 2013.

These were in the last week of the school's Term 2, and the first week of Term 3. A short sequence of lesson observations was undertaken in the same weeks as the interviews were conducted, with the researcher being in the school for a total of two weeks. The focus of the lesson observations was teacher practice.

By request of one participant, Anna, some lessons which had originally been planned to be observed, were not. This was in respect of this teacher's belief that revision lessons were not appropriate lessons for the researcher to record and observe. All participants were experienced teachers (>10 years overall teaching experience), although two of these three, while experienced with teaching the NCEA, considered themselves relatively inexperienced with the IBD curriculum. All of the participants had overseas teaching experience and experience of teaching chemistry courses towards different qualifications, including the GCSE, Bursary and School Certificate. Table 5.1 summarises the teaching load, responsibilities and experience of the teacher participants at School 1.

At the time of the researcher's school visit, all three participant teachers were teaching at least one senior class within each qualification framework (NCEA and IBD). This reflected the HoF's direction in that regard. Anna and Alison's teaching experience in the last 10 years had been mainly with the NCEA, whereas Robert had been mainly teaching the IBD. Anna had worked as an industrial chemist for ten years before going into teaching. She had no formal departmental responsibilities, preferring to be a full load classroom teacher. Robert and Alison had time allowance for being Head of Chemistry and Head of Faculty respectively. At the time of the researcher's visit to the school, no senior curriculum manager was available for an interview.

Table 5.1

School 1 participants (pseudonyms used). School 1 is an IBD/NCEA, decile 10, co-educational independent school.

Responsibilities	Participant	Total Teaching Experience	Teaching Load in 2013
No formalised responsibilities, but in practice took responsibility for the senior NCEA chemistry courses	Anna	>20 years plus 10 years as industrial chemist	Year 13 NCEA Chemistry (1) Year 12 NCEA Chemistry (2) Year 12 IBD Chemistry (1) Year 9 MYP Science (2)
Teacher in Charge Chemistry	Robert	>30 years	Year 13 IBD Chemistry (1) Year 13 NCEA Chemistry (1) Year 12 IBD Chemistry (1) Year 11 NCEA Extension Science (1)
Head of Faculty – Science	Alison	>20 years	Year 13 IBD Chemistry (1) Year 11 NCEA Science (1) Year 11 NCEA Extension Science (1) Year 7 Middle Years Programme (MYP) Science (1)

The data collected are presented in the following sections in three parts: Teachers' perspectives on curriculum, pedagogy, and assessment.

5.4 Curriculum: Teachers' perspectives and practices

The coding of the interview data from School 1 led to the emergence of findings that were related to implemented curriculum, and these are described in the following sections.

5.4.1 Alternative qualifications: NCEA and IBD.

Students of School 1 self-selected their senior qualification pathway (the NCEA or IBD). Prior to course selection, information evenings on both qualifications were held for Year 11 students and their families. One participant teacher (Anna), considered that for some students, the choice of which qualification they should undertake in Years 12–13 was a dilemma. Her own view was that the choice of qualification undertaken by students was relatively immaterial in terms of their university studies.

At the end of the day, I do have students who worry about whether they should be doing IB or NCEA, and it's their personal choice, but you know at the end of the day, it doesn't really matter, you go to university and you start all over again don't you? So, it doesn't really matter, that's my personal philosophy. (Anna, 4 July 2013).

When asked if there was targeting of some students for entry into the IBD, Anna rejected this. She was of the opinion that the Principal was deliberately giving messages that the NCEA is as "important" as the IBD. She felt that "In the past, students have felt maybe it isn't" (Anna, School 1, p. 9). Having been at the school at the time the NCEA was implemented, Anna felt that concerns about the NCEA at the time led to higher uptake of the IBD at School 1. However, she thought there was a trend of more students at the school now choosing the NCEA rather than IBD as their leaving qualification. Anna attributed this trend to be due to students seeing no advantage with the IBD in terms of university entry, and their concerns about completing the core components of the IBD:

Now, a lot of people realize that NCEA is just as good, useful for NZ universities and if they don't want to get bogged down with TOK and writing extended essays because they don't think they could cope with it, then NCEA is a good option. (Anna, 4 July 2013)

Later in the interview, Anna commented on her discomfort with teaching the Theory of Knowledge (TOK) aspects of the IBD course.

Anna and Robert saw differences in the abilities and approaches to learning of the IBD and the NCEA cohorts at School 1. Robert commented on the IBD students being "more focused", while Anna felt she had a greater rapport with the NCEA students. In her opinion, the more able students elected to study for the IBD. When asked what she liked most about the NCEA, she responded:

I like the students. I do! There is something different about them, at this school anyway, there is IB and the NCEA. And I love the IB students too, but the NCEA, what is it about them? I feel like I have more fun with them; and they're not necessarily the most brilliant of students, but I'm comfortable. (Anna, 4 July 2013)

At School 1, the teachers in the Science Faculty were consulted at the end of the year about their teaching loads for each following year. It was the personal philosophy of Alison, the HoF, that teachers taught NCEA and IBD senior classes as well as a more junior science class. She saw cross-curricula teaching as a means of ensuring dialogue between teachers, with the additional benefit of sharing the workload in terms of planning and resourcing courses.

This management approach affected Anna, who previously had been the sole teacher of Years 12 and 13 NCEA chemistry classes, and Robert, who had been teaching only IBD classes for several years. Both Anna and Robert had a collegial approach to their teaching practice, and were accepting of the relatively recent change to their class allocations. Robert said “I have a Year 13 NCEA, which I haven’t had for a while” (Robert, 30 July 2013). Anna put it like this: “We should all be sharing our knowledge and ideas, so I think it is fair that we all teach across both courses” (Anna, 4 July 2013). Anna however, did confess to being somewhat nervous about teaching the IBD course, and said she was more confident with her NCEA teaching: “I am probably better as an NCEA teacher, and that is where I have found my niche” (Anna, 4 July 2013). Alison was pleased with the outcome of Anna and Robert now teaching across both the NCEA and IBD, and she commented that: “they are now working very closely together, and that seems to have made a big difference to both of them actually” (Alison, 5 July 2013).

5.4.2 Course designs.

NCEA

The structure of the Year 12 and Year 13 NCEA courses at School 1 in 2013 are summarised in Table 5.2. The courses both offer opportunities for students to gain subject endorsement, which was clearly a driver in the design for both at School 1, and the Year 13 course meets UE approved subject requirements.

Table 5.2
The structure of Year 12 and 13 NCEA chemistry courses at School 1.

YEAR 12 CHEMISTRY COURSE (Level 2)	YEAR 13 CHEMISTRY COURSE (Level 3)
Carry out quantitative analysis. AS 91161 Internal	Demonstrate understanding of spectroscopic data in chemistry. AS 91388 Internal
Carry out procedures to identify ions present in solution. AS 91162 Internal	Demonstrate understanding of thermochemical principles and the properties of particles and substances. AS 91390 External
Demonstrate understanding of bonding, structure, properties and energy changes. AS 91164 External	Demonstrate understanding of the properties of organic compounds. AS91391 External
Demonstrate understanding of the properties of selected organic compounds. AS 91165 External	Demonstrate understanding of equilibrium principles in aqueous systems. AS 91392 External
Demonstrate understanding of chemical reactivity. AS 91166 External	Demonstrate understanding of oxidation-reduction processes. AS 91393 Internal
Demonstrate understanding of oxidation-reduction. AS 91167 Internal	
Total credits = 23 (comprising 10 internal; 13 external)	Total credits = 21 (comprising 6 internal; 15 external)

Alison commented on her changing philosophy towards course design, with fewer credits now being offered in the two senior NCEA chemistry courses. She wanted to move away from having “too many achievement standards crammed into one year” where the focus for students was merely on attaining a high number of credits. She put it like this:

Well in chemistry we were offering a huge number of credits in one course. So, we are looking for quality rather than quantity. (Alison, 5 July 2013)

Alison also talked about the flexibility that NCEA offered in terms of course design to be one aspect of that qualification that she liked the most:

With us starting our science course in Year 7, we can really plan a proper good foundation for our Year 12s. We decide what goes in there, and we can organize our own courses. So to me, the flexibility for the school, is a plus. (Alison, 5 July 2013)

Anna pointed out that the Year 12 NCEA course had been adjusted so that the students were prepared for the demands of the Year 13 course. Alison could see how courses could have too many achievement standards, with teachers having difficulty in terms of not covering some, and with implications for student outcomes. She argued that:

It is very hard for a passionate chemistry teacher to say OK, we won't teach that achievement standard... So, 'here are the achievement standards at Level 3, which ones do you, as a passionate chemistry teacher, think aren't important?' It is a difficult call to make. So, it has to be done very carefully, and once it is done well, I am not concerned about the students really. (Alison, 5 July 2013)

The Year 13 course comprised three external and two internal achievement standards, with the two internal standards included in order to satisfy the requirements of a subject endorsement:

We had a reshuffle at Level 3 this year because of the realignment. We wanted to offer the two internals, to give them the chance of endorsement. (Alison, 5 July 2013)

All of the School 1 participants noted that, previously, some students were not attempting all of the achievement standards set within a course, especially in the case of the externally assessed standards. Alison saw this trend as a way of students lessening their workload when they were faced with courses that were too large for the time available. She felt students had made these decisions (about not doing aspects of the set course) autonomously, and she had concerns about the implications for their further learning in the subject:

We were finding that students were deciding for themselves, 'well I won't do that achievement standard', so our results for one particular achievement standard were low, and it wasn't an achievement standard that we would have suggested to the students that they leave out, so we decided we would make the decisions for them, and we cut the number of achievement standards. So, timing isn't an issue this year, I don't believe, but I still have some staff telling me it still is. (Alison, 5 July 2013)

While in the past the Level 3 Chemistry standard, AS91387 (3.1) Carry out an investigation in chemistry involving quantitative analysis, had been offered as an optional part of the course, this was no longer the case. It was Anna's opinion that in previous years, the time taken to complete that one internally assessed achievement standard (3.1) was problematic. She saw 3.1 as incurring an opportunity cost to student's success in the end of year examination. When talking about the rationale for the 2013 Year 13 course structure, she explained:

It [3.1] wasn't included in the course, for the time it takes. They are better off having a more limited course and more likely to achieve more passes at the end of the year. That is my perspective, anyway. (Anna, 4 July 2013)

Alison had experience of running 3.1 at her previous school, and it was her belief that students “get a lot out of it”. However, Alison gave two reasons for no longer including 3.1 in the Year 13 course at School 1. Firstly, the manageability of running the practical work for the investigation was considered an issue for one of the teachers in the department, who in recent years had felt “overloaded by it”. Secondly, with the realignment, this standard no longer needed to be included in the course to satisfy the conditions of endorsement. In her words:

We were giving the students the opportunity to do the chemistry investigation, which was 3.1, but really we were forced to do that because they couldn't get endorsement without it, and now of course, they can. So, this year we've not suggested that anyone does the chemistry investigation, which is a shame I think, I think it was a great thing for them to do. (Alison, 5 July 2013)

At School 1, 3.1 had been offered in the past to students as an option, especially for those students who had then needed it in order to satisfy the conditions for a course endorsement. The work was done by arrangement in the student's and teacher's own time. Anna spoke strongly of her dislike of 3.1, which was linked to her dissatisfaction with grade outcomes for students in the standard:

I really struggle with teaching 3.1, I've done it before, I hate it. It's incredibly time consuming and I feel it's incredibly difficult to get excellence, especially with the NCEA students we've had going through here in the past. I did offer it last year, as an option, so that students could get the...[pause] number of credits they need for endorsement. I have done that for the last two years, and that has been in their own time, and my time, and in the holidays and things like that, to try and get it done. Because we had several students who just wanted the credits for it, and people who wanted to aim for endorsement. (Anna, 4 July 2013)

Robert talked about the NCEA achievement standards offered at School 1 reflecting the needs of their students, most of whom were going on to university studies. He also echoed the views of Anna and Alison, in terms of the available teaching time being a constraint to offering any more standards in either Year 12 or 13, and that offering a manageable number of credits per course was the right strategy. In Robert's view, students had “too many study periods”, and he would prefer to see a different school timetable structure with more teaching periods per course.

IBDP

The overall course structure is a prescribed one, and at the time of this research the teachers of IBD chemistry in different regions around the world were all working with reference to the same Chemistry Subject Guide (International Baccalaureate Organisation, 2007). Robert noted that at School 1, students undertaking Higher and Standard Level courses were taught together in one class. He would have preferred

to have separate classes for each of the two groups of students. He explained that the combining of both groups meant that teachers then planned to teach the Standard Level content in Year 12 and the Higher Level content in Year 13, the second year of the Diploma course. He noted that there was time pressure to finish teaching all of the required components of the Higher Level course:

We need to put some of the higher level into Year 12, otherwise we are not going to get things finished properly. (Robert, 30 July 2013)

Alison, the HoF, agreed with Robert's view that it would be preferable to have separate classes for SL and HL students. However, Alison, despite saying that the departmental staff were telling her that the allocated teaching hours were "a huge constraint", said she did not personally think that teaching hours were a difficulty in teaching the IBD course.

5.4.3 Planning and resourcing.

A focus for the chemistry department in 2013 for School 1, was to update documentation relating to the planning of units of work for the senior chemistry courses. This was the case for both NCEA and IBD courses.

At the moment we are trying to get people to take units of work and write schemes for them. It was a bit looser to start with, people were teaching from their own knowledge, but we are starting to put more structure into it. (Robert, 30 July 2013)

However, the participant teachers at School 1 all described having limited opportunities to meet with their colleagues and plan coursework in a collaborative way. Robert, as the curriculum manager for chemistry, had responsibilities for all chemistry programmes from Year 7 upwards at the school, with significant input from Anna in terms of the NCEA courses. Robert expressed the practical difficulties in finding time to work together:

I find it awkward personally, because one of my teachers looks after the Middle School Science and he is not very available to me in terms of producing resources or being available to discuss things when I want them discussed, because he is doing his thing. [Alison] as Head of Faculty, is often tied up with doing other things as well. So, it is very seldom that we get four of us together discussing chemistry. (Robert, 30 July 2013)

When Alison was asked about what were her main considerations in planning units of work, she described her preference to plan with a pedagogy focus. She explained that she could see her own views on what were important elements in unit plans were different from that of others in the department, for whom planning had an assessment focus. This is how she put it:

I think there are differences in what people want to have. I would like for every topic, there to be a pedagogical scheme, so not 'This is what you have to teach.'... I think for other staff, the big things are, 'Have I got the assessment right?' 'Is the mark-scheme workable?' So, they will look at teaching a topic, and assessment will be the focus. I think we all have a different way of looking at it. (Alison, 5 July 2013)

For Anna, course planning for the Year 12 and 13 NCEA classes was done to allow class time for revision at the end of the year. She saw this as important to facilitate students' success in the external examination.

In order to explore more fully the planning process undertaken by the participant teachers in planning a unit of work, they were each asked to describe their approach and resources used when planning a unit of work in organic chemistry. Robert said that when planning for the IBD course, he looked at notes and practical work that had been used in the past, he would then "assemble those into a folder" before writing an overall scheme "telling the next person what's actually in the folder". Alison said she used the electronic *Questionbank* discs supplied by the IBO and textbooks as well as the Subject Guide. Robert explained that a course outline giving an overview of the assessments for the year was prepared at the end of the year before. He saw similarities between his and the general approach taken by Anna when planning a unit for an NCEA class:

She would more look at the past and how it would have been done years ago and what was there before the realignment and what topics would have been taught? Start assembling worksheets and notes, and looking at the IB resources too. The folders are open for everyone. (Robert, 30 July 2013)

NZC (Ministry of Education, 2007) was not referred to by any of the teachers of NCEA interviewed in School 1. Instead, teachers described referring to the achievement standard statements to guide their planning of their NCEA units. Teaching to the achievement standards was explicitly stated. However, all of the teachers felt unsure of interpreting the achievement standards. Anna put it this way:

I think the achievement standards are a bit better now, with the realignment. But there were times when you wondered 'what are you supposed to be teaching here?' Which is why you have cluster meetings, and have discussions with other teachers, which is good, in terms of clarification about what you are supposed to be teaching students. In the past, you'd end up looking in a textbook to see 'am I doing what I am supposed to be doing?' 'Is it in the new textbook that has been printed out?' It is unclear at times what you are supposed to be teaching. (Anna, 4 July 2013)

As part of her planning work that was required as a result of the realignment process, Anna said “I go back to the achievement standard and compare that with the old one, and look at what’s missing.” Alison commented on the dearth of useful exemplars on the NZQA website, and felt that:

It is frustrating for teachers and that is what creates the negative spiral and negative NCEA talk because that would annoy anyone. So to give us the resources really, that would be a great thing. (Alison, 5 July 2013)

Alison said the department used “a couple of different textbooks” and also talked about referring to past examination papers and the achievement standard when planning a unit of work. She also used resources developed by Auckland University when planning units of work. The Level 3 NCEA teachers at School 1 had also shared some resources with teachers from other schools when they attended a local cluster meeting.

5.4.4 Teachers’ evaluation of the NCEA and IBDP.

Clarity

The IBD Subject Guide for chemistry (International Baccalaureate Organisation, 2007) was described by all of the participant teachers at School 1 as offering clear direction for planning units of work. However, teachers were less sure about what to teach for the NCEA courses.

The IB one is fairly straightforward because the syllabus is pretty well organized. You can basically just run through it in a teaching order, you can change the order a little bit, but it tells you exactly what you need to know in terms of the syllabus. As opposed to NCEA which is extremely vague, but the IB one is not vague at all. (Robert, 30 July 2013)

This uncertainty, or “vagueness” as Robert put it, evidently stemmed from difficulty teachers had in interpreting the demands of the achievement standards. Anna considered that teachers less experienced than her with NCEA may have difficulty in planning their courses. Robert said he referred to textbooks as a strategy to clarify the requirements of an NCEA unit of work. He went further, pointing to teaching to assessment, to say:

You need to go to past assessments, and you need to go to textbooks where the writers are sort of in cahoots with the people who are putting assessments together. (Robert, 30 July 2013)

Structural issues with the NCEA

All of the participant teachers at School 1 considered that the achievement standard structure of the NCEA offers accessibility; with students able to experience success with this format. However, the division of an NCEA course into discrete achievement standards has, the teachers said, negatively impacted on the teaching and learning of chemistry as a whole discipline. As an indicative comment on this issue of fragmentation, when asked what he liked, and then what he didn't like about the NCEA, Robert said:

What aspects of NCEA do you like the most?

Well, I don't like a lot about it to be honest. No I don't like much about it at all. I do like the fact that it is teaching chemistry, obviously, and it is teaching good chemistry, but I just don't like the way it is structured for the students because I think that you can take things out of context and some things make more sense if you mix it with another topic, but you are not allowed to.

What aspects of NCEA do you like the least?

The fact that they have chopped it up into pieces and also when you assess it in bite sizes like they have been doing, you can make one bite size harder than it should be, and it is very hard for students to show their knowledge. (Robert, 30 July 2013)

'Watering down' of the NCEA in the realignment process

Anna expressed the view that curriculum demand had been reduced through the re-alignment process; that content had been removed from the Level 2 course. She expanded on this:

I think I preferred it being two separate papers actually. I felt that when it was two separate papers and you had the quantitative 2.3, you were assessing more of their knowledge on quantitative chemistry. And I think it is probably easier to attain an excellence in that standard now, because they have reduced the amount of demand. I think it has been watered down a little bit. (Anna, 4 July 2013).

The IBDP: Challenging to teach

Alison and Anna were significantly less experienced than Robert in teaching the IBD course. Anna was less confident in teaching the IBD compared to the NCEA and said:

I don't like being out of my depth, and I'm being really honest here, sometimes IB it scares me a little bit; it is very high level some of it. Sometimes I feel like I can't answer everybody's questions, and I'll go to [Robert] and say to him I don't get this, or I don't understand this. The 12 is OK, but I tend to get anxious that I'm not giving the students what they need.

I have to explain things to myself. If I can explain things to myself, I can explain them to students really well. That is why I like NCEA, I can do that without having to encourage them to do TOK [Theory of Knowledge], that is what I like the least. That is what makes me nervous about teaching 13IB, and having to go places that I am not sure about in terms of debate and the development of science and knowledge is not me...so NCEA suits me well. So, I am probably better as an NCEA teacher, and that is where I have found my niche. (Anna, 4 July 2013)

The same teacher was more experienced with teaching the NCEA, and reported greater confidence with teaching towards that qualification:

Actually I find the [NCEA] course easy to teach. I know what I am doing, I think that having taught NCEA for a while, I have covered everything every year that I need to cover, without missing anything out for the students. (Anna, 4 July 2013).

Alison commented on her difficulty in teaching the 'options' component of the IBD course:

It's hard to do the options well. For a small number of teachers to be experts in all of those fields is quite a difficult thing, and we tend at this school to say to the students 'OK, here is the two options you can choose from', which is not the way I think it is meant to be. So, I like the idea of the options, whether we do it well here or not. (Alison, 5 July 2013)

The IBD is a 'broad' curriculum

Alison thought that the overall structure of the IBDP, meant that students were "well-rounded" when they left school. This, she explained, was because of the Diploma's core requirements of the Extended Essay and Theory of Knowledge, and students' courses comprise a selection from each of the subject groups. Robert talked about the breadth of the IBD curriculum this way:

It has good breadth of content that will let them cope really well with anything at university. I have had a look at university schemes of work; our students are really well prepared in all areas. (Robert, 30 July 2013)

Professional satisfaction

The chemistry teachers in School 1 cited different grounds for deriving professional satisfaction from their classroom teaching. Robert considered good grade outcomes for students (in both NCEA and IBD courses) as being a highlight for him professionally:

Highlights, well some of it was in results, because we continue to get extremely good IB results. So, for me personally, I managed to get 7's which I wouldn't have picked to be getting. With NCEA, our results have been picking up, which is a change in student attitude a little bit too. (Robert, 30 July 2013)

Anna referred to deriving satisfaction from the results her students had attained too, saying that for her Year 12 NCEA class “67% of my students got merit or excellence [subject] endorsement last year, which I think is pretty good”. Several times in her interview Anna described how developing positive relationships with her students was professionally rewarding for her. An example of this that she described was:

I've had one boy in my Year13 class currently, who I have taught for four years in a row and he still loves being in my class. ...he told me at a parents meeting that he has a passion for chemistry. So obviously that sort of thing makes you feel really good, that they still love being with you, and still learning from you. So, things like that. Students saying 'thank you'. (Anna, 4 July 2013)

For Alison, professional satisfaction came from reflecting on how she had improved her teaching practice over the last five years. She felt she had benefitted from her teaching experiences at her last school, where she worked with “passionate” colleagues, and she had worked hard to improve student engagement in her classes, with her teaching strategies “changing significantly” over time.

5.4.5 Preparedness of students.

Teachers' views on the preparedness of students for Years 12 and 13 chemistry courses (NCEA and IBD), and for first year university chemistry courses were sought.

When asked if School 1 set prerequisites for students with regard to entry into Year 12 chemistry classes (NCEA and IBD), Robert explained that the department had now set an entry level based on results for the externally assessed Year 11 science standards. He put it like this:

No matter what they do, they need to have two passes in externals, they can't have one and the internals to get through – it's not going to work. (Robert, 30 July 2013)

All of the teachers had views on the key skills and competencies students would need to succeed in university chemistry courses. Robert and Alison held the belief that to cope well with university study, students needed to be independent learners. Both Robert and Alison were of the view that the IBD students established good study and time management skills before leaving school. Alison said:

The IBD expects the students to work independently; expects good time management. If you look at the Extended Essay and the Theory of Knowledge work that they do, that's an expectation that would help them at university. NCEA doesn't have that. (Alison, 5 July 2013)

When Robert was asked about the NCEA students he said “I don’t think they tend to have the same good work habits”. He attributed this to be due to the Year 13 NCEA students doing five subjects and having too many study periods in their final year at school “that they waste”. He described IBD graduates giving feedback to him about their experiences of their first year university course:

They come back and say I am doing Chemistry this year and I am getting A’s in all my tests and I’m doing this work that we covered last year; we just go a little bit further in it, but I understand it all. (Robert, 30 July 2013)

He didn’t have a comparison to make with the NCEA leavers, as he had not taught senior NCEA chemistry for a while, he noted they did not come back to school to talk to him. Alison was concerned about previous students now at university, who tell her that they don’t go to lectures “because it is all online”. She felt that the students needed to know that the online materials were best used as materials to support lectures, rather than as a substitute for attending them. She had a son currently enrolled in a university chemistry course and so felt she had a good understanding of the expectations and scope of a university undergraduate course. Alison’s comment on the IBD chemistry course follows:

I think the chemistry content is well thought out as well. It definitely, from what I have seen of university papers, it flows to university papers so, the kind of broadness is good for students when they go to university. (Alison, 5 July 2013)

Anna considered basic mathematical skills to be a key competency for tertiary success. She described weaknesses she saw in the NCEA cohort:

Definitely a good understanding of maths, and we do get quite a few NCEA students through who do struggle with their math in the chemistry, and you do find that you have to help them with which buttons to press on the calculator. (Anna, 4 July 2013)

She also considered that fragmentation of learning was an issue for NCEA, but not IBD, students transitioning into university studies. She explained it like this:

I think NCEA provides them with the content. The trouble with NCEA, and I do actually say this in my classes, say you are teaching organic, what do you teach first? The redox? Because there is an overlap, and NCEA compartmentalizes each topic doesn’t it, and perhaps for organic you wouldn’t expect to write half equations for oxidising an alcohol into a carboxylic acid. They say write equations to support your answer, but..... they won’t have done redox yet. So, it breaks the course and compartmentalises it, and maybe students can’t link it all together when they go off to uni. Whereas, IB, they get a long answer exam which links it all together, which is quite useful to them. (Anna, 4 July 2013)

In Alison’s opinion, the “way the school organises things” was more important in terms of preparing students for university studies in chemistry, than if students

studied towards the IBD or the NCEA qualification. She raised the issue of NCEA courses differing between schools in terms of the achievement standards offered, and considered there to be implications for students in that in terms of their preparedness for university. She also felt that not all schools were sufficiently resourced to undertake adequate practical work. Overall, she thought that the IBD chemistry students had a broader course of study than did the NCEA students.

Does NCEA prepare them for the actual content they need to learn at university for a chemistry course? Probably not as well as the IBD does. I think that is changing, that the spectroscopy standard has been slotted into the NCEA course is massively advantageous for the NCEA kids, but some schools may choose not to do that. So, will all those NCEA students be as well prepared? It is difficult to say really. The fact that NCEA does offer choice of standards, it can be that some students are going off to university to do chemistry who maybe haven't got as good a foundation as others. I think the IBD, because it is a lot more prescriptive, you know exactly what they have done in the course, if you take the options out, you know exactly what has been done when they go off to university, and it's a lot more than it would be at NCEA Level 3. (Alison, 5 July 2013)

5.5 Pedagogy: Teachers' perspectives and practices

The classroom observations and coding of the interview data from School 1 led to the emergence of findings that are related to pedagogy, and these are described in the following sections.

5.5.1 Favoured teaching strategies.

All of the School 1 teachers commented on their use of digital technologies in their teaching. Alison's aim of improving student engagement in her classes, was linked in her comments around her use of digital technology to encourage student collaboration. She commented on her satisfaction with using specific software in this way:

Google docs, presentations, forms etc have changed things dramatically for me, because using google presentations for example, where you can get collaboration. The students presenting themselves; everyone working together on one area, just works brilliantly for me. (Alison, 5 July 2013)

School 1 has data projectors and interactive whiteboards in every laboratory. Alison said:

We don't have a lot of tools that we use well with smartboards, but we do use them from time to time. (Alison, 5 July 2013)

This agrees with the comments that Anna made, with regard to "not really using the smartboards". Anna said she also used video resources at times, and she was

observed doing so; playing a short clip on an industrial scale application of reduction-oxidation chemistry. School 1 also has a licence for the use of the online chemistry programme *Bestchoice*, developed by Auckland University, and Alison considered this resource to be “fantastic for NCEA, and quite good for IBD”. Robert also made use of *Bestchoice* and commented on other online resources used by his classes:

...for some of the more abstract concepts where you want to see simulations, that is absolutely ideal, and the students give really good feedback on that. The fact that they go home and use that is a really good sign. (Robert, 30 July 2013)

There was limited use of digital technologies in those lesson sequences observed at School 1 by the researcher. Although Alison had described in interviews how she used *Google* tools to encourage collaboration in her classes, this was not observed. Alison and Anna referred to using mini-whiteboards and laminated “traffic light” cards so, as Alison put it, “you can immediately see where you need to go to help”. Anna and Robert commented on finding the mini-whiteboards especially useful for teaching organic chemistry, this is what Anna said:

[Alison] has introduced whiteboard cards which I have been using quite a lot for quizzes, especially for organic, you know draw the structure, name this, and it is a good, easy way to see who needs extra help, so I will go around those students who need a bit of extra time. (Anna, 4 July 2013)

In a single observation of a Year 10 class taught by Alison, students were using the whiteboards and traffic light cards to respond to teacher questioning. However, neither of these resources were used by Years 12 or 13 chemistry students in the lesson sequences observed in School 1. Anna identified several elements that were key to her teaching strategies. She believed it was important that “students understand what they are trying to achieve”. She also thought it important to have lessons that offered a variety of learning tasks, and these should include some “fun activities”. She saw the inclusion of practical work as important for student engagement. She commented on the feedback she gave students on their homework and how she held them accountable for completing set homework:

I collect in a lot of homework, small worksheets, mark it, give them some feedback, it's not necessarily an A, M, E. I don't tend to mark homework like that. It will be more like an effort grade, and I will give them, I will annotate their homework and try to give them some feedback on what they need to do. I tend to go over homework as well, at the beginning of lessons, just to make sure that students are doing what they are supposed to do. (Anna, 4 July 2013)

She also said she was “not a workbook teacher”, and instead made use of worksheets that she had prepared herself for every unit of work. In two lesson

observations, Anna started the lessons by reviewing such homework she had set students, and responded to questions students had.

To explore more fully the range of teaching strategies used by teachers, Anna and Robert were asked to describe what they considered to be the most effective approaches to use when teaching organic chemistry. Robert saw that it was necessary to “break it up as much as you can because there is a lot of learning in it”. He noted that students “don’t like sitting down and learning organic chemistry, the rote learning parts”. He also described using molymod kits a lot with his classes. Anna described teaching organic chemistry to her students in two ways:

When I teach organic chemistry I tend to go through each type of compound first and what it does, but then at the end, we’ll go back and look at what compound undergoes substitution, ‘what reagents can we use to substitute this?’ So, we kind of work backwards and take a different viewpoint. (Anna, 4 July 2013)

Anna took time to reinforce the fundamental concepts at the start of teaching a unit of organic chemistry to a Year 12 class. She also aimed to improve the depth of her students’ understanding at the end of the unit by including practical problems for them to solve. She explained her approach like this:

We do the practical work, we do the quizzes, for Year 12 anyway, drawing compounds, recognizing functional groups, naming. I think if you can spend quite a bit of time reinforcing those, then the rest of it tends to flow afterwards, that is the big hurdle. Once you are over that, the other bits tend to fall into place don’t they? I do support it with practical work. We do the oxidation of alcohols, we attempt the Lucas reagent test. You know, alkanes, alkenes...and then at the end, we do quite a bit of organic analysis. I’ll give them some unknowns (I’ve just done that), so you give them a whole lot of reaction beakers labelled A, B, C, D and they construct reaction schemes. They can figure out everything they’ve learned. I think that really reinforces their learning. (Anna, 4 July 2013)

5.5.2 Practical work.

“Not a lot” and ‘none’ were Anna’s and Robert’s responses when asked how much of the practical work done in the NCEA courses at School 1 was open-ended investigation. Anna instead described using practical work to reinforce the theoretical concepts, rather than “leaving them [the students] to think about how they might do things themselves”. Robert said that the IBD students had opportunities for open-ended investigation in the practical components of their chemistry course, through the requirement for them to design, carry out, evaluate and write-up practical investigations work; their Group 4 interdisciplinary project; as well as if they wrote an Extended Essay in a chemistry topic of their choice. Robert replied, “as much as we can” when asked how much practical work he carried out

with his classes. He noted that more practical work was done by IBD compared to the NCEA students, and that the extent of the practical work done by the NCEA classes was tied to the nature of the internal assessment of achievement standards:

60 hours for IB. NCEA doesn't get as much, and I think that is a time thing. If we had one more period a week, you would tend to throw a little bit more in. But the internals that we are doing, neither of them involve any practical work, for Level 3. Whereas in Level 2, they are.

Which Level 3 [internal] standards are you doing?

We are doing spectroscopy, which doesn't involve any practical work at all, and redox. We will show them the stuff, but then we will test them with a theory test. Whereas in Level 2, they are very practical, the internals. (Robert, 30 July 2013)

By no longer offering the 3.1 achievement standard, Alison agreed with Robert and Anna's comments that there was now no opportunity for the Year 13 NCEA students to carry out an extended investigation in chemistry. Despite this, Alison held the belief that "actual hands-on laboratory skills, basic things" were important for students to develop. Anna too, believed in the importance of including practical work in her teaching. She saw practical work as being important in terms of student engagement:

I like to do a lot of practical work, because I think students find it interesting, not always the most helpful, but I think it makes it more interesting for them. I know other teachers might think it is a waste of time, but I like doing that. That is where I am coming from. (Anna, 4 July 2013)

5.5.3 Reflective practice.

When asked about how assessment data is used to inform teaching and learning in the chemistry department, all of the School 1 teachers described how, at the start of the year, students' final results for both NCEA and IBD were analysed, both within and across departments. For the NCEA, assessment results by achievement standard were considered:

For NCEA you will get a report for every standard so you will get an idea if there is any standard that is causing problems. (Robert, 30 July 2013)

In terms of informing her own practice, Anna said she was particularly concerned about students who did not attempt a particular standard in NCEA and how she might deal with that:

In terms of teaching, I would probably look and think 'well, what subjects did they choose not to sit?' 'What have I done, or what could I do better there to encourage them a bit more?' How I do that through the year, I don't know. But I am always aware

of the fact that this is one that they balk at, and so while I'm teaching that at the time, I think about 'are we being successful here, or not?'. (Anna, 4 July 2013)

She felt she knew her students very well, and so examination data from the year before was of limited value to her. She explained:

I do print off at the beginning of the year what they have done the year before. But, because I know my students and I know where they are at (probably I've taught them in Middle School as well) so by the time they come through with me, I am fairly aware where their strengths and weaknesses lie. (Anna, 4 July 2013)

Robert talked about data analysis that is done on the final assessment results for the IBD. He said that he analysed examination results by paper:

I have to write a report and in IB we would tend to look at which paper is causing any issues. The lowest of the three, why? Like is Paper 3 down from where you think it should be; do you need to give more attention to the options? Is Paper 1 lower than it should be; do we need to do more practice with multi-choice questions? That type of thing. (Robert, 30 July 2013)

Alison also described how results collected throughout the year were being utilised within the department to inform teaching. When asked "how is assessment data used to inform teaching and learning?" she explained:

We are working on making that a priority. This year we have used some of our faculty meeting time to get together in faculty groups and within those groups, we have looked at what results we got for a particular test last year, what we are doing about our teaching this year to address that. So, we are working towards a cycle of inquiry teaching. We have not done that very well previously. We teach a topic, have a test, teach a topic, have a test, and then teach a topic again next year and do a similar test. And, obviously to me, that isn't ideal. So, we are moving towards using data to inform our teaching, but we are on the first step I'd say. (Alison, 5 July, 2013)

5.5.4 Professional Development.

Alison reported having undertaken professional development over recent years that was related to developing pedagogy in general, rather than being subject specific. She had attended a google docs training course during one recent school holiday period, which she found "absolutely outstanding". However, she was far less satisfied with her "pretty useless" IBD training workshop, where the presenter was quite disorganised, and thought that an online course (which are also offered for different subjects by the IBO) would have been better. Robert had also previously attended IBD teacher workshops for chemistry. He was intending to go to another in the second half of 2015 because of the imminent changes to the chemistry syllabus. He gave the following reasons:

I would like to have a look at the new internal assessment for IB, which is happening for us in 2016. We will start teaching that in 2015. So, I would really like to get in on that, not at the first opportunity, but at the second opportunity so that you get feedback from some of the Northern Hemisphere schools that have already been through some of it. Second half of 2015 would be the best time, because we will be doing it in 2016. (Robert, 30 July 2013)

Anna thought that the professional development most useful to her would be on using digital tools effectively in teaching. She said:

Because I am not brilliantly confident using computers, that sort of PD you know, with the google docs, and even using the data loggers, I am slowly learning how to use those in my classroom and so on. More PD on using smartboards, and how I could use them wisely in my classroom to make it more interactive. I think I know what I am doing, in terms of the course, so I don't feel like I really need PD in terms of ...just ways to deliver the course, you get fixed...I get fixed. (Anna, 4 July 2013)

Anna and Robert explained that the logistics of undertaking professional development for NCEA that involved getting to another school was a hurdle for them. Robert blamed the traffic. Anna explained it this way:

I tend, honestly, to not go to the cluster meetings that they have, unless I am forced to [laughs]. Life is busy, and I know that I probably need to get out there more, and meet more people involved in chemistry, and share ideas with them, but the job becomes too big. (Anna, 4 July 2013)

Robert was dissatisfied with NZQA run professional development he had attended in the past. When asked if he had gone to Best Practice workshops, he said:

I have done. Some are a waste of time. Most Best Practice workshops are a total waste of time. The best courses we end up going to are ones out of [school named] with [facilitator named]. You have to pay for it, but they are proper PD courses. Best Practice talk about other things, which are not the slightest bit relevant to your teaching. The same with the thing at [another school named]; a lot of it was completely irrelevant. Talking about language and answering science things, and most of it was Biology, which has different issues to us. When you sit around, about 3 people want to talk about nothing but 3.1, and most people don't do it. Anyway, it's still nice to be with the people. (Robert, 30 July 2013)

Alison held the view that there was a need for improvement in what was offered by NZQA and the MoE in terms of professional development for teachers:

I think that what would give me real piece of mind in terms of where chemistry is going, would be organized well-thought out cluster meetings. We have cluster meetings for NCEA chemistry that are organized very well by volunteers. They are full-time teachers, so they are really busy. They say, 'right let's put a cluster meeting together for teachers'. What I'd love to see, would be for that to be someone's job, supported by the Ministry...Let's get chemistry teachers together and let's talk about...Even the cluster meetings, we had a parents evening, and so our staff couldn't

go. To me it is just a token. I really feel, hold on we need to have our profession back, this is actually really important that we all get together. In chemistry there are a lot of small schools with only 2 or 3 chemistry teachers. (Alison, 5 July 2013)

5.6 Assessment: Teachers' perspectives and practices

The classroom observations and coding of the interview data from School 1 led to the emergence of findings that are related to assessment, and these are described in the following sections.

5.6.1 Grade focused outcomes.

It was clear from their comments made in the interviews that all of the participant teachers in School 1 were very mindful of students' grade outcomes. This mindset was articulated too in their lessons. An example of this was observed in a lesson that was spent reviewing a recent end of topic test for a year 13 IBDP chemistry class. The teacher emphasised key marking points from the mark scheme to the students. In turn, several students took time to individually query the marking of some questions in their assessments with the teacher. Although the test paper was not part of any final grade, students appeared anxious to maximise their marks.

5.6.2 Workload.

Alison described how the school collated assessment calendars for both the NCEA and IBD, and with the students in mind, tried to "spread out" assessments. However, this was not always successfully done, and she said:

It doesn't always get sorted out. So, we do find times when the students are totally overloaded. And, looking at the calendar, you can see they are going to be overloaded, and so they will choose the high stakes assessments to work on. (Alison, 5 July 2013)

Alison also talked about the workload for staff that is associated with the internally assessed achievement standards as being her most significant concern with the NCEA. She elaborated:

The internal assessments have created a huge workload for the teachers. I would really like the ministry to put some money into that, and say 'OK these are done internally at the school and the credits are there during the course of the year, but if teachers are having to mark these, then some time is given'. I just think it is difficult to actually offer a number of internals and not create too much work for teachers. (Alison, 5 July 2015)

It was as a response to the teacher being "overloaded by it" that the 3.1 standard was no longer offered as part of the Year 13 NCEA course (see Section 5.4.2).

5.6.3 Teaching to assessment.

Assessment was clearly a significant driver of planning and teaching at School 1. When teaching NCEA students for upcoming internal assessments, Robert described how he was “constantly telling them how to write answers.” He expanded on his comments about such rehearsal strategies, with an example from the Year 13 NCEA course:

For instance, doing spectroscopy at the moment, all the way through you are saying ‘well you are going to get some spectra, could be one of these molecules and justify why it is and why it isn’t the other one. Just keep telling them the same thing. You will get a spectra like the ones you are looking at, at the moment, you may even get an example that you have seen before. In fact, they are likely to; we just throw as many at them as possible. (Robert, 30 July 2013)

Robert described his focus on past examination papers when preparing NCEA students for their external assessments, and added that “often you are second guessing what type of questions will be asked.” Anna planned her NCEA courses so as to have time for revision at the end of the year, and her focus then was on reviewing “terminology that you desperately need to get those Excellences.” When planning units of work Anna said she referred to past examination papers off the NZQA website, as well as practice examinations purchased from the New Zealand Institute of Chemistry (NZIC) and other suppliers. She summarised her approach to assessment:

NCEA, if I am thinking about chemistry assessment, then I do work towards exams and we look at mark schemes, and how they differ from year to year actually, because they do. One year there might be some key terminology that isn’t in there the following year, so what do with my classes in terms of assessment. We have prelim exams in ... I aim to finish the course early, so we have time to go back over everything, and I tend to revise the course with the students first, we will quiz each other, and then we will try exam questions. So, I do and redo. (Anna, 4 July 2013)

When teaching IBD, Robert also talked about using past examination questions:

I find that in IB in particular, the same sorts of questions crop up year after year, so it is really important they go through past papers. (Robert, 30 July 2013)

5.6.4 Formative assessment.

Alison had a clear intention of encouraging the use of formative assessment strategies by the teachers of the faculty:

I think what we are trying to do, is to include more formative assessment that is part of the learning, it’s quite a difficult thing to do, but obviously, teachers get into that trail of teach this, and assess it at the end. Trying to look at ways of using assessment as part of the learning. That are simple and part of the lesson, ‘how do I know that I know

this?'...actually as part of the lesson, so that is what we are trying to work towards. Using things like the whiteboards. So, this is what we have been trying to learn today, let's see if we know it. You know, how many people know it, and if you don't know it, you need to come and see me later, and not wait, and that kind of thing. Not wait until we have done 4 weeks of teaching before we have done any assessment. (Alison, 5 July 2013)

There had evidently been uptake of the use of the mini-whiteboards in their teaching by Anna and Robert, with both teachers describing using them as a formative assessment tool in their teaching of organic chemistry. However, this strategy was not used by either Anna or Robert in the short sequence of lessons observed.

5.6.5 Internal assessment.

All of the teachers at School 1 had much to say about internal assessment, and in particular around the resources and mark schemes available as well as their experiences of external moderation. For NCEA, Alison had doubts about how marking of internal achievement standards compared between schools. There were several comments made in her interview that related to her belief that assessments and the marking of them differed between schools:

With the internals, keeping the standards the same across different schools is an issue. I have visited lots of different schools and it's not the same. So actually, some training for teachers about keeping those standards the same would be absolutely great. (Alison, 5 July 2013)

And later:

I think that if the achievement standard is marked properly, and I know with internals there will be that issue of 'is everyone using the same standard to mark by'? But if it is done properly, if you are wanting excellence, there are certain things you want them to do. (Alison, 5 July 2013)

Anna talked about her difficulty in marking NCEA internal assessments. She had noted evident differences in the interpretation of an achievement standard on oxidation-reduction chemistry in the resources available on TKI and from the NZIC. She explained her conflict around this:

OK, NCEA, I've been doing it for a while now, so I feel like I should know what I'm doing. I know in the beginning it was a real struggle to decide what was acceptable as an A, M and E. Even last year, I know I was struggling with the redox internal assessment that they had on TKI. You had to get everything absolutely everything correct to get an Excellence. Because it was on TKI, I marked according to that, because I felt that I couldn't really change what was set there. In retrospect, missing out on an Excellence because you have missed putting an electron into your equation is ridiculous to me. So, I notice NZIC produced some redox papers where you weren't

even doing any practical work, you were just doing theory, and they were much less demanding in terms of the questions asked.

I do find that difficult with the marking of assessments, because TKI, they are exemplars, but you think, to get Excellence, that is ridiculous. Too hard; and yet that is the standard they are saying we need to be working at, with no flexibility I didn't think, for that standard anyway. And yet, here is another institution, NZIC, coming out with their interpretation, which is quite different. (Anna, 4 July 2013)

Anna saw the NZQA external moderation of NCEA internal assessment as “picky” in parts. She described her experiences:

There have been one or two instances where I've sent away something that I thought was Achieved, but it was Not Achieved according to them, or the other way around. So, it's difficult. Some of the things they come back with are minor, picky, and it wasn't asked for in the assessment anyway. They are picking you up on things that weren't written up in the assessment that they had to do....They didn't change the marks, but they are commenting on it. I didn't think it was necessary. In general the resources that I have sent down, I have written some things myself, they are fine, it is just marking of them and moderators interpretation of them and my interpretation. It is fair enough to write comments back, but I think they are quite picky and about things they didn't need to be picky about. (Anna, 4 July 2013)

Robert was more relaxed than Anna about feedback he had received in the past through the NZQA external moderation process, and noted that with standards changing from one year to the next (such as through the recent realignment process), “you aren't going to worry about it next year anyway.”

At the time of data collection, the internal assessment for the IBDP chemistry course comprised a portfolio of written reports from the required practical programme. Anna thought that this approach to practical work led to deeper learning in the IBDP compared to the NCEA, although she thought the written work could make practical work less enjoyable for the students. At School 1, students were given further opportunities for the internal assessments so as to be able attain a high standard of portfolio work.

I think that what happens is, we give them more than they need. For one, that gives them really good practice, and two, they can select their best pieces for their portfolio... So I think we over assess IAs, in that respect. I already have students in my 12IB class saying ohhh... So instead of practical work being an enjoyable experience and something they can learn by.... They probably get more learning out of it with the IB IAs because of the way they write it up and they are really thinking about it aren't they? But, the write-ups that go with it puts them off. (Anna, 4 July 2013)

With regard to the external moderation process for the IBD internal assessment portfolios, Anna remarked on the fact that the sample was selected by the IBO, thinking that “was quite fair”, and that it meant “you can’t cook it”.

5.6.6 External assessment.

The School 1 teachers all noted a trend whereby their Level 2 and 3 NCEA chemistry students had not attempted all of the papers in the external examination, typically only attempting two of the three. Teachers saw students merely “credit collecting” and this, they felt, had concerning implications for their further learning of the subject. Anna said:

This is the thing about NCEA assessment isn't it; the fact that they have separate exam papers, they can choose not to attempt a paper, which I find distressing. Especially if they think they are going in to Year 13 and they are just into the number of credits that will get them through. That bothers me a lot. (Anna, 4 July 2013)

Robert also attributed this behaviour to students having low expectations of success:

There's been a thing that has been happening with Levels 2 and 3 students 'I'm not very good at that one so I am not going to attempt it because I am probably going to fail it'. (Robert, 30 July 2013)

Robert believed NCEA students were more likely to prioritise their study time on internal assessments as they occurred throughout the year, and so compromised their learning of the content required for the external standards. He put it like this:

I have tended to notice it more this year, teaching a L3 which I haven't done for a while. Some will only focus on those. And then along comes a parent at interviews and says, 'well they are only focusing on their internals, they are going to focus on their externals at the end'. And I know they jolly well can't, because they have missed too much. (Robert, 30 July 2013)

Furthermore, in the NCEA he saw issues arising from the internal assessment demand in other subjects:

If some subjects have a lot of internals in them, they are going to spend a lot of time on those subjects and not on ones like mine, which need a lot more attention. (Robert, 30 July 2013)

The participants at School 1 held opposing views on the external assessments (examination papers) for the IBDP. Robert thought that the multi-choice paper, Paper 1, was a paper that demanded higher order reasoning by students. Alison, however, cited the same paper as being the aspect of the IBD course that she liked the least. She said:

I hate multiple-choice papers. I think they are really old-fashioned. If someone gets umm, 6 out of 10 for some multiple-choice questions then I know nothing about what that student knows. I dislike strongly the fact that when students are doing multiple-choice questions then there is the one answer that is designed to catch the student out. I can't believe really that we are still trying to catch students out in an assessment. It just feels so wrong to me. And also, the 'do you know this fact?' questions. So, my worries about IBD are all about the end of year assessment: the multi-choice questions and the write down the fact questions. You either know it or you don't know it, and that being as important as another question that requires a lot of understanding. (Alison, 5 July 2013)

This chapter has presented evidence from School 1 with respect to teachers' views and practice in relation to curriculum, pedagogy and assessment. In the interests of avoiding unnecessary repetition, findings from School 1 are not summarised here, but rather are tabulated at the start of Chapter Nine as part of the cross case analysis. Following the same format as for this chapter, Chapter Six presents results for School 2.

CHAPTER SIX:

Results Case Study 2

This chapter presents the analysis of data collected from the second case school. School 2 is a large urban, co-educational decile 10 state school in the North Island. At the time of the data collection in 2013, it offered senior students only the NCEA qualification in Years 12 and 13. The interviews were each around an hour long and conducted in school at times that were convenient for the participants. In addition to the interviews, short sequences of two-three lessons taught by the teacher participants were observed as a means of adding depth to the interview data. Selected departmental documentation also informed the analysis. This study was carried out in the last week of Term 2 in 2013 for School 2. Details that may identify the school have been removed and pseudonyms are used to protect the identity of the participants. In the first sections that follow, background information is given on the overall character of the school, as well as a brief description of the Science Faculty and the Chemistry Department in School 2. The research findings are then presented in separate sections under the themes of curriculum, assessment and pedagogy.

6.1 School 2

The case school was purposively selected from the secondary schools in the North Island. It was considered an important aspect of the research design that data was collected in an NCEA only school, in order to be able to determine teachers' perspectives on this qualification without potential confounding effects from the implementation of any alternate qualification within the school.

At the time of data collection, significant remedial building work was being undertaken at School 2. The campus is large and the school has seen significant roll growth over the last decade. The student body is ethnically diverse. At the time of data collection, the large staffroom had been recently refurbished and fitted with modern seating configurations that allowed for staff to have their breaks in departmental groups. The researcher's visit coincided with the end of a term, and there were several staff farewells over that week. These all ran over the morning tea break and into class time. Students waited for teachers outside the classrooms on these occasions. Class periods were 45 minutes in duration, with the school running on a 7 period day.

6.2 School 2: The Science Faculty and Chemistry Department

Led by a Head of Faculty who had been in the role for some time, the Science Faculty was housed in a designated multi-story science block. Teachers were timetabled in multiple laboratories during their teaching day. The observed class sizes were up to 32 students. Space in the laboratories appeared restricted in the larger classes, and so difficult for the teachers to circulate around the students. Several staff mentioned the difficulty they had with the lack of storage space for resources and equipment.

All of the faculty teachers had designated workspaces within a large workroom, although the HoF's office was on another level, adjacent to a tearoom designated for use by the science department staff. This tearoom appeared to be where most of the department chose to eat their lunches and the large table was also a place that class sets of resources were collated.

The NCEA courses for the Years 12 and 13 chemistry classes comprised selected standards from the NZQA chemistry matrix (see Section 6.4.2). Extension classes were identified from Year 11, and these classes studied multi-level chemistry courses in Year 12, and class time in Term 3 was dedicated to preparing students for sitting Scholarship at the end of Year 13 (see Section 6.4.5).

The school had recently moved to using the same series of purchased workbooks for all NCEA science classes in Years 11 and 12. The Year 13 chemistry classes also used commercially available workbooks which students were charged for. One teacher, Carla, said she would "still like to see us use our own workbooks and design our own courses for our students". While in 2013 the school was moving towards a Bring Your Own Device policy for students, this had not yet been implemented.

6.3 School 2: Approach taken to teacher interviews and lesson observations

The researcher first approached the Deputy Principal of Curriculum at School 2, himself a science teacher, about the school's participation in this study. He agreed to being interviewed himself, and it was he that, on behalf of the researcher, invited participation by two chemistry teachers within the school.

Table 6.1
School 2 participants. School 2 is a decile 10, co-educational state school offering the NCEA.

Responsibilities	Participant	Total Teaching Experience	Teaching Load in 2013
Teacher of Chemistry	Carla	>20 years	0.8 FTE Year 13 NCEA Chemistry Extension (1) Year 12 NCEA Chemistry (1) Year 11 NCEA Extension Physics/Chemistry (2)
Teacher in Charge Chemistry	Michael	>20 years	Year 13 NCEA Chemistry (1) Year 12 NCEA Chemistry (1) Year 11 NCEA Science (1) Year 10 Science (1.5)
Deputy Principal Curriculum/Principal's Nominee	Mark	>30 years	Year 11 Science Extension (1)

The classroom observations and semi-structured interviews were conducted at the end of Term 2, in the week beginning the 8th July 2013. Table 6.1 summarises the teaching load, responsibilities and experience of the School 2 participant teachers. Pseudonyms were used in the interests of confidentiality. All participants were experienced teachers, each having more than 20 years teaching experience. Michael and Carla had both worked within New Zealand and overseas and between them had experience of teaching within the framework of several qualifications other than the NCEA, including the IBD, GCSE, Cambridge, School Certificate and Bursary. Michael had a time allowance for his role as TiC of Chemistry and Carla held a teaching position that was 0.8 of a full-time equivalent (FTE). Michael and Carla each taught Years 12 and 13 chemistry classes, with Carla teaching an extension Year 13 class of scholarship candidates.

The data collected from School 2 are presented below in three parts: Teachers' perspectives on curriculum, pedagogy, and assessment. In reporting the coded interview data, indication is given of which teachers are responding. Quotations have been selected to give accurate representation of the teacher responses.

6.4 Curriculum: Teachers' perspectives and practices

The coding of the interview data from School 2 led to the emergence of findings that are related to curriculum, and these are described in the following sections.

6.4.1 Alternative qualifications: NCEA and IBD.

When interviewed, Mark (the Deputy Principal Curriculum), was able to offer his perspective on over-arching curriculum issues at School 2. At the beginning of the interview he talked about the initial inquiry that he was currently undertaking into the IBD qualification. This was previously unknown to the researcher. In a few weeks' time he was due to travel to Toronto to attend an IB workshop. Mark said "so far all we have done is expressed an interest and had a look at some of the literature." In his view the IBD curriculum offers breadth of study, and "fits the school philosophy". He considered the requirement for IBD students to study a second language as being aligned with the school goal to increase the uptake of second language learning at the school. Mark also saw that the IBD would fit with the aspirations, held by the majority of their student body, to attend university. He further explained his rationale for considering the IBD as an alternative qualification to the NCEA in School 2:

I have always been a strong advocate of NCEA. I still am. But I am the one who instigated the looking at IB. The reason I am looking at other curricula, is that I'm increasingly finding that that conservative thing that is coming down from the universities means that the strengths of NCEA are being eroded every year. When we first - as we got into it, it was very exciting. Over a period of time the universities have just gradually closed us down every year and said 'we don't know what the hell that means', and 'we can't deal with that, we don't know what a mark in that means'. So they've said 'we only want these subjects'. Over 80% when we survey them in Year 9 want to go to university, so there is a high level of expectation from the students and the parents and so we have to tailor what we do in terms of university requirements. (Mark, 11 July 2013)

The issue Mark raised of the impact of stipulated university entrance requirements on school course design is more fully described in Section 6.4.2 below.

6.4.2 Course designs.

Mark stated that a school-wide strategy for School 2 was to identify and extend the top academic students from Year 11. The ambition for this group of students, he explained, was to stream them into extension classes where they studied multi-level courses comprising of achievement standards from NCEA Levels 1 and 2 for the extension Year 11 classes, and from NCEA Levels 2 and 3 for the Year 12 extension classes. By effectively anticipating some standards, that then allowed the

Year 13 extension classes time to prepare for sitting scholarship examinations. Mark explained the strategy, referring to his Year 11 Extension Science class as an example:

[There is] small time acceleration via one or two standards in subjects and students are in accelerant classes where they are doing just a small chunk of the next year's work. My class for instance, do two Level 2 standards, one in chemistry, one in biology. Next year, they will do the equivalent L3 standards and that will lighten their workload in Year 13. (Mark, 11 July, 2013)

So, there were two different NCEA chemistry courses at Years 12 and 13 at School 2. These are summarised in Tables 6.2 and 6.3. Each course offered students the opportunity to gain a subject endorsement and the opportunity to meet university entrance requirements for chemistry as an approved subject.

Mark was very clear about the school's desire to encourage students to aim for "quality" in their NCEA work, which he argued, was a shift away from the situation when NCEA was first implemented. He said:

The interest is predominantly in terms of quality. When NCEA first came out a lot of the talk was around credits, credits, credits. What difference does it make? It's just how many you bundle up. 'You get no more credits for getting a merit than an excellence, why bother? You might just as well get achieved'. Now, Auckland University particularly is looking at the GPA for students best 80 credits, and so with that in mind, it is quality. So we have had a strong focus on quality of passes, not quantity. (Mark, 11 July 2013)

Mark also saw university course requirements as having a significant effect on course design at School 2. He noted that the stipulations made by Auckland University with regard to entry into first year university courses, negated the flexibility of the NCEA.

The big advantage of NCEA was the ability to mix and match and put together whatever you want. So a course could be long, short, across a couple of levels, it could be across a couple of domains. Now, what we are finding is that at the top end we are gradually having to move them back to a prescribed set of standards, in other words we are heading back towards Bursary. So, it is an unfortunate consequence of the squeeze from Auckland University. Most of ours want to go to Auckland [University], so that does restrict our Level 3 courses. (Mark, 11 July 2013)

Table 6.2
NCEA Chemistry course structures at School 2

YEAR 12 CHEMISTRY COURSE (Level 2)	YEAR 13 CHEMISTRY COURSE (Level 3)
Carry out quantitative analysis. AS 91161 Internal	Demonstrate understanding of spectroscopic data in chemistry. AS 91388 Internal
Carry out procedures to identify ions present in solution. AS 91162 Internal	Demonstrate understanding of thermochemical principles and the properties of particles and substances. AS 91390 External
Demonstrate understanding of bonding, structure, properties and energy changes. AS 91164 External	Demonstrate understanding of the properties of organic compounds. AS91391 External
Demonstrate understanding of the properties of selected organic compounds. AS 91165 External	Demonstrate understanding of equilibrium principles in aqueous systems. AS 91392 External
Demonstrate understanding of chemical reactivity. AS 91166 External	Demonstrate understanding of oxidation-reduction processes. AS 91393 Internal
Demonstrate understanding of oxidation-reduction. AS 91167 Internal	Carry out an investigation in chemistry involving quantitative analysis. AS91387 Internal
Total credits = 23 (comprising 10 internal; 13 external)	Total credits = 25 (comprising 10 internal; 15 external)

Table 6.3
Extension NCEA Chemistry course structures at School 2.

Year 12 EXTENSION CHEMISTRY COURSE (Level 2/3)	YEAR 13 EXTENSION CHEMISTRY COURSE (Level 3/Scholarship)
Carry out quantitative analysis. AS 91161 Internal	Demonstrate understanding of spectroscopic data in chemistry. AS 91388 Internal
Carry out procedures to identify ions present in solution. AS 91162 Internal	Demonstrate understanding of thermochemical principles and the properties of particles and substances. AS 91390 External
Demonstrate understanding of bonding, structure, properties and energy changes. AS 91164 External	Demonstrate understanding of equilibrium principles in aqueous systems. AS 91392 External
Demonstrate understanding of the properties of organic compounds. AS91391 External (Level 3)	Demonstrate understanding of oxidation-reduction processes. AS 91393 Internal
Demonstrate understanding of chemical reactivity. AS 91166 External	Carry out an investigation in chemistry involving quantitative analysis. AS91387 Internal
Demonstrate understanding of oxidation-reduction. AS 91167 Internal	Scholarship
Total credits = 24 (comprising 10 internal; 14 external)	Total credits = 20 (comprising 10 internal; 10 external)

Furthermore, he believed that a driver for students in choosing subjects was the *university approved subject* lists:

I'd like to think that students would restrict their Level 3 listed Auckland University subjects to 3 which should be enough, but they get panicky and so they'll do 4 or even 5. (Mark, 11 July 2013)

If students were intent on studying a subject in Year 13, then this would, he said, also mean they had to study that subject in Year 12 and so there was "a trickle-down effect." Universities are now specifying the external achievement standards required for entry into specific courses such as Engineering (see letter from The University of Auckland, Appendix U). Mark described his understanding about this, as gained from his dialogue with representatives from Auckland University:

NCEA just doesn't make sense to them. The flexibility of NCEA just doesn't help them in terms of student selection, and basically all they are interested in is student selection. Even in subjects where the pre-requisites might be pretty open in terms of the subjects, they won't let you do just Level 3. They want to know: 'We call this a subject, what is your grade in that?'. Whereas we go: 'Well you know, Level 3 is a

level, and any subject at Level 3 should count equally in that regard'. They won't listen. It is an increasing frustration in that sense. The real advantage of NCEA was always in terms of flexibility. Now, that's decreasing that's all. (Mark, 11 July 2013)

Mark also noted that there was a difference in school course selections made by those students whose intent was to not go to university, with them being more likely to choose "the less mainline subjects in Level 2". He said that in the longer term, School 2 was aiming to develop a distinct vocational pathway from Year 11.

Mark described how, in School 2, subject selection and timetable was as "open" as possible. The only compulsory subjects for Year 11 students at School 2 were Mathematics and English, and Science was not compulsory at that level. In Year 12, all students studied either a Level 2 English or an English for Speakers of Other Languages course. Mark stated that the students at School 2 had a "huge array" of subjects to choose from and that some subjects "move in or out of favour over a short period of time". He also noted a trend whereby students were making subject choices based on what was currently on television. He put it like this:

All of the cooking programmes on TV are driving us crazy, because everyone wants to do food! We can't generate food rooms as quickly as we can generate students who want to do food. (Mark, 11 July 2013)

Mark saw the introduction of subject and certificate endorsements for the NCEA as "a positive move", and said that students "are very aware" of the requirements to attain these, so focussing their attention on the quality of passes. He brought up the issue of creating opportunities for students to gain subject endorsement, and asserted that in his view that should not be a driver for course design:

I have to stop staff from deliberately setting up a course to make sure it reaches subject endorsement. I'm saying, 'tell me why you want to do these standards'. 'Well we want to have at least three for the external to get the endorsement'. That is not a good reason. If it is for a curriculum reason, if it is to do with what they need to know for future years, that's fine, but otherwise it shouldn't swing it. (Mark, 11 July 2013)

At the departmental level, the TiC of Chemistry, Michael, spoke about being conscious of subject endorsement in his course planning. He went on to explain that he was also mindful of the demands of tertiary courses, and how he felt responsible for ensuring students were well prepared for their university courses, and so that was a consideration for him in deciding which achievement standards to include in each course. He did say that senior curriculum managers at School 2 had put "a lot of pressure on us a few years ago to drop all those externals." This was, he said, because of poor results; with a high number of Standard Not Attempted (SNAs) being recorded. Carla also said it was her understanding that a drive for higher

grade outcomes for students was the primary reason for including three internal achievement standards in both the Level 2 and 3 chemistry courses. She expressed her doubts about, as she put it, “offering all of these credits.” She also noted that there was no consultation within the department about course design, it was solely Michael’s responsibility.

Michael prepared a term by term year planner for the senior chemistry courses, and he said he insisted that the department’s teachers keep to this in terms of their teaching time per unit. The planners showed that teaching was scheduled to finish in August, with the extension Year 13 class to finish by mid-July. After that time, the planners showed time was dedicated to revision and school examinations before students went on study leave prior to the NZQA examinations in November. Michael described his views relating to teaching time constraints which he believed to be a challenge for his department like this:

We never have enough time for the course during the year. Since being HoD, I have just realigned which standards we start with. I am reminding staff all the time, we are finishing this topic up as of tomorrow, but they know the timeline, there is no give or take extending it. We are absolutely fixed. Term 4 we don’t count on any longer for instructional time; from our point of view it is a complete waste of time. In late Term 3 it is entrance examinations and other things that happen. So we write off essentially 3, 4 weeks. So, time is a huge factor. (Michael, 10 July 2013)

6.4.3 Planning and resourcing.

Michael explained to the researcher that the chemistry teachers at School 2 spread the load of planning units of work by each taking on the responsibility for planning and resourcing one or two standards. Teaching and assessment resources were uploaded to the school intranet so that they could be shared by staff.

6.4.4 Teachers’ perspectives of the NCEA

Clarity

Michael said he and his department needed support in terms of the “delivery of standards.” He talked about the benefits of problem-solving with colleagues in other schools when it came to interpretation of achievement standards, and preparing resources for teaching and assessing these. He said that he found assessment resources on TKI to be unreliable:

TKI for teachers, no offence to TKI, it is useless. We can’t rely on it. There isn’t one standard we can take and modify....it needs major overhauling. (Michael, 10 July 2013)

Michael wondered what other schools were doing around assessment, and talked about his wish for more professional development on that (also see Section 6.6.4). He saw the need for professional development on the implementation of curriculum:

...implementation; it would bring my chemistry teachers up to a level where they were far more confident in being sure what they are doing is right. Sometimes I/we feel we are just behind the eight ball. (Michael, 10 July 2013)

Accessibility

Carla thought that the modular design of the NCEA and that it comprised standards based assessment made this qualification accessible for some students. When she was asked “*What aspects of NCEA do you like the most?*”, she responded:

I guess I think it is quite motivating for some students in that they can see what they can achieve and that it is a standard. They can achieve a particular standard. Can I stop there? That’s it. (Carla, 10 July 2013)

Flexibility

Michael asserted that flexibility was what he liked most about the NCEA. He explained how courses could be amended to best meet the needs of students:

You can pick and choose. It has got a bit of everything in it. You can make up courses, flexibility of offering a range of standards to meet a kid’s ability. Theoretically we could run a lower course chemistry, they would have a manageable number of credits they could still carry on with tertiary study...I could turn around and make up a course say chemistry intermediate where I have maybe some of the internals and maybe only one external and make a course out of that. I could push forward, and we do have the accelerant programmes where we pick and choose a Level 3 standard and put it into Year 12. We could choose a physics standard like radiation and put it in to a Year 12. That part is absolutely brilliant. (Michael, 10 July 2013)

Structural issues of the NCEA

The achievement structure of the NCEA has, said Carla and Michael, implications for learning. When Carla was asked “*What aspects of NCEA do you like the least?*”, she replied with the following comment as her foremost concern:

I do not like how it chops chemistry up into topics and we never revisit it, because chemistry is a whole subject. It is a jigsaw puzzle and all the pieces lock together all the time. So, when I teach my scholarship class and they have questions where it is feeding in strands of redox and organic and that, it does not work, and they have to rethink how they think. (Carla, 10 July 2013)

Carla also raised issues related to the structure of the NCEA when talking about the preparedness of students for first year university courses (see Section 6.4.4 above).

Scholarship

Carla regarded students' success in Scholarship (in the prior year: 9 Scholarships, including 2 outstanding) as being a recent highlight of her teaching practice. She acknowledged the work of other teachers too, and saw it as important that the "the whole scholarly attitude" continue to be fostered in students at the school. Carla talked about having to teach students to "rethink how they think" in order to prepare them for sitting Scholarship in chemistry. Michael talked about the difficulty he had in selecting students for their extension programmes and so scholarship; he said he saw no correlation between the attainment of scholarship and excellence grades in NCEA chemistry:

Choosing our kids for scholarship programme is a nightmare. It isn't the top kids that get Scholarship. There is more to it than that. We always think it should be top kids with straight excellences that should be in the scholarship programme, but statistically it says that is not the case. We get as many kids outside of our scholarship classes as we do in those classes. Last year we had 9 Schols, 5 of them came from outside the scholarship class. (Michael, 10 July 2013)

Carla expressed some uncertainty about teaching Scholarship, even though several of her students had been successful in the past. She explained:

I'd really like more stuff from the ministry about Schol. They don't put out much at all. It is very vague. And we heard at the [x school] meeting, this woman came up from Wellington, that the scholarship panel don't talk to the Level 3 panel. That's not particularly helpful. We are trying to unravel this mystery about how to get scholarships. Every school is trying to do something else. So I don't know why that kid got one, and that kid should have got one. So that is where I am at. (Carla, 10 July 2013)

Carla described the Scholarship candidates that she taught as being "intellectual" and "very maths oriented, and used to solving problems on their own". Carla described the teaching strategies she emphasised when teaching Scholarship as being ones that encouraged students to collaborate, and she could see the benefits of this approach in her classroom:

They're talking more, about what they're doing. They are trying to use the correct chemical language to describe chemical ideas. The ones that are not doing so well are supported, and they are hearing really good things. The ones that are at the top of the class are having to explain themselves using different language. (Carla, 10 July 2013)

Section 6.6.1 below describes more fully Carla's pedagogical approach with regard to teaching Scholarship.

Realignment

Mark became quite heated when asked about his views on the realignment of achievement standards with the New Zealand Curriculum (Ministry of Education, 2007). In his view little had been gained from the realignment process, despite he said, all of the work that was involved:

Alignment has been a farce! It's no more been alignment than fly. It's has been a complete revision of vast numbers of standards. I can look at science and going through and looking at the realignment of L1 standards that I had a look at, and basically it was take this one from here and put it into that standard. And then take this from that standard because it is now too big. If you cut it all up in bits of paper and rearranged them all, they are all back in but in different standards. For what gain? The only purpose of realignment was to say does the accumulation of standards meet the curriculum for that level? That wasn't what happened. What happened was a complete revision all across the school, for L1, L2, L3. People with their hobby horses putting stuff in, moving stuff out. There was no need for most of it. So an awful lot of work for a lot of people up and down the country. And the gain? I would say near zero. In most cases the stuff was already in there somewhere. All they have done is shifted it. If there were big chunks missing or big chunks put in, I'm not hearing that. Mostly what I am hearing is 'we're changing how we are interpreting this', or what was an external has become an internal. What was an internal is now an external. (Mark, July 11 2013)

Michael and Carla both talked about how the content demand of the NCEA had been reduced as a result of the recent realignment, and considered this to have implications for students "broad knowledge" of chemistry. Michael reflected:

I don't like the fact that NCEA keeps taking stuff out, and it is starting to fall short in some major, critical areas. If I just look at NCEA...we have taken out transition metals, we have taken out radiation, we have taken out this, we have taken out that, we are losing a lot and that is good solid chemistry. A problem that we have got coming through now: 2.1 has lost robustness in the mole calculations, they are very simplistic mole calculations, very simple titrations. One doesn't blend into the other. (Michael, 10 July 2013)

Michael stated that in his view the issue of content reduction through the realignment process was more of a problem in the Level 2 rather than the Level 3 achievement standards. He talked about this making Year 13 more difficult for students. He referred to teaching and learning as related to two Level 2 achievement standards in particular:

Redox has been dumbed-down a bit. We are very much teaching to a quick, succession of rules, jump through the hoops and away we go. Before we were teaching a lot more openly...and a few more things could be added into it. That is not the case any more. In 2.1, I'd like to see students going back to a better comprehension of moles. It is too weak currently. It was better when they did the

titrations separate from the calculations. Now it is all amalgamated. I see that problem. (Michael, 10 July 2013)

6.4.5 Preparedness of students.

Teachers were firstly asked about their views as to how well students were prepared for senior chemistry courses at School 2. Secondly, they were asked for their views on how well students were prepared for studies in first year university courses. Carla recognised weaknesses in students' math skills coming in to senior NCEA chemistry courses in School 2. She explained:

Maths is a real issue, especially algebra, it is very weak...They are coming in to do the mole or pH calculations and they don't understand logs. They can't read...when the calculator says E 10-2, they will write down the E in their answer. I am having to teach them calculator skills in my class and I don't have time to do that. So, the maths is very weak that is coming through and it is a real concern. (Carla, 10 July 2013)

Michael shared Carla's views on students' math skills being a difficulty in learning chemistry in Year 12. When asked if the school had a prerequisite in terms of mathematics for entry into senior chemistry, he explained:

No, but it is something we are certainly looking at now. It is a concern... Year 10 Maths is not good enough, and I would question where they sit with what we call the internal mathematics. There is a weakness there. (Michael, 10 July 2013)

Michael thought in order for students to do well in university courses, they needed to be independent learners. Carla's view was that key skills for students going on to university were the ability to work collaboratively; to be able to communicate effectively; to have sound maths and problem-solving ability; and to have good literacy skills in terms of comprehension of subject texts. When Carla was asked about how well she thought the NCEA course prepared students for university, she brought up the concerns she had:

The whole thing about it chopping chemistry up and not revisiting things, I think is a big disservice to chemistry and I do worry about that. The product, the students that we are sending on, how good is their chemistry? We don't get feedback from universities about that. We don't know. We hear about when they apply for some scholarship or something. But, we don't really know about how they get on in Level 1 courses. (Carla, 10 July 2013)

She was supportive of universities setting their own entry requirements, including the requirement for attainment of the Level 3 externally assessed achievement standards. As well as an independent approach to learning, Michael considered NCEA students to be well-prepared for university studies if they had sound

knowledge of the content specified by the externally assessed achievement standards, which he referred to as the “rigorous” and “academic standards”:

They have to have a good, broad knowledge of the rigorous standards. They have to know redox, they have to know the mole concept. They have to know atomic structure, they have to know physical states, they have to know enthalpy. So, the academic standards, the external standards, they need to know at a reasonably high level. (Michael, 10 July 2013)

6.5 Pedagogy: Teachers’ perspectives and practices

The coding of the interview data, together with the data from classroom observations, at School 2 led to the emergence of findings related to pedagogy. These are described in the following sections.

6.5.1 Favoured teaching practices.

Teachers in the Chemistry Department said they were in the process of creating and uploading resources to the school intranet for access by students in their home-based study. Michael said he “had an issue with some staff” in terms of how they were teaching chemistry in School 2. He felt some staff had moved little in their practices over time:

Talk and chalk – I’ve got an issue with some of the staff. It is the way they were taught, and it is the way they are teaching. It didn’t work 15 years ago, and less so now. (Michael, 10 July 2013)

Having said this, Michael acknowledged that in his experience, many students at the school enjoyed lessons where they copied notes from the board. Michael said “breaking up lessons is an absolute must”, although he said he was constrained in his own teaching practice by a lack of time. It was because of his perceived lack of time that he said he did not have the opportunity to revisit key concepts or always include practical work that might reinforce theoretical ideas. He said:

We are always pushing, pushing, pushing for time... Students are always behind. It would be lovely to go back and reinforce some conceptual ideas, but everyone has got to be pragmatic about what is valid. (Michael, 10 July 2013)

Michael said he sometimes used digital resources to break up lessons. Carla described how, for her scholarship class, she had set herself the goal of having the students to work collaboratively in class, rather than have them “sit there and write their own answers”. She used a range of teaching strategies to encourage collaboration.

Sometimes I'll do chemletics and take them down to the netball courts. They will be in teams where they have to answer little questions and run around but I'll say teams of 3, you will have to have one from the opposite sex in it or someone you haven't worked with. So it is breaking up groups and getting them to work with different people. I do a lot of group work things. The one that you saw today, they had written answers, but I wanted them to talk about their answers and have a look and see what other people had written and self-marked. Sometimes we do peer-marking and things like that, but that one was all about let's get the best answer out of 3 of us and put it together. I am always thinking how can I get them to work together collaboratively? They tend to be quite competitive in some ways. So, that is my biggest challenge. (Carla, 10 July 2013)

The chemletics activity was observed by the researcher. The students were required to do shuttle runs as they completed written answers to questions and appeared highly engaged. The teacher's intention of having them work together to discuss the wording of their responses to Scholarship questions set in the task was evidently successful. The students appeared to enjoy the energetic movement the task involved, and the teacher had a chocolate bar prize for the winning group.

Carla also referred to making explicit connections between particle theory, observations and symbolic representations when teaching. When asked to describe the strategies she used when teaching organic chemistry, she said:

I do try and incorporate practical work into almost every lesson. That is the sort of teacher I am, so we get the gear out and do something. We have lots of molymod and so there is a lot of molymod that goes on there. We've also got a lot of internet resources that we can use as well, so looking at molecules in 3D and shape and so on, and getting them to realize that these are just models, it is not how these things actually look like. (Carla, 10 July 2013)

6.5.2 Practical work.

Michael appeared to contradict himself to some extent when talking about including practical work in his teaching. He first said that "in chemistry we are lucky, there is always good practical work to do" when he was talking about the importance of breaking up lessons. However, he then went on to say that:

Some practicals, even though they are in the book, they are useless, and I can't see any benefit out of it. Sometimes a short demonstration is substantially better. (Michael, 10 July 2013)

He described how, for him, the decision to include practical work in his teaching was also constrained by the amount of class time available to do it. One issue, he said, was the short 45 minute periods, and the other was the need to keep to the teaching calendar. He explained his dilemma:

If I was, for example, talking about the...and its solubility, is there time to stop the lesson and do the foundation, a practical experiment or something like that, or do you just move on? (Michael, 10 July 2013)

From observations of Michael's lessons, the only practical work included in the sequence was a teacher demonstration of colours of some reduction-oxidation reactions. When done, the teacher taped the test-tubes to the whiteboard and referred back to these as the lesson progressed; emphasising the symbolic representation of the ionic species involved with the observed colours.

When asked "*what open-ended investigation work was done by the Year 12 and 13 students?*" Michael responded:

Year 12, very limited; it's almost all directed. There is actually no open-ended investigative work, because all the titration work is absolutely led by us. The precipitation work is a case of following the flowchart. Redox, it's almost become pointless; it's quite horrible actually. No, Year 12, investigation is very very limited. (Michael, 10 July 2013)

In contrast to the programme for Year 12 students, Michael said the investigation work done by the Year 13 chemists "was quite major", and in saying this he referred to the investigations carried out towards the 3.1 achievement standard. He described how the scope of the 3.1 investigation task was controlled at School 2, in order to make it manageable for the department's staff. At School 2, students could choose to do an investigation based on one of three of the offered titrimetric methods:

This is our 3rd year running it. It was brought in somewhat reluctantly because of the complexity. We homed in on 3 practicals: Alcohol, Vitamin C and Cl^- ion, and just kept it to these to keep it under control. (Michael, 10 July 2013)

Michael then went on to explain what was and was not asked of the Year 13 students in carrying out their investigations:

We gave them some outline of what they need to do; we gave them some indication; dilution factor for alcohol... They all had to standardize a solution. We gave them the initial solution in bulk, but they had to standardize that to a known. So, they didn't have to make up any of their own solutions, they had their solutions made up, but one was of unknown concentration so they had to standardize. This year we got students to make up their own solutions to standardize, but we'll go back to last years I think just because it took an extra amount of time which we found problematic. (Michael, 10 July 2013)

The total class time allowed for the investigation on the course planner was three weeks. Michael explained that this equated to students having one week to standardise their solutions, one week to "get the parameters right", and a third week

to collect and record their data. Glassware and any required chemicals were ordered on behalf of the students and supplied by the technicians. In addition to the allocated class time, the students were allowed four weeks, including the two week holiday between terms, to complete their write-up. Michael talked about some students who “struggled” and others who “got fantastic results” and he also said he had received feedback from former students about it being rewarding. Michael said that leading the 3.1 investigation was demanding for staff and as he put it: “It is a pressure; the blood pressure across the department goes up”.

Carla spoke at some length about the difficulty in running the 3.1 investigation at School 2. She questioned the time and resources that had been committed to doing this one achievement standard; in her words:

I really don't know what the philosophy is about offering it. Some people said it was about offering endorsement, or the maximum opportunity, some inherent things about doing investigation we feel is good for them before they go off to university. There are a lot of factors there, but it is a large workload. (Carla, 10 July 2013)

She admitted to feeling “ambivalent” about the inclusion of the 3.1 achievement standard in the Year 13 course. While she said she could see “some benefits”, she could also see significant “drawbacks” to doing it. In her opinion a practical investigation would be best left to the extension classes:

I don't like having 3 weeks out of my teaching time doing that. It is quite stressful at the beginning for both students and staff because they haven't got a feel for what they are doing. It can go horribly wrong for them. And I've had students in a real panic about that, where I can't do anything about it for them. It's just not going to work out for them. In my opinion, if I was the curriculum manager, I would leave it to the extension classes and I would change it somewhat. (Carla, 10 July 2013)

More generally, Carla spoke about aiming to include some practical work into most lessons that she taught. She described sharing ideas for practical work with her colleagues:

The staff here are very willing to share that stuff. Although there is no fixed time where we can get the experiments out and just have a look at them, like we used to, which is a shame. (Carla, 10 July 2013)

6.5.3 Reflective practice.

Carla described how goals for departments at School 2 were set at the start of a teaching year, and were based on a statistical analysis of NCEA results. In the chemistry department, the results for organic chemistry were a focus for improvement in 2013. Carla explained:

This year Mark has redone the Year 12 timetable to try and do something about those organic marks, which haven't been good in the past. So we've tried to bring the programme forward so we get more revision time after the entrance exams and before they leave, to see if they can do something. So that is a new initiative, that is a new change. Also we've got a department and school wide goal of lifting our Year 12 performance generally. (Carla, 10 July 2013)

Carla talked about the requirement for teachers at School 2 to each identify 3-4 students that "are struggling". She said that once students were identified for intervention, teachers would review assessment data, and plan targeted learning strategies for them with a view to lifting their levels of achievement. This initiative was linked into a school-wide professional development focus on pedagogy. Carla described her approach with some Year 12 boys that she had identified as needing extra support with their learning in chemistry:

I approach that from a personal view. I know boys like to have that personal contact. I'm a Mum, have sons, so that is how I approach it. So I try and make time for that personal stuff. With the timing and stuff we are told, just pick 3 or 4 to do this with and see how you go with it. With one I've seen a huge improvement with how he is going. He has gone from getting an A/NA to now getting a M in the last test. For me it works on the personal thing – it is just how I teach. Other teachers will have other things they will be doing when monitoring the situation. (Carla, 10 July 2013)

Michael described the student data that was collated and available for use by teachers to inform their practice; these data were in addition to the NCEA results from the previous year:

We keep data on students' learning styles. We keep track of their report grades in chemistry as opposed to other subjects. We report back to parents six times a year, and all of those reports come as soon as they are marked. We have an electronic markbook. So we keep their grades for every class we teach...I can get a fairly good idea of where a kid stands in any class. Used to have PAT data, as a Dean I would use those. So those are the main tools we have right now. So I look at all of that. All of that data is immediately available.

6.5.4 Professional development.

Carla cited professional development that she had undertaken in the last few years on how to use different ICT tools had made a big difference to her pedagogical knowledge. She said her "knowledge had increased amazingly." She was now writing resources for upload to YouTube, and moving towards "flipping" her classrooms more often as well as using ICT based strategies to improve collaboration. She said she would value more professional development on Web 2.0 tools in that regard, and also some chemistry specific pedagogy professional

development would be useful to her. Michael wanted professional development that had an NCEA implementation focus:

To have PD where we have actually got a number of standards being discussed, or levels being discussed so we have got innovative ideas coming through. They are being shared, they are being talked about; implementation. (Michael, 10 July 2013)

6.6 Assessment: Teachers' perspectives and practices

Classroom observations and coded interview data from teachers at School 2 led to the emergence of findings that are related to assessment, and these are described in the sections that follow.

6.6.1 Grade focused outcomes.

Throughout all three interviews at School 2, teachers made references to their students' NCEA results. A school-wide focus in 2013 was the lifting of achievement in Year 12 (see Section 6.5.3). Michael described how teacher and student grade expectations were recorded during the year:

We do survey all the kids at the start of the year and half way through the year, in terms of where they see themselves in terms of grades. So we do have students expectations and teachers expectations, we put them down. So a kid might say 'I'm an E'; but a teacher might say 'A'. And we just watch that progress.

Does a student know what their teacher expectations are?

No. Not that way around, but certainly a teacher knows a student's expectations. It does change mid-year I might add, quite significantly because students know where they're at mid-year. (Michael, 10 July 2013)

Mark explained how the analysis of NCEA results could dictate the achievement standards being offered at School 2:

We do a lot of data collection, we investigate individual standards for the results in standards, internal and external, we analyse those in terms of how they compare with other standards in the same subject, and base some of our decisions on the data we get from that. So, we might decide to drop a standard or to continue with a standard, based on the fact that the results are up to expectation or below. (Mark, 11 July 2013)

He also commented on how data analysis by standard and by class made staff accountable: "It is incredibly powerful in that it puts people under a high degree of accountability" (Mark, 11 July 2013).

With reference to results for the chemistry and physics courses, he said:

But why aren't they doing as well? Physics and chemistry both run the line that their subjects are harder than other subjects, and so that's why their results are lower. But,

it doesn't cut an awful lot of ice and so we do have discussions about 'we need to be fixing this up'. So we have discussions about 'well how many internals are they doing?', because results for internals are roughly about 10% higher than results for externals. 'So how many internals are you doing? What are the staff doing that means that we are not improving?' So then we put in staff development and start putting pressure on people. (Mark, 11 July 2013)

6.6.2 Workload.

Teachers at School 2 talked about the workload associated with internal assessment being a significant concern for them; they saw workload as having negative impacts for both staff and student wellbeing. The findings reported here overlap with those reported under the theme of assessment in Section 6.6.5 (Internal assessment) and Section 6.6.6 (External assessment).

Part of Mark's responsibilities as Deputy Principal Curriculum was staff appraisal. He noted that there was a trend whereby there was more internally assessed achievement standards in the courses and that this had implications for both staff and students, "with a lot more pressures on staff and students in terms of meeting expectations continuously throughout the year" (Mark, 11 July 2013). He also commented on the workload for staff he said was associated with the recent realignment process. With the aim of managing the internal assessment load for students, the school had compiled an assessment calendar, however Mark described that planning this was "a nightmare" in terms of departments trying to fit their assessments into the time available. It was school policy not to run internal assessments in Term 3.

Carla described how she had struggled with the required workload in the past, and had resolved this by reducing her hours and becoming a part-time teacher:

I am a 0.8 teacher. That happened two years ago. I was struggling with 3 children, and a full-time load here and a 7 period day. I didn't feel I could put in what I wanted to, and I just had to reduce my workload somehow. I was just not coping, and I had other responsibilities too. I just felt that I could do a better job if I had more non-contact time and the only way to do that was to go 0.8. So, when that happened, I got given my chemistry scholarship class which doubled my workload again. So it has kind of worked out that I've got more flexible time to work on my extension classes but I am still flat out and I couldn't do this full-time, it is just a fact, it is too hard. (Carla, 10 July 2013)

She echoed Mark's concerns about the workload associated with internal assessment in the NCEA, saying "the marking load is huge with the internals". Workload was a recurring theme in the interview with Carla; in her view NCEA internal assessment was "under-resourced". She thought that planning for internal

assessments should be supported by a time allocation (see Section 6.4.3). Also, she was uneasy about what she saw as the negative impact of too much internal assessment on student learning (this is picked up in Section 6.5.5 below).

6.6.3 Approaches to learning and assessment.

When asked what her key considerations were in teaching a unit of work, Carla said:

I always look at the assessment and see where I am headed, and then I plan backwards from that. I like to work from a set of objectives, which I write from looking at the assessment. (Carla, 10 July 2013)

When asked by the researcher: “What scope is there for learning that is not assessed summatively?”, Carla responded:

Learning for the sake of learning? Very little time to do that. We have planners, that are set down, and we stick to it. (Carla, 10 July 2013)

When Michael was asked the same question, he echoed Carla’s comment:

That has been whittled away a bit I guess. No, there is little left. It is all testing, I dare say towards to the descriptor. We don’t like wandering away from that because we end up running short of time. (Michael, 10 July 2013)

6.6.4 Formative assessment.

Carla described her own approach to assessment as being “assessment to learn; before it came out as a saying”. She thought feeding back to students was very important and she had made digital resources to support students’ learning at home.

Michael used *formative* assessment to mean an assessment given to students as a practice prior to a summative assessment set at the end of a unit of work. He believed this protocol to be “crucial”. He described the approach to assessment with which he led in this department:

All standards would be thoroughly assessed formatively to each class. There should be no surprises to any student as to what would be tested on or examined at the end of a teaching cycle, before the summative test -whatever it be. A topic test for an external, or the internal test, whatever it might be, whatever, there will be some form of formative test and that is quite crucial in the whole structure. So, for example today is redox, the test for that is the second Friday of next term. That second week I’ve got it down that all teachers are going to start giving the formative test next Tuesday, it can be reviewed, it can be gone over with the class on Wednesday to Thursday so that the summative test on Friday is all go. (Michael, 10 July 2013)

6.6.5 Internal assessment.

Teachers had much to say about internal assessment. Michael and Carla spoke at length in their interviews about this aspect of their courses. The findings reported here are also related to those for course design (Section 6.4.2); workload (Section 6.6.2); and external assessment (Section 6.6.6).

Michael commented on the results for external assessed standards in their chemistry course as being “substantially” lower than for the internally assessed standards. This, he explained, was a consideration in the “external/internal balance” when planning courses, and he was concerned about maintaining “quite good GPAs” by ensuring the inclusion of three internally assessed achievement standards in both the Year 12 and Year 13 courses. He also thought this was important so as to offer the best opportunity for students to obtain subject endorsements. Carla said that grade expectations for internal assessments were “unrealistic” and “almost meaningless”. She questioned why the Year 12 course at the school included three internally assessed achievement standards, and noted the expectation she felt for her students to attain excellence grades in the internal assessments:

We are at the stage now where everybody is able to take Year 12 Chemistry and they should be able to get Excellence. The pressure in internals for them to all get Excellences because it makes the school look good, is false, and I think we are mis-educating the children. (Carla, 10 July 2013)

She also talked about being able to get almost any student an Excellence in a chemistry internal standard, but this meant little in her view, in terms of their real ability overall in the subject.

Students prioritising work for internal assessments done throughout the year, at the expense of learning content required for external assessment at the end of the year, was a concern for Michael and Carla. They saw this tension between internal and external assessment occurring between subjects as well as within a subject. In Michael’s experience, students were often poorly prepared for end of topic practice tests for chemistry units where content was to be externally assessed, and in the end ran out of time to learn material properly before the end of year examination. He said:

They [students] are more focused on internals in other subjects. With the Year 12s doing six subjects, and at this time of year a lot of internals, their priority will go to credits that will count. (Michael, 10 July 2013)

Carla talked about the internally assessed component of the NCEA was “overbearing” and encouraged a credit counting mindset. She saw an issue whereby

some students who had attained sufficient credits through internal assessment (across all of their subjects) for the award of their level certificate did not attempt one or more external standards in chemistry. Carla expressed her disquiet about internal assessment:

It encourages students if they get enough credits, to not focus on externals in some of those topics, and some of those topics in chemistry are so important. Because they've got the credits, they don't need to get the credits somewhere else, and they will sacrifice learning for that. (Carla, 10 July 2013)

Carla also commented on the amount of time taken up with preparing students for an internal assessment. "Currently with Year 12, let's say I'm taking a four week internal, a whole week would be preparation for assessment. A whole week!" (Carla, 10 July 2013).

It was evident from the interviews that the preparation of assessment tasks and schedules for internal assessment, as well as marking and then reviewing these in light of the external moderation feedback, was a priority for teachers at School 2. However, Michael expressed some concerns about the results of external moderation, saying "I still have doubts about what the Moderator was thinking". He expanded on his experiences:

We are having a few issues with our feedback from moderation. Our interpretation and their interpretation are a little bit different. We have tended to be either a little bit too harsh or a little bit too lenient. Some of the ways we are marking our work doesn't seem in keeping with the way NCEA want, the Moderator has wanted. We have been rapped over the knuckles a bit. So, I am not really comfortable there. (Michael, 10 July 2013)

In terms of responding to the Moderator feedback around internal assessment, he said "We need to make changes in light of the Moderators' Reports, but we are not too sure which way to do it" (Michael, 10 July 2013).

In summary, these teachers at School 2 talked about internal assessment in Levels 2 and 3 NCEA chemistry in terms of:

- i. there being higher grade outcomes for internal compared to external assessment;
- ii. a trend towards more internal assessment;
- iii. the time taken to prepare students for internal assessments;
- iv. internal assessment encouraging a credit-counting mindset in students;

- v. tensions existing between learning of externally assessed content in chemistry and the more immediate demands of internal assessment in other subjects;
- vi. being uncertain about how to respond to the feedback received from the external moderation of internal assessment.

6.6.6 External assessment.

Teachers in School 2 made clear connections between internal assessment (see Sections 6.6.2 and 6.6.5), students' mindset around "credit collecting", and students' approaches to external assessment. Carla commented on the evident workload for students and the impact of internal assessment on externally assessed content:

We know that guidance have a lot of referrals there, about workloads on students. We're not surprised when we hear things like 'I have enough credits now, I'm not going to worry so much about doing well in this one', which from a subject point of view is really disappointing because how do you not do organic if you are going to do chemistry? I don't think we've found the perfect balance at all yet. I don't know what the philosophy is for offering all of these credits, because I know a lot of other schools don't. (Carla, 10 July 2013)

Carla saw a pattern, saying that in her view it was the last topic that was taught each year where the highest number of Standard Not Attempted (SNA) results were recorded in the end of year examination. She speculated on possible reasons for students not attempting papers:

Our results generally, for the last achievement standard that we teach, which is organic, usually organic, are not great, and we have been wondering about that for some time. Is it because they haven't had enough time on it? Haven't revised it? That they've just got to the end of the year and decided 'this is too hard'? Is it because organic is last, is it because they've got enough credits and they don't need those credits in the exam? So there are a whole lot of variables going on there.

When you say not great, is that students who are not attempting the standard?

Yes, a lot of not attempts. Or just very low marks compared to the other achievement standards. (Carla, 10 July 2013)

Michael described students as "voting with their feet" in terms of not attempting papers in the end of year examination, and he too interpreted this behaviour as being due to the teaching timeline, with the last material to be taught in a year being the most likely to be avoided by students in their final assessments. Referring to the school's external assessment results in the previous few years and the order in which topics were taught in Year 13, he said:

We were finishing with Aqueous, and Aqueous just got slaughtered. Last year we moved Aqueous forward, and moved Organic later, Organic got slaughtered; we had shocking results. But the other two were fine. (Michael, 10 July 2013)

He went on to explain how he felt let down by students who did not prepare well for their assessments.

Sometimes when you are teaching a subject it just goes a bit flat. You put a lot of effort into getting the kids up to speed, and at the 11th hour, very little is done. That is quite upsetting. (Michael, 10 July 2013)

A summary of findings from School 2, an NCEA only school, are presented at the start of Chapter Nine as part of the cross case analysis. Chapter Seven presents results from School 3 in the same format as for Chapters Five and Six.

CHAPTER SEVEN:

Results Case Study 3

Presented in this chapter is the analysis of data collected from the third case school. School 3 is a medium-sized, co-educational, decile 10, integrated school in the North Island. It offers students a choice of academic qualification from Year 12: the NCEA or the IBD. Four participants were interviewed at School 3; three being chemistry teachers and one the Deputy Principal Curriculum. Interviews were semi-structured in design, each interview being around an hour long, and these were conducted in the school at times convenient to the participants. Each of the chemistry teacher participants were also observed when teaching a short sequence of lessons (2–4) to either Year 12 or Year 13 chemistry students. Selected documents within the chemistry department were also viewed by the researcher and informed the analysis. This researcher was in the school at the start of Term 3, 2013. Details that may identify the school have been removed and the participants are referred to using pseudonyms. In the first sections that follow, brief descriptions of School 3, the Science Faculty and Chemistry Department are given. The research findings are then presented in separate sections under the themes of curriculum, assessment and pedagogy.

7.1 School 3

This case school was purposively selected as a secondary school in the North Island offering alternative qualification pathways (the NCEA and IBD) to its senior students, and so fitted the research design requirements. The school also offers the Cambridge International Examinations (CIE) in three subjects: Mathematics, Business Studies and Physical Education. These examinations were undertaken by students in Year 10 and Year 11. School 3 comprises a large campus and has both day and boarding students. Class periods were 60 minutes long and the school timetable ran on a 5 period day.

7.2 School 3: The Science Faculty and Chemistry Department.

At the time of data collection in 2013, several new science laboratories had been recently added to the designated single-level science teaching block. Teachers were timetabled to one laboratory for their teaching. The Head of Faculty was relatively new to the role. The observed Years 12 and 13 class sizes were small, of between 6 and 18 students. All of the faculty teachers worked from designated workstations in spacious workrooms. The HoF's office was separate and included a small meeting

table. One full-time technician had responsibilities for organising resources needed by teachers for practical work. There was also a designated tearoom for the Science Faculty in the science block.

The NCEA courses for the Year 12 and 13 chemistry classes are described in Section 7.4.2. The Years 12 and 13 IBD chemistry classes were being taught from the then current Subject Guide (International Baccalaureate Organisation, 2007). The NCEA chemistry students were using commercially available workbooks and study guides. The IBD students were issued with textbooks and had also individually purchased workbooks. Students in School 3 brought their own laptops to class as part of the school's *Bring Your Own Device* policy.

7.3 School 3: Approach taken to teacher interviews and lesson observations

The researcher first approached a Deputy Principal of the school about participation, and she then forwarded the invitation to chemistry teachers within the school to participate in this study. Table 7.1 summarises the responsibilities, teaching load and experience of the participants. For reasons of confidentiality, pseudonyms are used.

All participants in School 3 were experienced teachers, each having more than 10 years teaching experience. Susan, the Deputy Principal Curriculum, did not have any allocated classes to teach in 2013. Jo, David and Nicole all taught Years 12 and 13 chemistry classes. At the time of data collection, Nicole had around five years' experience, and Jo and David each had less than two years' experience of teaching chemistry towards the IBD qualification. All were more experienced in teaching towards the NCEA, having taught senior students since its implementation. Jo had a management time allowance for her responsibilities as HoF. Nicole, the TiC of Chemistry, had come into teaching after first working for a period as a research chemist.

Table 7.1

School 3 participants. School 3 is a decile 10 co-educational, independent school offering both the NCEA and IBD qualifications.

Responsibilities	Participant	Total Teaching Experience	Teaching Load in 2013
Deputy Principal Curriculum	Susan	>20 years	Nil
Head of Faculty – Science	Jo	>10 years	Year 13 NCEA Chemistry (2) Year 12 IBD Chemistry (1) Year 11 NCEA Science (1)
Teacher of Chemistry	David	>10 years	Year 13 IBD Chemistry (1) Year 12 NCEA Chemistry (2) Year 11 NCEA Chemistry (2)
Teacher in Charge Chemistry	Nicole	>20 years	Year 13 IBD Chemistry (1) Year 12 IBD Chemistry (1) Year 12 NCEA Extension Chemistry (1) Year 11 NCEA Extension Chemistry (2)

The data collected from School 3 are presented below in three parts: Teachers' perspectives on curriculum, pedagogy, and assessment. In reporting the analysed interview data, indication is given of which teacher or teachers are responding. The quotations included have been chosen as being representative and illustrative of a participant's views.

7.4 Curriculum: Teachers' perspectives and practices

The analysis of coded interview data from School 3 led to the emergence of findings that are related to curriculum, and these are detailed in the following sections.

7.4.1 Alternative qualifications: NCEA and IBD.

Susan, the Deputy Principal Curriculum, explained that the Cambridge International Examinations (CIE) were introduced into Years 10 and 11 to lift the standard of mathematics in the school. She described how, within the senior management team, there was "dissatisfaction about the NCEA programme". In her view, the earlier establishment of the CIE programme at the school was an advantage when the IBD was introduced. Now she saw the CIE as being required preparation, especially in mathematics, for entry into the IBD:

Latterly, it has been the need for good dovetailing into the IB Diploma programme. It was a bonus because Cambridge was already in place before the IB. (Susan, 1 August 2013)

Susan said that the introduction of the IBD at School 3 was “a very cosy match for who we are”, explaining that she saw that the IBD fitted well with the overall mission of the school.

It fitted with our culture, it fitted with our holistic philosophy and our desire to offer a broad based curriculum and indeed education in the wider sense. (Susan, 1 August 2013)

Susan went on to explain that strategically, the school saw implementation of the IBD programme as a means of lifting student achievement at the school:

We have had concerns about our achievement over the years, particularly at the top end, and we felt that a higher stakes, internationally highly regarded academic programme would help lift our results across the whole school because often achievement is about expectations and believing you can do things. (Susan, 1 August 2013)

Susan also commented on her beliefs about students perceptions of the IBD:

I think students aspire to do IB, some students do. They talk about it at prep level ‘I want to do IB’. So we are pretty keen to have an aspirational culture and I think IB does that for us. (Susan, 1 August 2013)

Some tension between IBD and NCEA students existed, she said:

I think there is some NCEA element that feel that the IB students are better looked after; given more care and attention. There are some that feel they are missing out. Equally, some IB students feel they are missing out. (Susan, 1 August 2013)

Susan stated that the senior managers of School 3 “have been very careful and consistent about our messages on the dual pathway”. She went on to explain how the school strived to manage perceptions about the IBD and NCEA:

I can’t imagine a time when we would not have NCEA, because IB is not for everyone. There is a need, and so I think the way we set it up is still the right way, in terms of offering it as a dual pathway. Both valued and we keep giving those messages, although I know there are varying perceptions out there. In general, people are happy with both pathways, we’ve got smart kids in both pathways. We have Duxes from both pathways, we’ve had head girls and boys from both pathways. (Susan, 1 August 2013)

Susan commented that some students perceived differences in the allocation of teachers between the NCEA and IBD at the school:

Most teachers teach both. We have had it levelled at us that 'all the good teachers teach IB', but actually all of the teachers are teaching both. I can't think of anyone that is just teaching IB. (Susan, 1 August 2013)

In terms of staffing, Susan noted that the IBD made teaching staff accountable in terms of results:

I feel as though every single teacher in the Diploma Programme has given 110% to upskill and has worked incredibly hard...to get it up and running and do a good job. It is high-stakes for us as well; we have a quantifiable measure on our performance. We are very careful to make sure we are doing the best job possible. (Susan, 1 August 2013)

Susan also noted the demand the IBD placed on staff, saying:

It's quite demanding intellectually for staff. If you are a weak teacher, and you are put into a high stakes environment, it can be uncomfortable. (Susan, 1 August 2013)

At the faculty level, Jo described a "transparent" allocation of teachers to IBD and NCEA classes that was done in consultation with staff. She said that some staff viewed the IBD as "exclusive" and she took care to make the teaching allocations "fair." Jo went on to explain that some staff preferred not to teach the IBD. She put it like this:

There are 2 or 3 members of our faculty that don't want to touch it [the IBD]. I deem them as being slightly lazy, and they don't want to challenge themselves and put more effort into teaching it. (Jo, 2 August 2013)

Susan thought that teacher performance was not as easily determined in the NCEA as it was in the IBD, because grade outcomes for individual achievement standards within a subject in the NCEA were harder to interpret. She said:

I think it is much easier to be fudgy in NCEA, and I think the kids feel the same way, because there is no one outcome for the NCEA. (Susan, 1 August 2013)

Susan explained that the students at School 3 self-selected the qualification pathway that they would undertake in Year 12, with the school message being that the IBD "is suitable for average and above" students. However, she did note that it was students from the top (two of eight) streamed classes that were selecting the IBD:

In reality we draw from class 1 & 2 and a sprinkling from elsewhere. (Susan, 1 August 2013)

Jo also saw the IBD programme at School 3 attracting the more academic students, saying:

The top academic kids go into the IB, so automatically they are a lot more driven. (Jo, 2 August 2013)

Susan succinctly explained the drivers for curriculum decision-making in School 3:

Our student needs drive us. We are an independent school and we are responsive to what students want. (Susan, 1 August, 2013)

Susan also noted the influence of universities on students' course selection within the school:

The tertiary requirements are driving their [students] choices at IB and NCEA.

7.4.2 Course design.

The structure of the NCEA chemistry courses at School 3 were planned at the end of the fourth term each year. Jo explained that there was then a sharing of responsibilities across the department. She said:

We discuss what the needs of the students are for next year. Then we are going to go off and work on different courses. So, there is a teacher in charge of each year level and off we go and we talk to each other. It is done quite informally because we struggle to find time to meet as a department. (Jo, 2 August 2013)

Jo remarked on how she saw the 3.1 investigation standard as offering students an opportunity to develop practical skills, although there was a workload issue for staff associated with it (see Section 7.5.2). It was being offered as an optional standard for students to do. She also talked about her reasons for not including the research based achievement standards (Chemistry 2.3 and 3.3) in the Years 12 and 13 NCEA courses:

What I don't like is the research based standards. I don't see the point in that when there is research done all over the school. So, I don't particularly like those ones in terms of what we are trying to achieve for our students ...other than credit gathering that is about it. (Jo, 2 August 2013)

Table 7.2
NCEA Chemistry course structures at School 3

YEAR 12 CHEMISTRY COURSE (Level 2)	YEAR 13 CHEMISTRY COURSE (Level 3)
Carry out quantitative analysis. AS 91161 Internal	Demonstrate understanding of spectroscopic data in chemistry. AS 91388 Internal
Carry out procedures to identify ions present in solution. AS 91162 Internal	Demonstrate understanding of thermochemical principles and the properties of particles and substances. AS 91390 External
Demonstrate understanding of bonding, structure, properties and energy changes. AS 91164 External	Demonstrate understanding of the properties of organic compounds. AS91391 External
Demonstrate understanding of the properties of selected organic compounds. AS 91165 External	Demonstrate understanding of equilibrium principles in aqueous systems. AS 91392 External
Demonstrate understanding of chemical reactivity. AS 91166 External	Demonstrate understanding of oxidation-reduction processes. AS 91393 Internal
Demonstrate understanding of oxidation-reduction. AS 91167 Internal	Carry out an investigation in chemistry involving quantitative analysis AS91387 Internal (optional)
Total credits = 23 (comprising 10 internal; 13 external)	Total credits = 25 (comprising 10 internal; 15 external)

David held the view that the 3.1 investigation was included in the Level 3 NCEA course to “give them a chance of endorsement”. At the time of the researcher’s school visit the students undertaking the 3.1 investigation had completed their practical work. No Year 12 or 13 chemistry lessons involving practical work were observed.

Nicole said that she felt she was under time pressure when teaching both the NCEA and the IBD. This impacted on her planning for different units of work. For the IBD, the students were expected to undertake independent study of one of the two option topics. Nicole had prepared several resources including a workbook to support students’ independent learning of the Drugs and Medicine option. Nicole also talked about reviewing the overall course structure for the IBD, and making changes to the teaching order of topics. She also talked about having the two options offered to

students at School 3 being stipulated by the HoF. Nicole explained how she worked to give students in her classes more choice than that:

From above I got, 'most of our kids are going to do medicine, so you will do these two topics'. But there is more than medicine kids in the classes that we teach. But we are catering for those kids and not catering for all of our kids. So, what I do, is I say to the kids, 'these are the two options the school makes me do with you, I don't have any input into that. But, if you would like to do one of the other topics, let me know early because then I will produce something for you that you will be able to use. Forget about when we are doing biochemistry in class, you will work on this. You can put your hand up and ask me questions'. (Nicole, 3 August 2013)

Two lessons were observed where Nicole was teaching her IBDP students material from the Drugs and Medicine option topic. Both lessons were very structured and teacher directed, with students working through set pages of the teacher's workbook. The teacher spent significant time working her way around the (small) class to check on progress and clarify/emphasise key points in the molecular structures being studied. The workbook notes followed exactly the learning objectives of the IBD Subject Guide (International Baccalaureate Organisation, 2007) and past examination questions for the option topic were included for students to work through.

7.4.3 Planning units of work.

Jo talked about assessment being a key element for her when planning units of work:

Assessment. That would be the key thing. Also, key skills that the kids walk away with, we need to look at what actual skills they need to have. Practical skills, life skills, can you actually write coherent passages, are you able to think and analyse. Thinking skills basically. I suppose also with our unit planning you need to incorporate our [school] learner profiles; have all those elements in it. You put it into your curriculum maps and then...it is all in there, but you don't refer to it that often. I just use learner outcomes. (Jo, 2 August 2013)

Jo and Nicole talked about referring to online resources when planning an NCEA unit of work. Jo put it this way:

NCEA – you are guided by what is on TKI and NZQA, what is on those websites, the assessment influences what you are doing. (Jo, 2 August 2013)

She expanded on this, and talked about using the achievement standards in her planning:

NCEA – you go through what the achievement standard states, and then you match it up and make sure you have covered everything in the standard. That is basically it; it

is just a matter of sitting down and nutting out what is in the achievement standard, and off we go. (Jo, 2 August 2013)

David too, referred to using the achievement standard as a starting point in his planning units of work for his NCEA classes. Nicole talked about how she allocated teaching time to specific concepts within a unit of work based on her judgement of what students would find difficult (see Section 7.5.1). Jo reiterated her focus on assessment when describing her approach to teaching a unit on organic chemistry. Her comments here also reflect a focus on students' grade outcomes (see Section 7.6.1).

With organic, I am very focused on the assessment. Those kids have to be able to get excellence. That is the crucial thing: 'What am I doing in my teaching to ensure that top grades are being achieved?'(Jo, 2 August 2013)

In terms of teaching resources for units of work, Nicole said there was "no sharing amongst three colleagues".

7.4.4 Teachers' perspectives of the NCEA and IBD.

Clarity

Jo found the IBD curriculum was clearly understood:

IB is very prescriptive, you are not guessing what they want, it is very clear. (Jo, 2 August 2013)

Nicole too, commented on her reliance of the IBD chemistry Subject Guide (International Baccalaureate Organisation, 2007) when planning her courses:

Planning for IB is really good, because we have that teachers guide so we literally, put that two year planner together. (Nicole, 3 August 2013)

In comparison with the IBD, Jo found the NCEA required more interpretation by teachers:

If you muck up IB, and can't work out what's in the curriculum, you need not to be teaching, that's the way I look at it. Whereas NCEA, there is a hell of a lot of interpretation... (Jo, 2 August 2013)

David also commented on his experiences of referring to NCEA and IBD documentation in his teaching: the chemistry achievement standard statements, and the IBD Subject Guide (International Baccalaureate Organisation, 2007) respectively. He said:

The [IB] curriculum document, is MAGNIFICENT. NCEA could learn a heck of a lot from that. Because, it's very detailed in what the kids do and don't need to know, and there are really never any surprises in the exam. It says what it can ask, and it tends to ask those things. Whereas NCEA, it seems quite subjective, you don't necessarily know the kinds of questions they might ask, and some of the things they might ask, until you see them, and by that stage, it is too late for that cohort. So, you teach to the best that you can. I guess experience helps with that, but sometimes you get a few curly ones in there, and you think, I haven't even contemplated they might ask that. Whereas in the IB, they will try and put a different slant on it, but very black and white, if you compare an AS [achievement standard] compared to the IB curriculum document, it doesn't compare at all. (David, 31 July 2013)

He revisited this issue later in the interview, saying about the NCEA:

I dislike the achievement standard [document] – the depth of information supplied to a teacher as to what may or may not be assessed – there is no depth. (David, 31 July 2013)

Jo said she worried about issues related to internal assessment in the NCEA (also see Section 7.6.5), and how assessment practices at School 3 compared to other schools. She talked about more clarification from NZQA being needed around the implementation of achievement standards:

Clarification from NZQA would be really handy for some of the internals coming in and assessment; whether we are actually doing the right thing or going off on a tangent. I do worry sometimes that we are being too hard on our kids with what we expect from them. Compared to other state schools; you hear about what is happening in some state schools and you think, hang on, this is not a level playing field. So, it is just more clarification around those. (Jo, 2 August 2013)

Challenge

Jo described her experience of starting to teach the IBDP:

I love IB content, because it challenged me. You've been teaching a while and you get into auto-pilot and then all of a sudden you've got this new curriculum that you've got to learn.... I actually went back and grabbed some old uni notes and thought, right, I did do that. It made you think again, which is really nice. (Jo, 2 August 2013)

David too talked about the IBDP being challenging, for both teachers and students alike. He said this about his experiences of teaching the NCEA and IBDP chemistry courses:

When you teach NCEA only, you teach the same things all the time, which has its pros and its cons. But some of the things in IB chem, particularly Higher Level, was stuff that I hadn't dealt with in a long time, if at all, so that was a nice challenge. But quite time consuming. I like that it is challenging. The kids really buy into the IB programme, and they get quite good at managing their time and I like that aspect of the course too. (David, 31 July 2013)

Nicole commented on her experiences of teaching IBD and NCEA chemistry as follows:

I would say, over the last couple of years with the IB, I can do way more contextual teaching. Where NCEA, when it comes down to it, I've found very boring. It is very black and white to me because of the way our school runs, I don't have the time to do the practicals I would have done under the old UE system. (Nicole, 3 August 2013)

Accessibility

David said he thought that the achievement standard structure of the NCEA allowed weaker students to experience some success. He explained it like this:

You can be assessed on atomic structure and bonding for example, and hopefully can pass that paper. If you are weak at organic, you might fail that paper, but you still get some credits for the things that you are strong at. So a kid, a lower end kid, could have some measure of success as opposed to [being] a complete failure and [gain] no benefit from having done the course. So, I like that aspect. (David, 31 July 2013)

Flexibility

Jo commented that the flexibility of course design that the NCEA allowed was a positive aspect of the qualification.

Structural issues of the NCEA

Nicole saw a difference in the IBD and the NCEA in terms of the extent to which chemistry concepts were linked together. She also talked about the difference she saw in the two courses as taught at School 3, in terms of the inclusion of relevant real life contexts. She said:

Very little contextual comes into it [the NCEA], unless I am bringing something quickly in, because we would never get our course finished. Therefore for me, in NCEA, I've lost the love of the chemistry. It is not the chemistry I remember as a kid, it is not the chemistry I used to teach when we had School Cert., UE, Bursary – when that was around. IB I really like, because I like the idea I can bring in medicine and drugs, and start bringing different topic areas back in with each other, which to me is real chemistry....NCEA is destroying my subject, at this school anyway. (Nicole, 3 August 2013)

With reference to teaching organic chemistry to Year 12 NCEA students, Nicole described the limitations she saw with the 2.5 achievement standard:

I think this is why kids don't do terribly well at organic, it is flash card learning style equations and that turns kids off. Unless you like making coloured flip cards...If they did mechanisms, you could at least bring atomic structure and bonding back into it...but there will be kids in my classes making a 1001 flip cards to try and remember, and...gives me a dibromoalkane. Why? You are just creating more work. But that is

the problem with that NCEA, that would be the one topic I think NCEA really needs to look at, to rejig that 2.5. I don't think they are teaching the kids the chemistry behind it. They are testing kids' recall ability. You could bring your redox in there, you could bring your 2.1 in there, which is what we used to do in UE. ...A lot of thought hasn't gone into how this helps kids cognitively develop the skills of chemistry. It is 99.9% rote learning, but can you process the question to figure out what they are asking so you can pull out that stuff and dump it? Because even their questions are so repetitive. (Nicole, 3 August 2013)

Realignment

Jo commented on the effect of the realignment of the NCEA in terms of course content:

The content of NCEA is fine really. They have watered it down from what we did years ago, but at the end of the day they are matching what the NZ society needs in terms of what they want I assume, that is what they are trying to do with NZQA. (Jo, 2 August 2013)

Nicole saw few significant changes in the NCEA chemistry course due to the realignment. In her view the move from four papers to three in the external examination was a good change. In her words:

I like the fact that there are 3 external standards now. Realistically, the rest of the course hasn't really changed. It is the same old stuff. (Nicole, 3 August 2013)

7.4.5 Preparedness of students.

Susan did note that each year the school had some new enrolments into Year 12 and the IBD programme. These students typically had an NCEA mathematics background, and in her view were less prepared for the IBD programme than their peers who had studied mathematics towards the IGCSE. She said:

We do have some students who come into Yr12 in the Diploma with only NCEA Maths, and they report that they feel it takes them 6 months to come up to speed. (Susan, 1 August 2013)

Nicole described weaknesses she saw in NCEA Level 3 students in terms of their chemistry background. She explained it like this:

About 3 years ago, I had a class of 10 kids, out of that class of 10 kids, there were 7 who had not passed a single standard in L2 that got into L3. This school has an open door policy. (Nicole, 3 August 2013)

She added that when teaching NCEA Year 13 chemistry students with weak mathematics skills, she recommended that they withdraw from the Level 3 aqueous chemistry standard on the basis that they could not cope with the calculations.

Jo talked about having a “limited” understanding of the content of current first year university courses in chemistry. She said she was somewhat informed by conversations she had had with past students who had gone on to study at Otago University. However, she described being less informed about courses at Auckland University or Victoria University of Wellington. Jo was quite clear about the requirements for students to succeed in university chemistry courses:

They need some practical skills and they need the basic content knowledge. That is the long and the short of it. (Jo, 2 August 2013)

Jo suggested that the IBD chemistry students were taught to a higher level in terms of content, than their NCEA peers. She also considered the NCEA to be “fine” in terms of their preparedness for university courses; she put it like this:

IBD HL chemistry is the ultimate if you want to do medicine or vet, because you are really prepared well with content knowledge. NCEA – fine. It matches in, that is what the majority of NZ does, the universities are prepared for that, all is well. Whereas the IB, you do teach them to a higher level.

Jo’s belief was that the 3.1 *Investigation* NCEA standard was good preparation for university (see Section 7.5.2). David said of the NCEA students:

I think they are quite strong in some content areas because of the AS they sit. Practically, I think they are probably fairly limited; mostly focused on titration skills. Obviously, there is some of that at university but not a significant amount. So I think, it is OK but not as strong as it could be. (David, 31 July 2013)

David stated his views of IBD students’ preparedness for university as follows:

I think the course and the way they link to other subjects, they probably gain those skills better. It might be a function of those students who tend to choose IB as well.... They are used to a much more significant workload; they work a hell of a lot harder as a generalization, they work longer, so they get much better at getting those skills. So, my hunch is that the IB kids are going to be better at university. The course they do is broader, some of the practical work they do is broader. I feel like I am a ringing endorsement for the IBD. (David, 31 July 2013)

Nicole held the view that there was a proliferation of summer bridging courses on offer at universities, and this was indicative of weaknesses in NCEA students’ learning. She also talked about hearing from IBD leavers from School 3:

Their comments are that they are coping better in their first year at university because they had to do practical work, they had to do independent learning, I’ve heard from....student in her 4th year now, she is only just starting to find the work hard now. The NCEA kids have caught up, but she has had that lead time because of the skills she developed during her IB programme. We quite often have kids coming back for this Group 4 project ... and they tell the kids about what they have found useful about IB that has helped them at university. (Nicole, 3 August 2013)

7.5 Pedagogy: Teachers' perspectives and practices

The analysis of interview data, together with data from classroom observations, at School 3 led to the emergence of findings related to teachers' perspectives on pedagogy.

7.5.1 Favoured teaching practices.

Jo said she believed it necessary to “chunk” lessons, but commented that she saw differences in teaching NCEA and IBD students:

I've worked out you've got to chunk it for students. There is a clear difference between NCEA and IB. So, I'll do NCEA first. You need to chunk it, they need hands on, regular breaks and clear expectations for each lesson. Also, looking at exam questions and writing model answers is really important. The assignments where we write model answers is really important. Putting it together for them is really critical.

IB – the kids in general ...you can actually get away with less chunking. You can actually set them a task which they work on solidly for ½ an hour and there is no problems; they are totally focused, all is well...They are a lot more self-driven, whereas I have to drive the NCEA kids. (Jo, 2 August 2013)

In the lessons observed where Jo was teaching, the lessons were somewhat interrupted with some students arriving late and others leaving early for sports practices. Jo was observed making the learning intentions explicit for her students at the start of each lesson and she had evidently planned several activities for each lesson. Gaining the attention of her students seemed a challenge for her. In the interview, Nicole described how, in her planning of units of work, she would use her experience to judge the amount of teaching time to spend on specific concepts:

I say 'I need this many periods to do this this and this, because I know this is where you struggle as kids, so we I need to spend a little bit more time here, less time there'. (Nicole, 3 August 2013)

In the classroom she appeared quite comfortable with adjusting her teaching approach according to the questions asked and level of engagement demonstrated by her students. Her lessons were “full” in that she expected to have the students work for the full class period. However, the school culture seemed one where many school-based activities were happening, and these did impact on teaching time.

Nicole went on to talk about how she found using analogies and examples useful when teaching some concepts. She said about this:

The weirder they are and the crazier they are, the more memorable. So, I use that strategy. (Nicole, 3 August 2013)

Nicole also said she prepared assignments made up of “a million and one of the same kind of questions” for students to practise their calculations. This was seen by the researcher in the materials she shared with me. Nicole evidently believed that preparing students for assessments required them to complete past examination questions. She commented on her students making good use of the resources on Moodle. Nicole also described her move recently to flipping her teaching, and how she believed that had benefits for students, especially those missing class time. That students were out of class a lot was evidently a challenge for her (as it was for Jo).

I am trying to flip my classrooms, because I've just learned about what flipping classrooms means. Its 'OK, can someone please answer me and not go to music or whatever'; they are always coming in and out. Now I often get kids to do stuff for homework, so when they come to class I can start asking them questions so I can test their understanding. Kids often tell me that is what they like, they prefer that versus me just going through notes up on the board, they copy them down and are then expected to do questions. (Nicole, 3 August)

Nicole did show me the extensive number of digital resources she had prepared for students in her classes, and she was confident they were using them. In the lessons that were observed, however, it was unclear as to what extent the relevant theory had been covered by the students beforehand. It seemed that for the Drugs and Medicine topic being studied at the time by her IBDP class, there was significant note taking while in class.

Nicole talked about how she aimed to manage students' questions in a way to promote their confidence:

Kids know that they can ask questions of me, and they know I am not going to say 'OMG you can't do that'. Any kid that asks me a question, I will tend to twist it so I'm asking them a question back, so they are actually physically answering their own questions. Then I can say, 'see you knew the answer', which I've found really good because that is the confidence thing. (Nicole, 3 August 2013)

In her classroom, Nicole appeared engaging, and students warmed to her style. They were relaxed about asking lots of questions about the work at hand (and some off task ones as well).

David talked about having “varied approaches” to teaching. He described how he “tried to mix it up” this way:

Sometimes I will find myself presenting material almost lecture style, notes etc, to give the kids knowledge and then do exam questions and practical work to help reinforce that idea and sometimes I will more do a practical and try and let the kids discover it for themselves. (David, 31 July 2013)

In the observed short sequence of lessons, David's lecture style was observed; he read excerpts from the textbook to the class; students then completed set questions from the text.

7.5.2 Practical work.

Jo saw practical work as a key consideration in her planning, and she talked about this in the context of teaching a unit in aqueous chemistry:

I want to make sure that they have got some practical skills so that they are enjoying class. For my latest aqueous unit, I wanted each lesson to have something practical. That is my thing with that, so each lesson I want something hands on or a demo or something like that. (Jo, 2 August 2013)

Jo also described the professional satisfaction she derived from supervising individual chemistry investigations for the Extended Essay in the IBD programme. She explained:

I love the chemistry EEs. I think they are brilliant, anything like that I think is great. Some staff I know hate them, and it does take a lot of work. I seem to pick up the problematic students, but I still love it, but then I have a passion for that sort of thing. 'We don't know the answer to that question - so let's figure it out together'. It is a bit of academic stimulation; you have to go and do a bit of background research because you don't know the question. We have an idea – that is good. (Jo, 2 August 2013)

Despite the workload associated with marking the IBD internal assessment of practical skills, Jo saw that the programme offered students the opportunity to develop their skills in that area. She commented as follows on the practical work in the IBD and NCEA courses:

I think that for IB, the practical side of it, even though the IAs [internal assessments of practical work] ...by the end of next term I'll be thinking 'I'm getting killed off with the start of the L2 IAs coming in', I do think the kids do walk away with a fantastic skill set. Whereas my NCEA kids, I do worry about the practical that they walk away with. That is why I offered 3.1 Investigation this year. For me, it is more than the knowledge; they've got to have skills that will set them up and do practicals, and think and solve problems. In that 3.1 is beautiful, but it does come at a high cost and it does put the kids under pressure, 3.1. But, in some ways it sets them up for university and bigger things, and they end up enjoying the practical aspect of 3.1. (Jo, 2 August 2013)

Nicole too, talked about the differences she saw in the IBD and NCEA courses in terms of the practical work done. When she was asked "*what extent is practical work a part of your teaching units?*", she answered:

It varies. Very little in NCEA... realistically we would do 2.7 – it is practical work, and 2.1 – it is practical work, forget about 2.4 and 2.5, I will show you, but that is about all of the time we have got. That's the other reason I like IB, because you have to do the

practical work, there are no if buts and maybes about it, you have to do those hours of practical. Which to me is better, you have to start thinking about what you are doing. 'Is it proving what you are doing theoretically in class?', and 'now we can think about the reasons why it doesn't'.... Everything is thinking about 'how reliable is my data when I've typed it up?'. NCEA is not about reliability at all, it is just do it. So there is very little, I think NCEA has just killed my love of it, in that sense of it, we just don't have time. (Nicole, 3 August 2013)

Similarly, David described the differences he saw in the practical work done in the IBD and NCEA courses. With regard to the IBD programme he said:

We tend to focus on getting a lot of our practical work done earlier rather than later in the course so as to focus on the exams at the end. It is a fairly even spread. (David, 31 July 2013)

For the NCEA courses, David commented:

Some of the AS [achievement standards] are heavily practically based; your titration, your precipitation, along with your investigation. So, that is not an even spread. I guess there that those topics that are heavily practically based; you do all your practicals then...We get under some serious time constraints, so rightfully or wrongfully, it is easier to drop them [practicals] out of Structure and Bonding type topics. Organic chemistry, we do some pracs in that, Equilibrium, I like to do some more, but we are fairly time limited, so there is a quite a lot of practical work that comes in, but it tends to be quite blocked. (David, 32 July 2013)

Nicole and David each went on in their interviews to talk about the opportunities for open-ended investigation work to be done in the Level 2 and Level 3 NCEA chemistry courses at School 3. They said that no investigations were done in the Level 2 chemistry course, while the 3.1 investigation was done in Year 13:

None...other than our investigations in Year 13, which is optional at present with 3.1. Even that, 'here are the three practicals you choose from'; it wasn't kids choosing. Open-ended, no, it is very directed at Level 3 NCEA.

What did you offer them?

They were offered temperature changes on chlorate ion concentration, bleach; the permanganate one with time; and I think a student did something with oxygen. That was basically the three things. The kids were given a choice [of techniques] to run with, just because of time. Most of them would have been looking at change of temperature with the active component in bleach.

When asked about investigations done in the IBD, Nicole said:

There are no open-ended investigations at all, unless they chose an EE [Extended Essay] in chemistry, which we advised them not to. Because they are all one period practicals when we assess them. With being 32 periods short anyway, we've given them just plain straight practicals, just typical design...

With the Design ones, most of them have to come in after school if they want to trial it, because we don't have the time in class. We did it the first year, just giving them the Designs, but then we discovered that was the worst thing you ever did because you had kids for electrolysis saying they were going to put sodium metal into water the size of a swimming pool... without them doing it. (Nicole, 3 August 2013)

David noted that at School 3, the Design tasks done by IBD students in chemistry were not usually carried out to completion, with data collected, processed and evaluated, even though students were encouraged to do some trialling of their designed method.

7.5.3 Reflective practice.

Susan talked about the process by which senior curriculum managers at School 3 undertook data analysis and review in terms of results for the NCEA and IBD. She said that an aim for the school was to raise student achievement. In terms of NCEA data, she said:

We buy in an analysis of our results after each NCEA examination round. That data is broken down into useable bits by our academic dean. This year, for example we've focused on looking at our excellence grades because we feel we are really underdone, so we pulled out the data and showed staff the data for our school and for national average, decile 8-10. (Susan, 1 August 2013)

The NCEA data analysis led to a review:

...that included back-tracking and looking at attendance, time in class, our assessment policies, re-submission rules. Having a really good look at why our achievement is not in the place where we want it. (Susan, 1 August 2013)

For the analysis of IBD data, Susan cautioned that "small numbers can make a big difference in stats", and described the process:

IB results, we get a really good breakdown, really easy simple, quick, easy to interpret breakdown from IB and we definitely look at those. We look at ourselves in relation to international, and Asia-Pacific. We pull out Australia and NZ as well. (Susan, 1 August 2013)

Susan remarked that over the preceding few years, the total IBD points average for students at School 3 had fallen by "almost 2 points". She attributed this to teachers at the school starting to "relax":

It is interesting because when teachers start a programme they are very fastidious. But, as they get more familiar, it is human nature to relax a little bit and be a bit less fussy about things. It is quite hard to maintain momentum, irrespective of qualifications. (Susan, 1 August 2013)

At the faculty level, Jo talked about using assessment data to inform teaching practice. She explained that at the start of a new school year there was a faculty meeting to review examination result data, and from this review teachers would reflect on their practice. She said:

We go through, look at where the kids have under-performed/over-performed. And then think 'why has that happened?' OK, [I need to] change what I did. This has worked really well for this unit...so therefore I need to change my teaching approach. We have a brief discussion about that at the beginning of the year..... (Jo, 2 August 2013)

Nicole talked about listening to student feedback on her teaching:

From the kids, because kids are quite open, they tell me when they find something hard, or 'that's good, or have you thought about this Miss [x]?...' I think that's good, because you are the best critiquers, I'd rather listen to what you have to critique me on than my colleagues because you are the ones that I teach'. (Nicole, 3 August 2013)

However, when asked "how is assessment data used to inform your teaching and learning?", Nicole replied:

It's not. It is literally filed, we do not use it. We don't look at it to see where kids go. There is no tracking at all. (Nicole, 3 August 2013)

David too, said he made little use of the departmental data analysis he received on past examination results.

7.5.4 Professional development.

Jo considered her past experience as a marker for the NZQA chemistry examinations as being useful professional development. She described this:

Marking for NZQA is very useful for curriculum development...because you have seen 1000 scripts with 1000 mistakes, of all of the same nature. That has really helped my teaching immensely. (Jo, 2 August 2013)

Jo also commented that professional development that had an NCEA implementation focus would be useful. In terms of NCEA professional development, Nicole said:

I've found a lot of courses, like the NCEA jumbo one I went on, it got side-tracked completely. (Nicole, 3 August 2013)

Nicole said she found an online IBDP workshop she had done covering aspects of the internal assessment component to be "the best PD I've been on". She commented that she would like to enrol for another online course covering the then

imminent new subject guide. David talked about his experiences of a face-to-face IBDP chemistry workshop he had attended in Melbourne around five years ago:

I found it completely overwhelming, because I hadn't yet taught it and it was just gobbledegook essentially and I really regret going when I did. Although, I guess we had to go when we did. But I would have far preferred to go at the end of the first year of teaching it and it would have been massively, massively beneficial. (David, 31 July 2013)

David said that he had not undertaken any professional development outside of the school in the two years before the 2013 interview, but in 2013 he was involved in a development programme run in School 3:

This year we have started up our learning groups within the school and I am looking at a SOLO taxonomy that I have tried to bring in to chemistry teaching. (David, 31 July 2013)

Nicole talked about there being limited opportunity within School 3 for the chemistry teachers to discuss curriculum and pedagogy issues. She put it like this:

We have enough trouble having our science faculty meeting. There are no real cluster group meetings. We don't have the time to do it. We have one [faculty] meeting a term to sit down; it is appalling. It is not a faculty let alone a department working... (Nicole, 3 August 2013)

7.6 Assessment: Teachers' perspectives and practices

Classroom observations and coded teacher interview data from School 3 led to findings related to assessment that are described in the sections below.

7.6.1 Grade focused outcomes.

Jo succinctly described the importance of grade outcomes to the parents of students at School 3:

At the end of the day with those senior subjects, Year 12, 13, you are assessment driven, sorry but in our school the results count. The kids need to enjoy learning, but at the end of the day, parents want top grades and that is what we've got to deliver. (Jo, 2 August 2013)

7.6.2 Workload.

Jo, the HoF, talked about the issues she had managing her "huge" workload, saying she was "struggling to keep up." She felt that the dual pathway of the NCEA and IBD at School 3 had led to conflicts between staff of the Science Faculty:

Doing IB from our experience, has put more pressure on, which has caused relationship issues within the Faculty. With the extra workload, the extra pressure,

when you get tired, you know.... I can predict when things are going to happen now in terms of HR issues. It [the IBD] is higher stakes, I think, that's what it comes across as. (Jo, 2 August 2013)

In Jo's view, the workload associated with internal assessment in the IBD chemistry course caused more stress for staff than that for the NCEA:

The internal assessments for IB has caused major stress, whereas NCEA [staff] don't seem to be so stressed, for whatever reason. I think it is just that we feel like it is higher stakes for the IB kids. (Jo, 2 August 2013)

For the IBD, Jo said that the "marking and moderation of IAs [internal assessments of practical work] has killed me completely". Jo came back to the issue of workload later in the interview, and said that more allocated time for developing resources and lesson planning was, the greatest need for staff in her department. She put it this way:

The biggest thing we need is time to develop resources, really we've all got the curriculum knowledge, but it is time to think more in depth about our lessons. That's what I'd really like. (Jo, 2 August 2013)

Nicole brought up the issue of her workload at several points in the interview. When she was asked about teaching allocations in the chemistry department, she said:

If they introduce the MYP [IB Middle Years Programme] I am going to burst, and I am a workaholic. It is unusual for a workaholic to say they are about to burst because of their workload. They normally like to work. I like to work, but I won't be able to have time to fit anything in. I will just walk out. (Nicole, 3 August 2013)

Nicole and David each talked about dissuading IBD students from undertaking their Extended Essay in a chemistry topic. The supervision of the lab work involved was, they said, a workload issue.

It is such a heavy workload for us as staff, we have to be here to watch the kids, they can't be in the lab by themselves. (Nicole, 3 August 2013)

7.6.3 Approaches to learning and assessment.

Jo described herself as being "exam focused" in her teaching of both the NCEA and IBD students. This was evident in classroom observations; every lesson involved at least one task where students were asked to write answers to past examination questions. These were then unpacked in whole class discussions. She advocated using exemplars when preparing students for internal assessment in both NCEA and IBD, saying that it was important for students to know the standard that was expected of them. Jo talked about developing students' scientific literacy, and

aiming for them to write “very succinct answers using the correct terminology.” One strategy she said she found useful was to have students mark responses to examination questions. She said:

That actually helps their understanding. If you can mark it, you understand the content.....IB, the other thing that we have found really useful as a department, we have homework assignments for every topic: 40 multi-choice, 50 long-answer response questions....That has been really successful for IB, because the kids have said that is what has really helped. Exam focus. (Jo, 2 August 2013)

In describing his approach to internal assessment in the NCEA, David said:

we would spend however much time as needed to learn the skill or the process we are going to be assessing. Usually, we would have a bit of a practice run with a different but hopefully ‘similarish’ task...Then hopefully they are pretty skilled up so they are not going in particularly blind to the internal assessments. (David, 31 July 2013)

He said he saw the approach to internal assessment in the IBD programme differently:

IB: certainly not the guidance that goes in to whatever happens in NCEA. For whatever reason, I guess they get a few more opportunities to make mistakes in their earlier practicals, even though their following practicals are different practicals. They get to choose their best two for each aspect to go forward. So IB, essentially flying blind in terms of their pracs: here you go, make of this what you will. NCEA, [there is] a whole lot more guidance. (David, 31 July 2013)

David said “NCEA: we only teach the achievement standards” when asked about the scope for learning in his classes that was not assessed summatively. In the IBD course, while he noted that Theory of Knowledge aspects were included, he also saw little scope for learning outside of the syllabus course work.

7.6.4 Formative assessment.

No specific comments were made by teachers at School 3 about their use of formative strategies with their classes.

7.6.5 Internal assessment.

Jo said that it was the workload associated with the internal assessment component of Group 4 subjects in the IBD that was the issue in terms of staff relations:

The biggest stress for us in science has been the workload with the IAs [internal assessments]. That has been major. Hours of work. It is more work than NCEA in some respects, and that there has put huge pressures on staff to keep up with marking internal assessments, or even getting the drafts, or the pre-teaching so they can sit the assessments. You’ve got to mark those, give feedback. The feedback that you give needs to be very targeted, otherwise the kids fall over. So, the pressure that

has come with IAs is huge and that has caused issues between staff members. Physics is the only department that has not had those issues. Biology and chemistry, it has caused some quite major HR stuff. We have worked through, trying to put strategies in place, but if you stayed here for a term you would see it. I think in another 3 weeks' time, there is another big workload about to start and you can just see what is about to happen. (Jo, 2 August 2013)

Jo evidently perceived differences between schools in managing internal assessment in the NCEA, saying:

What I don't like about NCEA is the inconsistency that seems to be of the internal assessments. What one school marks, moderates, processes is totally different to another school. I don't think it is fair to all kids in NZ. Whereas the externals, it is a level playing field. (Jo, 2 August 2013)

She explained how her views on this were informed by seeing work from other schools. Jo went on to explain how she would have liked more feedback through the external moderation process to clarify marking and grading of internal assessment. She expressed doubts about marking internal assessments:

When you go to some of these chemistry meetings, you take along internals. Sometimes you go 'OMG there is no way we would give that an E for this, this and this reason'. Where our moderation always comes back perfect from NZQA, but is that because we are marking too hard? They don't tell you if you are marking too tightly. Yep, you come back perfect, it meets the standards, it meets everything, so is that...they don't give you enough feedback. That is something with NCEA I'd like: more feedback in terms of if we are on track with moderation with internal assessment. You think you've got it sorted, but you don't actually know. It is very difficult to get real clarification around that. (Jo, 2 August 2013)

Through the interview, Jo made several comments about her own uncertainty around implementation of NCEA internal assessment in chemistry. For example, with regard to marking, she said:

[I'm] a bit shaky, still. You hope you are doing the right thing for the Year 13s, but until you get the feedback you don't know. You assume you are. (Jo, 2 August, 2013).

Nicole and David each talked about the internal achievement standards being a positive aspect of NCEA chemistry, on the grounds that they emphasised the development of practical skills in chemistry. Nicole went on to add:

That is the only thing I like about NCEA. I don't like anything else about NCEA because it has pigeon-holed my subject into chapters. (Nicole, 3 August 2013)

Nicole's stated views relating to the structure of the NCEA are reported in Section 7.4.5. Nicole also commented on her "frustration" with what she saw as inconsistent feedback received from the NZQA moderator on internal assessment tasks she had prepared at School 3. She said she would prefer a common NCEA

internal assessment task to be sent to schools “and on this particular day everybody has to do them no matter what”. She elaborated:

At least there would be consistency and internals would actually start to have some true meaning. The opinion out there is that internals are manipulated in such a way that just about every kid gets an Excellence; so there is no meaning. (Nicole, 3 August 2013)

David perceived differences existed in the marking of NCEA internal assessments between schools. He put it like this:

I dislike the moderation process of internal assessments. The lack of accountability between schools. The fact that you really don't know how the school down the road is marking...We were talking this morning about how, at this school, we are very black and white: you get one chance at this internal assessment; no hints as to what you might have done wrong. Whereas, another school might offer infinite resubmissions and keep going until every kid gets an Excellence....I find that hugely frustrating. (David, 31 July 2013)

David also stated his views on differences in the outcomes of the external moderation process in the IBD and NCEA:

In the NCEA, [I'd like] feedback about what other people are doing. I'd like an even playing field. At least you get that feeling in the IB in that a mark will be adjusted. Whereas NCEA, you might be told that you are doing something wrong, but a grade won't be adjusted. (David, 31 July 2013)

Jo made comments about being more sure of her marking of internal assessments in the IBD following moderation feedback and advice of the scaling factors applied to the samples of work sent in each year.

[I'm] a lot more confident now. We always get scaled up, so we are marking too hard, so we just need to ease back. We need to ease back on the CE's [Conclusion, Evaluation criteria]. We know what we are expecting is too much, but we are not that upset by having to get scaled up. It is better to get scaled up than down. (Jo, 2 August 2013)

However, David expressed dissatisfaction with the level of feedback received through the IBD moderation process. In his view, sufficient detail regarding the marking of particular aspects or problems with specific practicals was not given. He said:

I really dislike that guidance in marking internals, it's fairly non-existent, to the point where we had to go and pay for an old school IB teacher to come in and teach us how to do it. (David, 31 July 2013)

David said he had made use of the chemistry forums on the Online Curriculum Centre (OCC) for the IBD, and found them “quite good” for clarification of internal

assessment issues, and that he would like to have more time to access that more often. Jo talked about the workload associated with internal assessment in the IBD and the NCEA (Section 7.6.2).

7.6.6 External assessment.

Jo talked about a problematic past trend at School 3, where a significant number of students in Year 12 and 13 had not attempted all of the external achievement standards in the end of year NZQA chemistry examination. The organic chemistry standard was the one most often not attempted out of the three externally assessed standards at Levels 2 and 3. However, she saw interventions by staff as having a positive effect. She saw the problem arising from students having “enough credits”, and she explained it like this:

Four years ago the void issue was disgusting. We have been trying to get the message across, and it seems to be a lot better. Last year in Year 13 chemistry, there was a little spate of voiding the organic, which just so happened to be the easiest paper to pass. So that was an issue, and it came out of these kids deciding that they had enough credits and they only wanted to do two standards.

They had enough credits from their internal accumulation?

Yes, out of the internals, and they didn't need any more out of all of the NCEA subjects. That was pretty gutting when I discovered that in January and actually figured out what was going on. (Jo, 2 August 2013)

Jo described the policy that the department had adopted since there was a “major issue” with Year 12 students not attempting all external standards. She talked about passes in all three Level 2 chemistry external standards now being a prerequisite for entry into the Level 3 course. She justified this stance when she said:

That is one way that we have come up with to try and get those kids to perform. If they can't achieve in all of those externals, they are not suitable for Year 13. (Jo, 2 August 2013)

A summary of findings from School 3 are tabulated at the start of Chapter Nine as part of the cross case analysis. What follows in Chapter Eight is an analysis of national NCEA data for chemistry to provide a context for the commentary from the participants in this study.

CHAPTER EIGHT:

National NCEA Data Analysis

This chapter comprises analysis of national data for NCEA Level 2 Chemistry and Level 3 Chemistry for a five year period from 2010. These statistical data on the NCEA are included in the research design to provide relevant national contextual information to the qualitative data collected from participant teacher interviews. This approach, of using different methods of data collection, is a means to achieve methodological triangulation in order to obtain evidence of coherence or corroboration. The NCEA data were analysed following coding of the teacher interviews had been completed, and so allowed scope for the researcher to explore the NCEA data in line with the emergent findings from the case schools. The basis for the questions asked of the national NCEA results is described in Section 8.1.

The statistical data were obtained from the NZQA website, and were initially selected for decile 10 schools and both male and female students, so as to correspond to the profile of the case schools central to this research. The results from that analysis, however, led the researcher to question if the decile 10 data was somehow aberrant, and so grade distribution data for NCEA Levels 2 and 3 Chemistry by standard type (Internal and External) was then compiled for *all* deciles.

Presentation of statistical data are organised into the following sections:

- 8.1 Questions asked of the national statistical data
- 8.2 National NCEA results: Level 2 Chemistry (decile 10)
- 8.3 National NCEA results: Level 3 Chemistry (decile 10)
- 8.4 National NCEA results: Oxidation-reduction (decile 10)
- 8.5 National NCEA analysis: Levels 2 and 3 Chemistry (all deciles)
- 8.6 Summary

The following chapter (Chapter Nine) discusses findings from the qualitative data integrated with the national NCEA results analysis presented in Sections 8.1 to 8.5.

8.1 Questions asked of the national statistical data

The analysis of qualitative data from the participant teacher interviews showed recurring distinctions made between internally and externally assessed achievement standards. The teachers referred to the selection of achievement standards being the design unit of their NCEA courses, and that careful consideration was given at the departmental level as to which standards to include. Decisions, they said, to include a standard (or not) were primarily based on the statistical analysis done within their departments of the previous year's results. The school-wide goals in all three case schools were to improve grade outcomes. The teachers in this study articulated the belief that grade outcomes for internally assessed standards were higher than for externally assessed standards. It was on this basis, they believed, that there was a move to include more internally assessed standards in the NCEA Levels 2 and 3 courses. This then had a positive impact on the percent of course endorsements for their departments. The data from the case schools showed that the number of standards included per course, especially the number of internally assessed standards, had several implications, including an increase in workload for teachers and students.

To provide a national context as a background to the findings outlined above that were derived from the interviews, a simple statistical analysis of national NCEA data for Levels 2 and 3 Chemistry was undertaken (refer to Chapter Four, Section 4.6.1). The further research sub-questions arising with regard to NCEA results for internally and externally assessed achievement standards were:

- *What percentage of results (nationally) were recorded for the two types of standard (Internal and External) since 2010?*
- *In the case schools, the chemistry courses showed little variation; nationally, which standards were done?*
- *The teachers in this study were clearly of the view that there were differences in grade distributions between the two types of standards (Internal and External); How do results for internally and externally assessed achievement standards compare for NCEA Level 2 and Level 3 Chemistry?*
- *Are the decile 10 data congruent in terms of trends, with the national NCEA data (Level 2 and Level 3 Chemistry) for all deciles?*
- *What was the effect on result distributions when, as a result of realignment, reduction-oxidation chemistry was assessed internally rather than externally?*

- *How do Certificate Endorsement results over the last five years compare with the trends in results by standard type (Internal/External)?*

With a view of aiding comprehension of the following data, Tables 8.1 and 8.2 provide the reader a summary of the available achievement standards, compiled from the NCEA Level 2 and Level 3 Chemistry matrix (Section 2.3.5; Figure 2.3).

Table 8.1
NCEA Level 2 Chemistry achievement standards

Number	Type	Reference	Title	Abbreviated Title*
Level 2				
AS90305_X	Internal	2.1	Carry out qualitative analysis	Qualitative
AS90306_X	Internal	2.2	Carry out an acid-base volumetric analysis	Titration
AS90763_X	Internal	2.3	Solve simple quantitative chemical problems	Quantitative
AS90308_X	External	2.4	Describe the nature of structure and bonding in different substances	Structure and Bonding
AS90309_X	External	2.5	Describe the structural formulae and reactions of compounds containing selected organic functional groups	Organic
AS90310_X	External	2.6	Describe principles of chemical reactivity	Reactivity
AS90311_X	External	2.7	Describe oxidation-reduction reactions	Redox
AS91161	Internal	2.1	Carry out quantitative analysis	Quantitative
AS91162	Internal	2.2	Carry out procedures to identify ions present in solution	Ions
AS91163	Internal	2.3	Demonstrate understanding of the chemistry used in the development of a current technology	Technology
AS91164	External	2.4	Demonstrate understanding of bonding, structure, properties and energy changes	Bonding
AS91165	External	2.5	Demonstrate understanding of selected organic compounds	Organic
AS91166	External	2.6	Demonstrate understanding of chemical reactivity	Reactivity
AS91167	Internal	2.7	Demonstrate understanding of oxidation-reduction	Redox

*Abbreviated title utilised in this thesis

X: *Standard expired in italics*

Table 8.2
NCEA Level 3 Chemistry achievement standards

Number	Type	Reference	Title	Abbreviated Title*
Level 3				
AS90694_X	Internal	3.1	Carry out an extended practical investigation involving quantitative analysis	Investigation
AS90695_X	Internal	3.2	Determine the concentration of an oxidant or reductant by titration	Titration
AS90696_X	External	3.3	Describe oxidation-reduction processes	Redox
AS90698_X	External	3.5	Describe aspects of organic chemistry	Organic
AS90700_X	External	3.7	Describe properties of aqueous systems	Aqueous
AS90780_X	External	3.4	Describe properties of particles and thermochemical principles	Thermochemistry
AS91387	Internal	3.1	Carry out an investigation in chemistry involving quantitative analysis	Investigation
AS91388	Internal	3.2	Demonstrate understanding of spectroscopic data in chemistry	Spectroscopy
AS91389	Internal	3.3	Demonstrate understanding of chemical processes in the world around us	Chemical processes
AS91390	External	3.4	Demonstrate understanding of thermochemical principles and the properties of particles and substances	Thermochemistry
AS91391	External	3.5	Demonstrate understanding of the properties of organic compounds	Organic
AS91392	External	3.6	Demonstrate understanding of equilibrium principles in aqueous systems	Aqueous
AS91393	Internal	3.7	Demonstrate understanding of oxidation-reduction processes	Redox

*Abbreviated title utilised in this thesis

X: Standard expired in italics

8.2 National NCEA results: Level 2 Chemistry (decile 10)

In this section, analysis of the national data from 2010 to 2014 sought to explore the questions:

- *How do results for internally and externally assessed achievement standards compare for NCEA Level 2 Chemistry?*
- *Which standards were done nationally?*

Tables 8.3 and 8.4 compare the number of results recorded nationally for each of the individual achievement standards in Level 2 Chemistry matrix (decile 10, male and female candidates) from 2010 to 2014.

Presented in Table 8.3 are results data for externally assessed (*External*), and in Table 8.4 are data for internally assessed (*Internal*) achievement standards. New *realigned* achievement standards were in effect for NCEA Level 2 from 2012 (see Section 2.3.4), with registration of the earlier achievement standards expiring at the end of 2011.

From 2012 there was a reduction in the number of Level 2 Chemistry results in External, and an increase in the total number of results recorded for Internal standards. The number of results recorded for AS91163 for the three years from 2012 are notably lower than for the other three Internal standards (AS91161, AS91162, AS91167) over that same time period; results for AS91163 correspond to less than one percent of the total number of results for each year from 2012 to 2014.

Over the five years from 2010 to 2014 there was a national increase in NCEA Level 2 Chemistry results of 442 in decile 10 schools, as shown in Table 8.5.

Table 8.3

Numbers of results by externally assessed achievement standard for NCEA Level 2 Chemistry for 2010 to 2014. Data extracted from national NZQA data for decile 10 schools, male and female candidates.

	AS90308	AS90309	AS90310	AS90311	AS91164	AS91165	AS91166	Total #	# as % total results*
2010	2057	1848	1922	1889				7716	56.93
2011	1949	1949	1870	1735				7503	55.85
2012					2155	1969	2166	6290	48.51
2013					2200	2060	2185	6445	49.78
2014					2473	2278	2403	7154	51.11

*Refer Table 8.5

Table 8.4

Numbers of results by internally assessed achievement standard for NCEA Level 2 Chemistry for 2010 to 2014. Data extracted from national NZQA data for decile 10 schools, male and female candidates.

	AS90305	AS90306	AS90763	AS91161	AS91162	AS91163	AS91167	Total #	# as % total results*
2010	1734	2053	2051					5838	43.07
2011	1969	1967	1994					5930	44.15
2012				2413	1876	15	2372	6676	51.49
2013				2422	1694	36	2349	6501	50.22
2014				2593	1690	18	2541	6842	48.89

*Refer Table 8.5

Table 8.5

Calculation of total NCEA Level 2 Chemistry results from numbers of entries for internally and externally assessed achievement standards for 2010 to 2014.

	Total # L2 External achievement standard results	Total # L2 Internal achievement standard results	Total # L2 results
2010	7716	5838	13554
2011	7503	5930	13433
2012	6290	6676	12966
2013	6445	6501	12946
2014	7154	6842	13996

Shown in Figure 8.1 is nationally, an overall increase in the number of Internal results for Level 2 Chemistry as a percentage of total results from 43.07% in 2010 to 48.89% in 2014. In relative terms, this represents an increase of 14% from 2010. A corresponding decrease in the number of External results is also evident. Post-realignment, the contribution of Internal (48.89% in 2014) and External (51.11% in 2014) results as a percentage of total results are seen to converge.

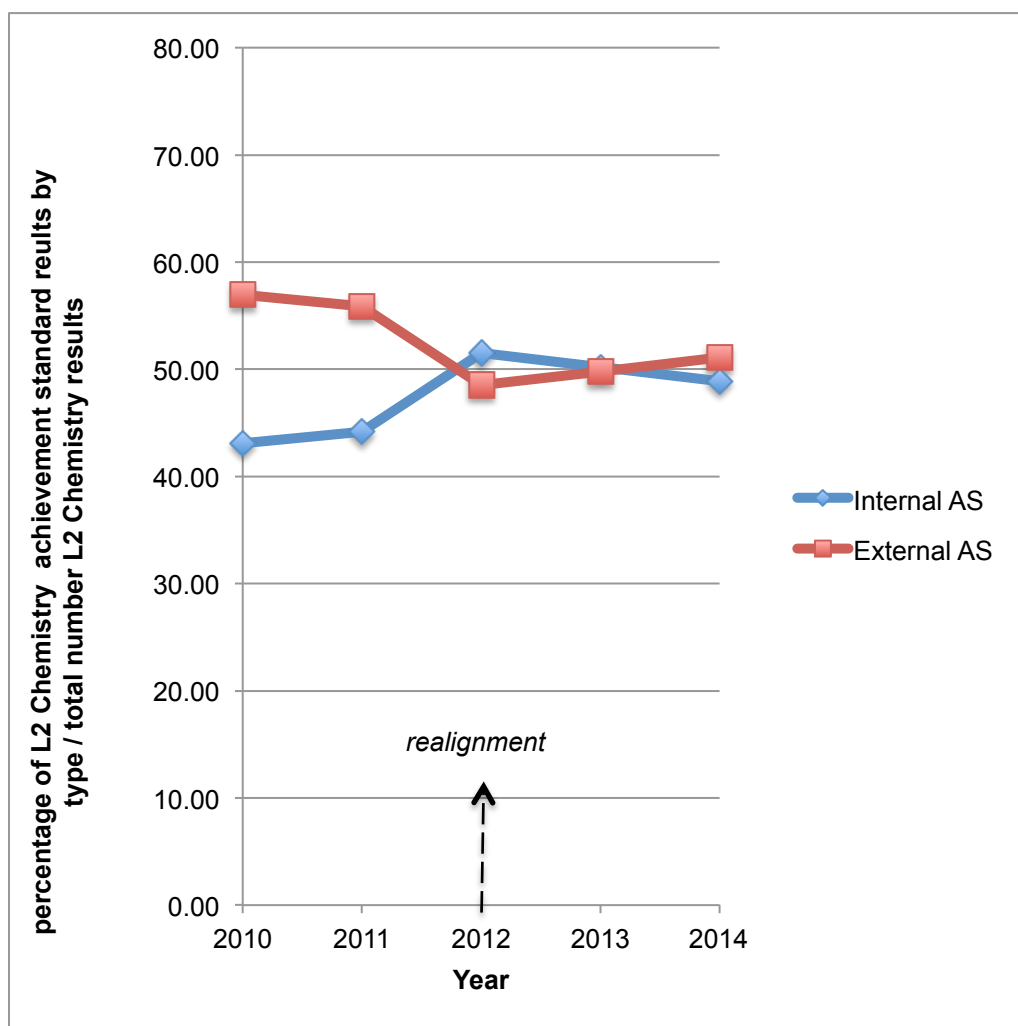


Figure 8.1. Numbers of Level 2 Chemistry achievement standard results by type (external and internal), as a percentage of total results for 2010 to 2014. Extracted from national NZQA data for decile 10 schools, male and female candidates.

8.2.1 Result distributions: *External* Level 2 Chemistry standards.

Figures 8.2–8.4 show national grade distributions for the three individual *External* achievement standards (AS91164, AS91165, AS9116) in 2013 and 2014. In abbreviated form, these standards are referred to here as Bonding, Organic, and Reactivity respectively (see Table 8.1).

Not achieved grades comprise between 22.9 and 35.0 as a percentage of assessed results for these External achievement standards in the two years of data shown for 2013 and 2014.

Excellence grades comprise between 6.8 and 13.5 as a percentage of assessed results for these three External achievement standards in 2013 and 2014.

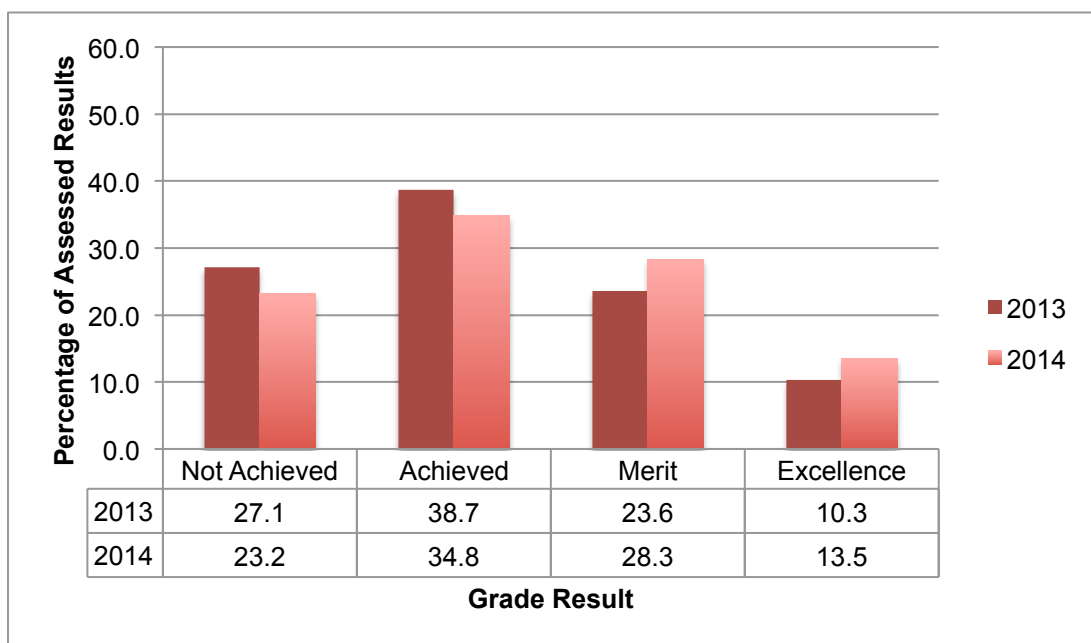


Figure 8.2. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 2 Chemistry AS91164 (External) in 2013 and 2014.

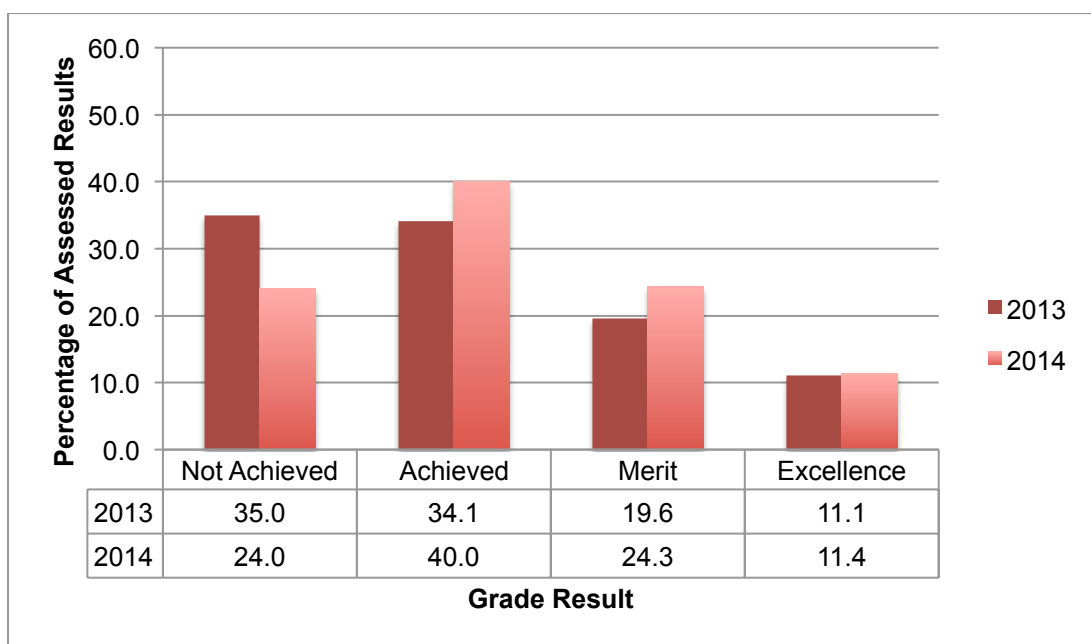


Figure 8.3. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 2 Chemistry AS91165 (External) in 2013 and 2014.

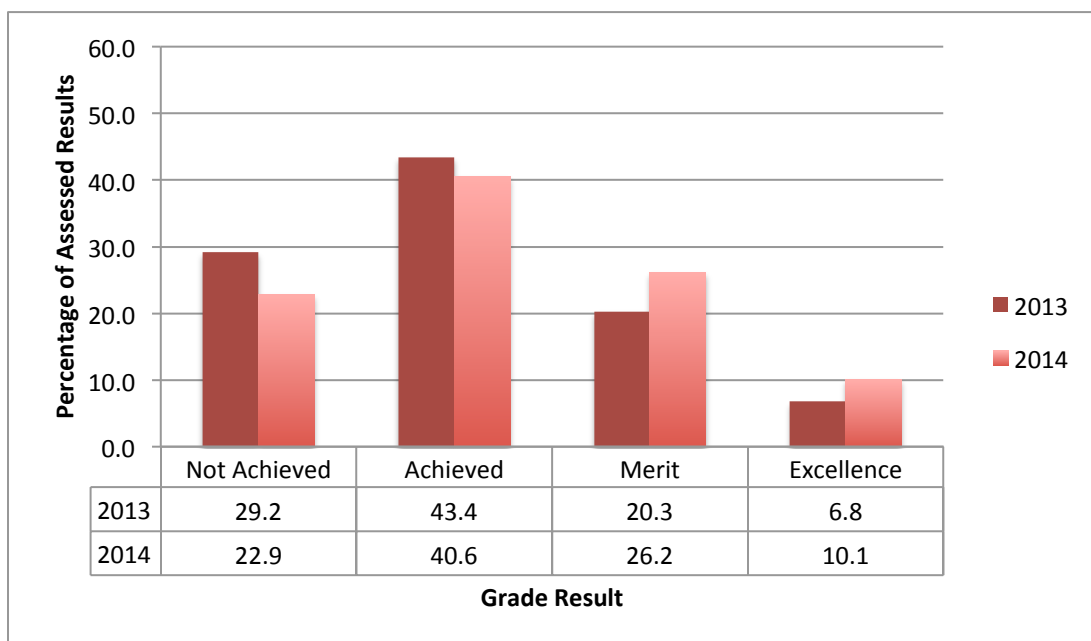


Figure 8.4. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 2 Chemistry AS91166 (External) in 2013 and 2014.

8.2.2 Result distributions: *Internal* Level 2 Chemistry standards.

Figures 8.5–8.8 show national grade distributions for the four individual *Internal* achievement standards (AS91161, AS91162, AS91163, and AS91167) from the Level 2 Chemistry matrix (Section 2.3.5; Figure 2.3) in 2013 and 2014. Table 8.1 provides a summary of the scope of these standards; referred to here in abbreviated terms as Quantitative, Ions, Technology, and Redox respectively.

Not achieved grades comprise between 8.9 and 21.2 as a percentage of assessed results for these *Internal* achievement standards in the two years of data shown for 2013 and 2014.

Excellence grades comprise between 27.5 and 50.9 as a percentage of assessed results for these four *Internal* achievement standards in 2013 and 2014.

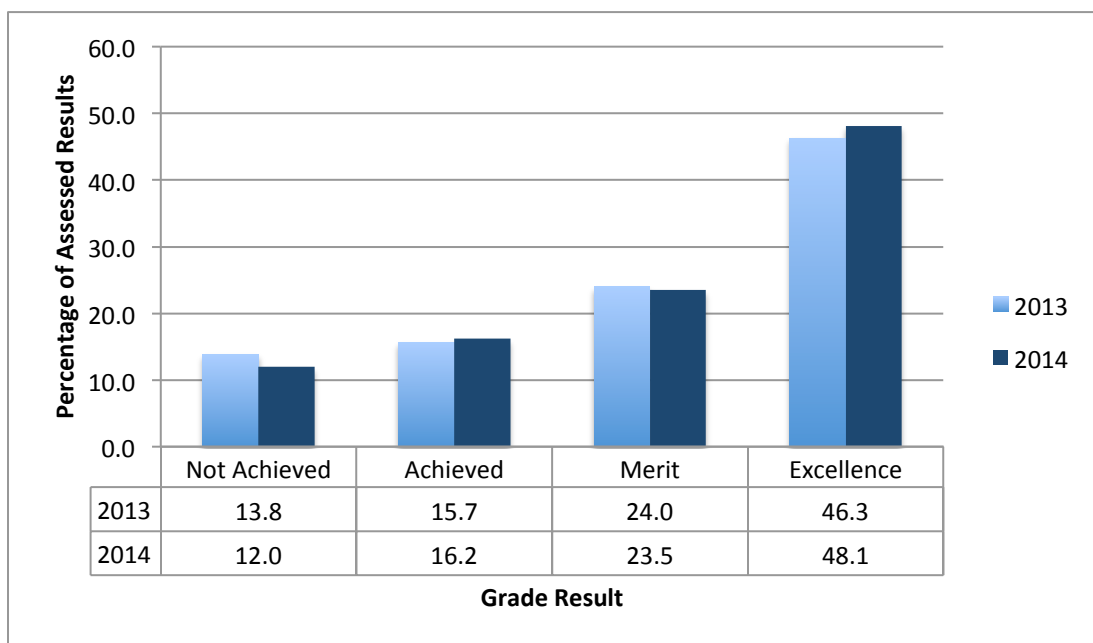


Figure 8.5. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 2 Chemistry AS91161 (Internal) in 2013 and 2014.

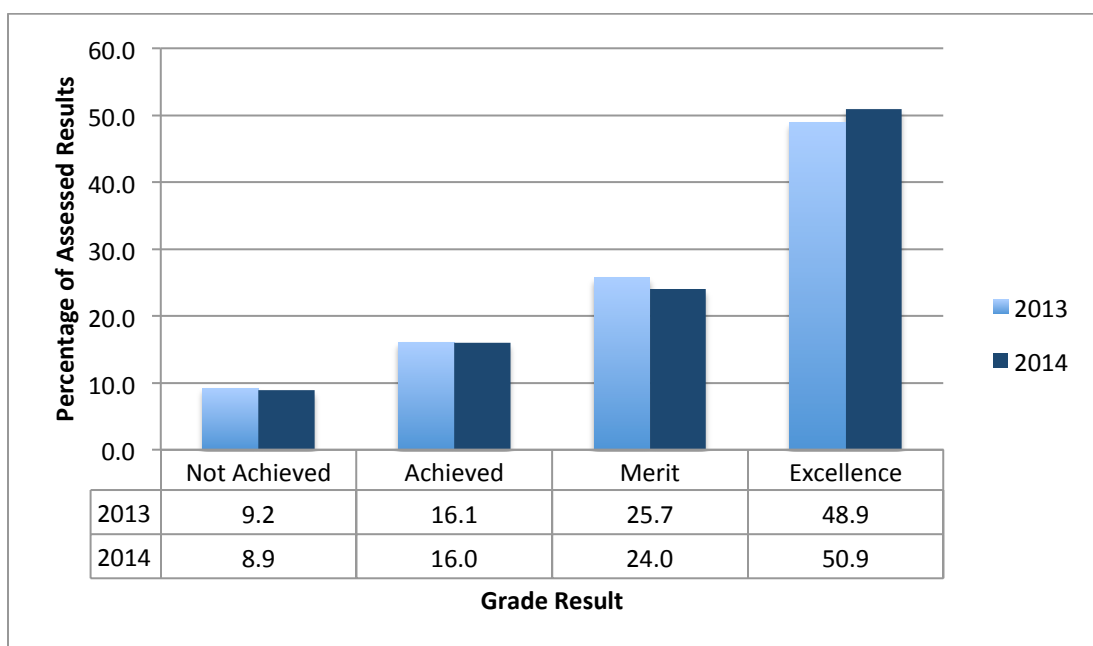


Figure 8.6. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 2 Chemistry AS91162 (Internal) in 2013 and 2014.

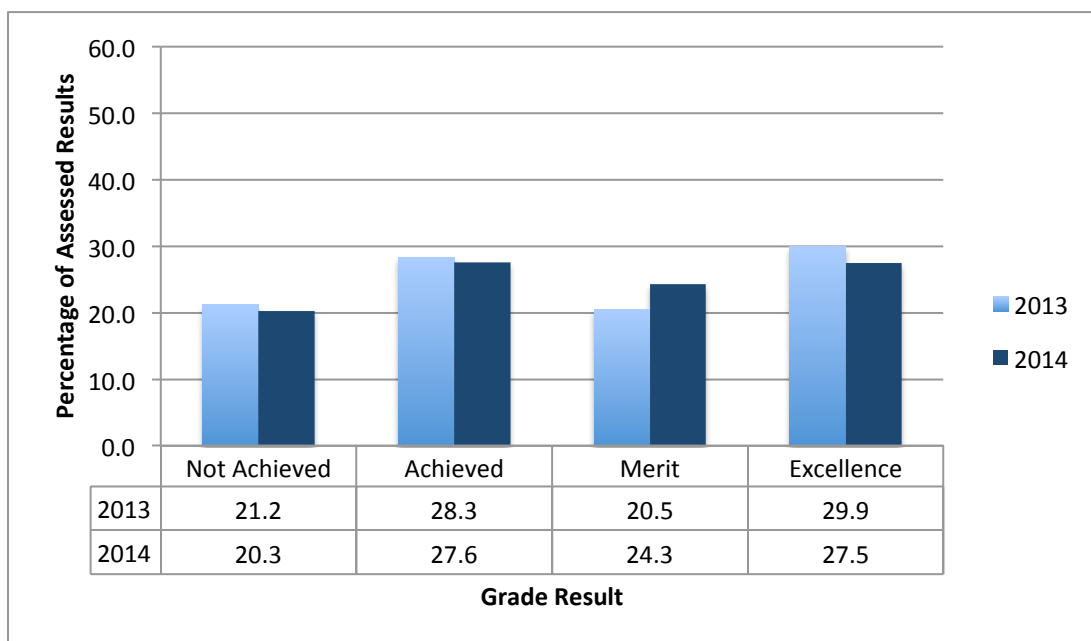


Figure 8.7. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 2 Chemistry AS91163 (Internal) in 2013 and 2014.

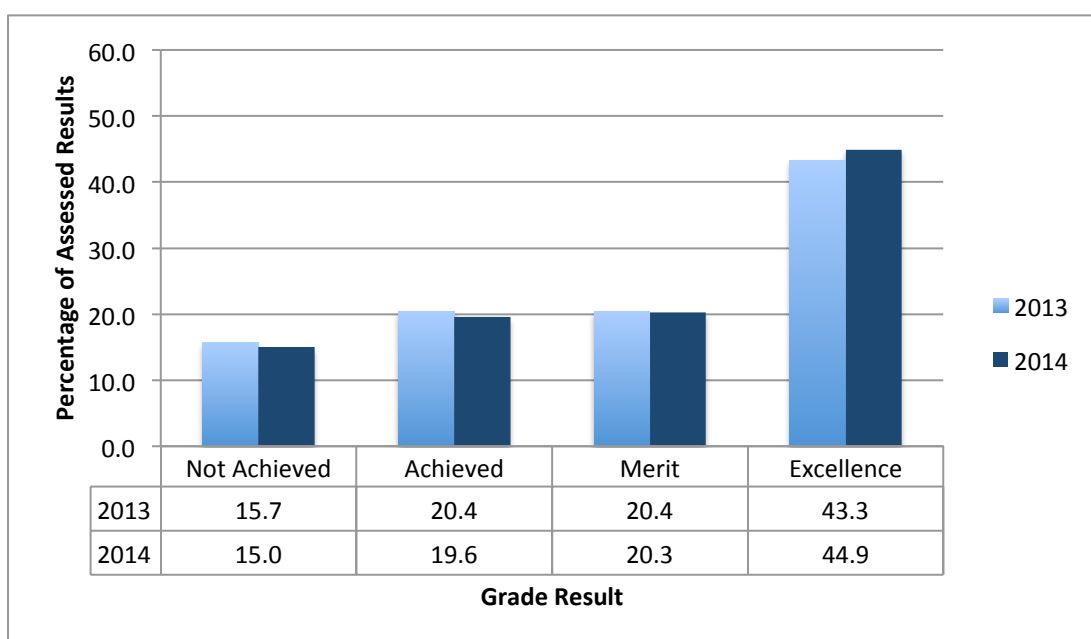


Figure 8.8. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 2 Chemistry AS91167 (Internal) in 2013 and 2014.

8.2.3 National NCEA results: Level 3 Chemistry (decile 10)

For the reasons outlined in Section 8.1, further research sub-questions arose in this study with regard to results for internally and externally assessed achievement standards, and a simple statistical analysis of national NCEA data sought to answer these questions.

In this section, analysis of the national data sought to explore these questions: *How do results for Internal and External achievement standards compare for NCEA Level 3 Chemistry? Which standards are done nationally?*

Tables 8.6 and 8.7 compare the number of results recorded nationally for individual achievement standards in Level 3 Chemistry (decile 10 schools, and male and female candidates) from 2010 to 2014.

Presented in Table 8.6 are data for externally assessed (*External*), and in Table 8.7 are data for internally assessed (*Internal*) achievement standards. New *realigned* achievement standards for Level 3 NCEA were in effect from 2013 (see Section 2.3.4), with the earlier registered achievement standards expiring at the end of 2012.

Over the five years from 2010 to 2014 there was a national increase in NCEA Level 3 Chemistry results of 316, as shown in Table 8.8.

Table 8.6
Numbers of results by externally assessed achievement standard for NCEA Level 3 Chemistry for 2010 to 2014. Data extracted from national NZQA data for decile 10 schools, male and female candidates.

	AS90696	AS90698	AS90700	AS90780	AS91390	AS91391	AS91392	Total #	# as % total results*
2010	1330	1278	1211	1433				5252	73.12
2011	1276	1226	1163	1397				5062	70.47
2012	1327	1286	1276	1480				5369	69.11
2013					1660	1397	1411	4468	59.85
2014					1621	1406	1370	4397	58.63

*Refer Table 8.8

Table 8.7
Numbers of results by internally assessed achievement standard for NCEA Level 3 Chemistry for 2010 to 2014. Data extracted from national NZQA data for decile 10 schools, male and female candidates.

	AS90694	AS90695	AS91387	AS91388	AS91389	AS91393	total # results	# as % total results*
2010	439	1492					1931	26.88
2011	703	1418					2121	29.53
2012	814	1586					2400	30.89
2013		96	680	1150	94	1753	2997	40.15
2014			593	1276	157	1669	3102	41.37

*Refer Table 8.8

Table 8.8
Calculation of total NCEA Level 3 Chemistry results from numbers of entries for internally and externally assessed achievement standards for 2010 to 2014.

	Total # L3 External achievement standard results	Total # L3 Internal achievement standard results	Total # L3 results
2010	5252	1931	7183
2011	5062	2121	7183
2012	5369	2400	7769
2013	4468	2997	7465
2014	4397	3102	7499

Shown in Figure 8.9 is nationally, an increase in the number of Internal results for Level 3 Chemistry as a percentage of total results from 26.88% in 2010 to 41.37% in 2014. This represents a relative increase of 53.90% from 2010. A corresponding decrease in the number of Externals is also evident. The numbers of results reported in 2013 and 2014 for AS91387 (680 and 593 respectively), and AS91389 (94 and 157 respectively) are low compared to the total number of Level 3 Chemistry results. It is noteworthy that AS91387 assesses investigation skills and AS91389 understanding of chemical processes (see Table 8.2).

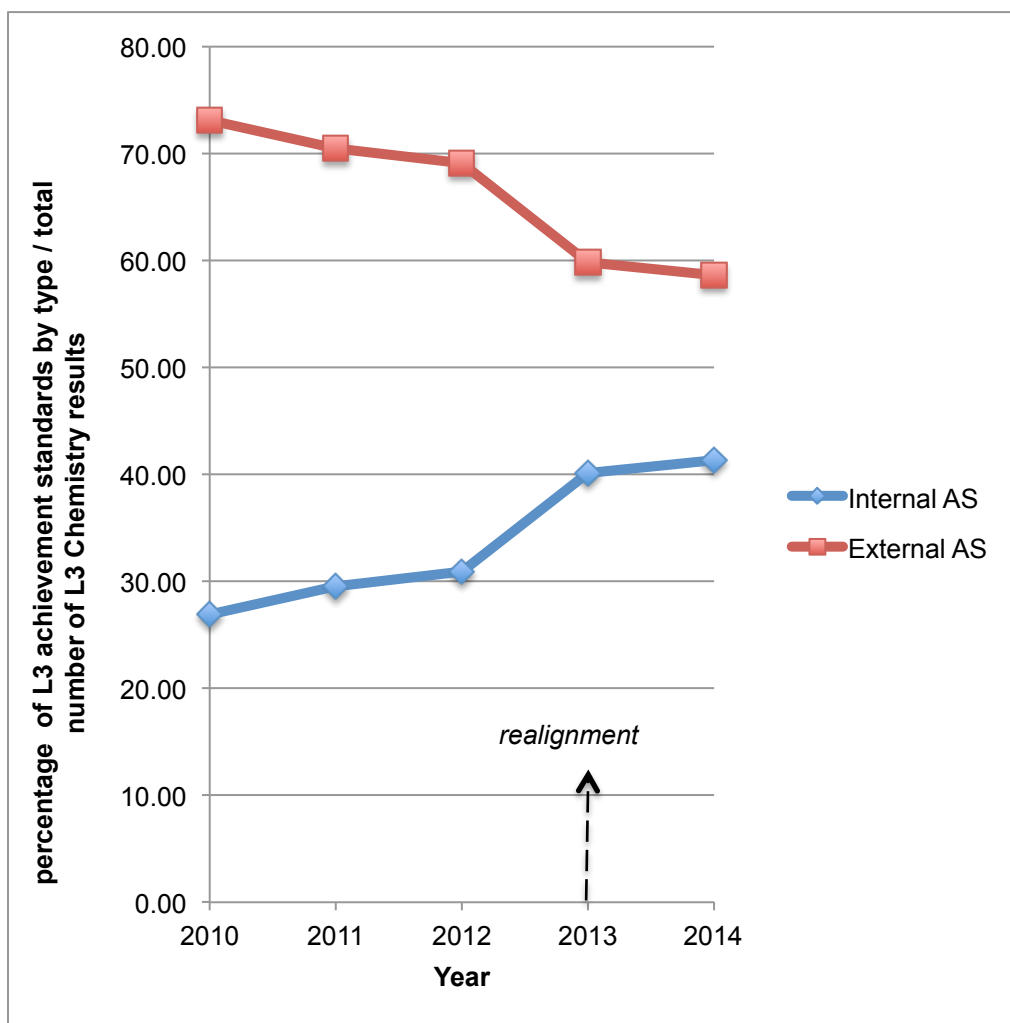


Figure 8.9. Numbers of Level 3 Chemistry achievement standard results by type (external and internal), as a percentage of total results for 2010 to 2014. Extracted from national NZQA data for decile 10 schools, male and female candidates.

8.2.4 Result distributions: *External* Level 3 Chemistry standards.

Figures 8.10–8.12 show national grade distributions for individual *External* achievement standards (AS91390, AS91391, AS91392) for Level 3 Chemistry in 2013 and 2014. In abbreviated form, these standards assess students' understanding of: Thermochemistry, Organic, and Aqueous chemistry (see Table 8.2).

Not achieved grades comprise between 24.1 and 37.6 percent of assessed results for these *External* achievement standards in the two years of data shown for 2013 and 2014.

Excellence grades comprise between 6.9 and 13.0 percent of assessed results for these three *External* achievement standards in 2013 and 2014.

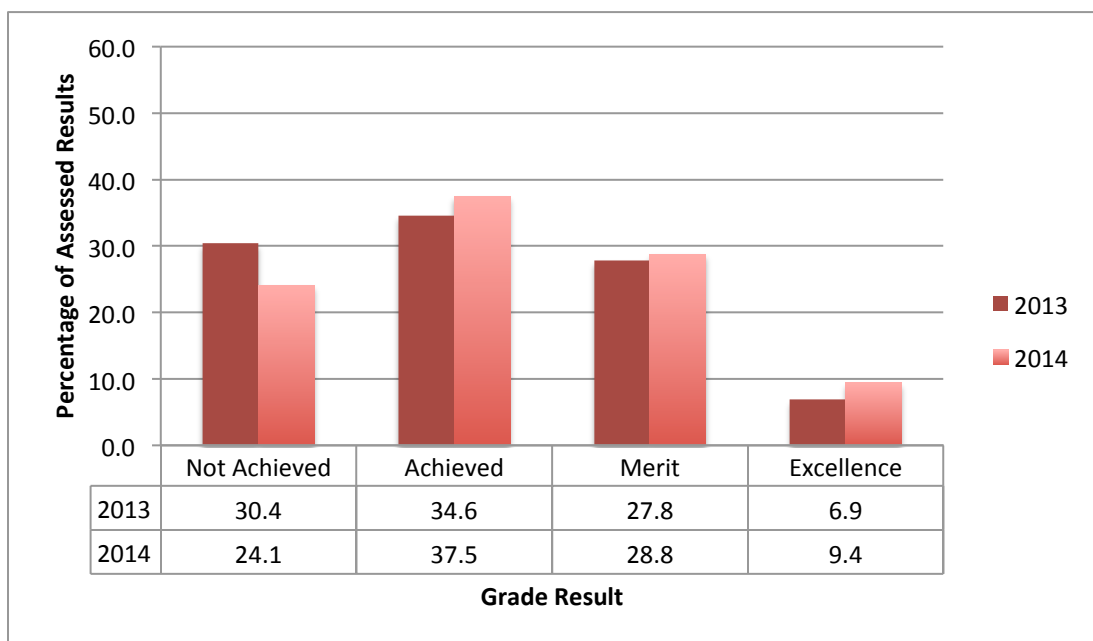


Figure 8.10. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 3 Chemistry AS91390 (External).

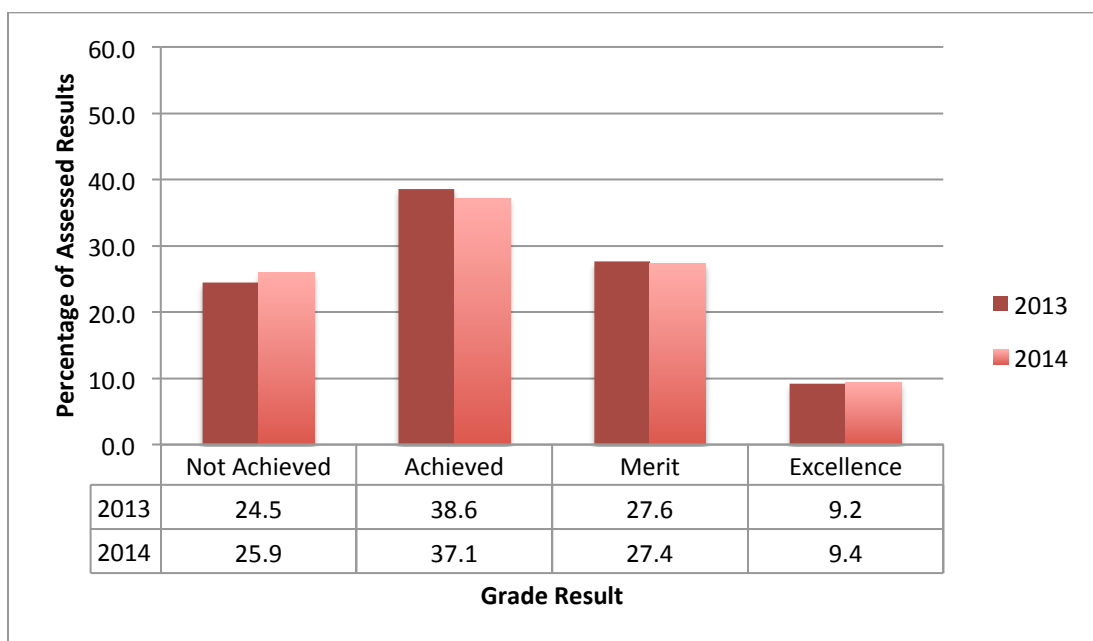


Figure 8.11. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 3 Chemistry AS91391 (External) in 2013 and 2014.



Figure 8.12. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 3 Chemistry AS91392 (External) in 2013 and 2014

8.2.5 Result distributions: *Internal* Level 3 Chemistry standards.

Figures 8.13–8.16 show national grade distributions for individual *Internal* achievement standards (AS91387, AS91388, AS91389, AS91393) for NCEA Level 3 Chemistry in 2013 and 2014.

Not achieved grades comprise between 4.7 and 14.3 as a percentage of assessed results for these *Internal* achievement standards in the two years of data shown for 2013 and 2014.

Excellence grades comprise between 28.4 and 48.2 as a percentage of assessed results for these four *Internal* achievement standards in 2013 and 2014.

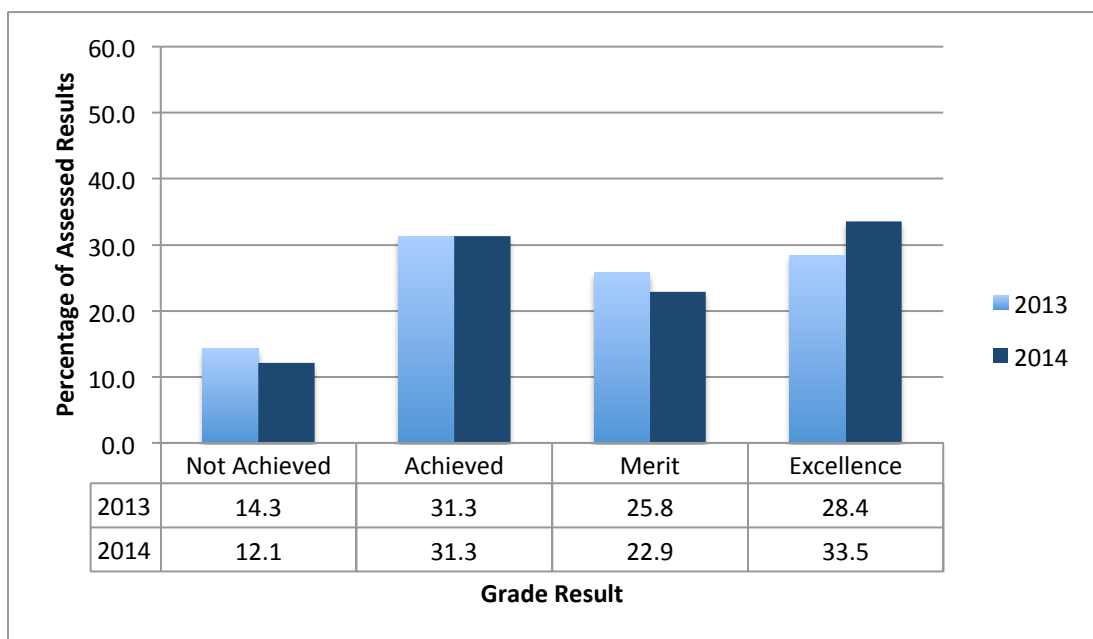


Figure 8.13. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 3 Chemistry AS91387 (Internal) in 2013 and 2014.

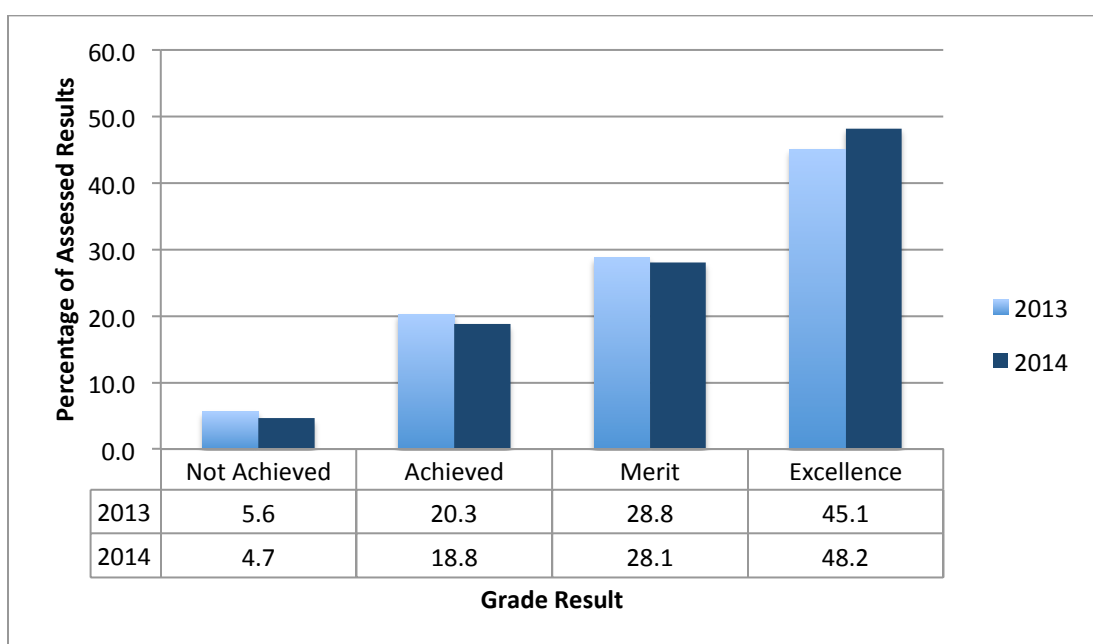


Figure 8.14. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 3 Chemistry AS91388 (Internal) in 2013 and 2014.

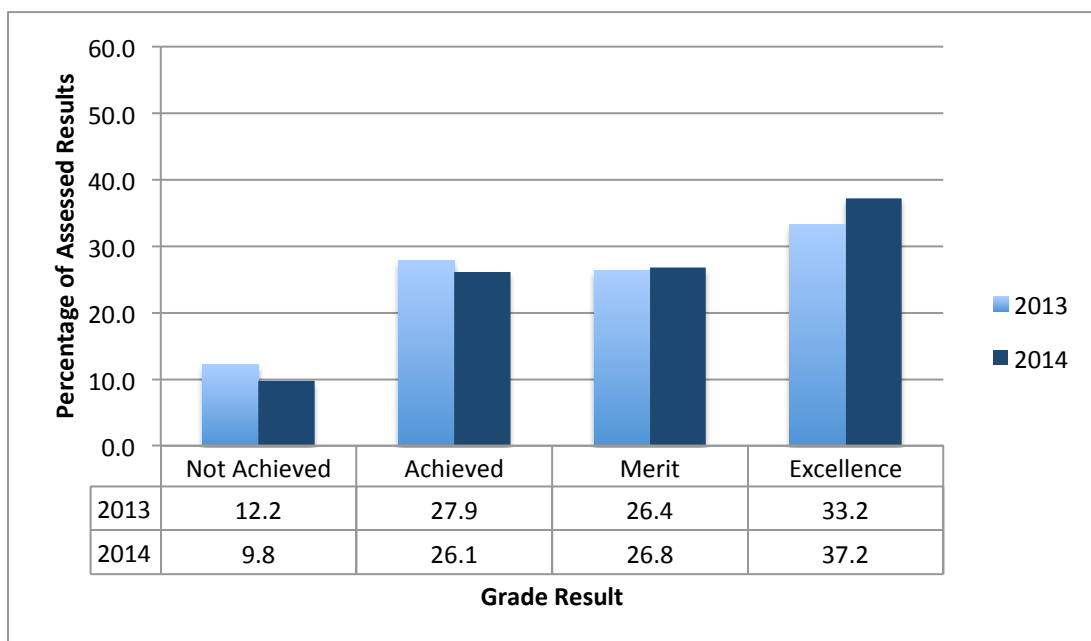


Figure 8.15. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 3 Chemistry AS91389 (Internal) in 2013 and 2014.

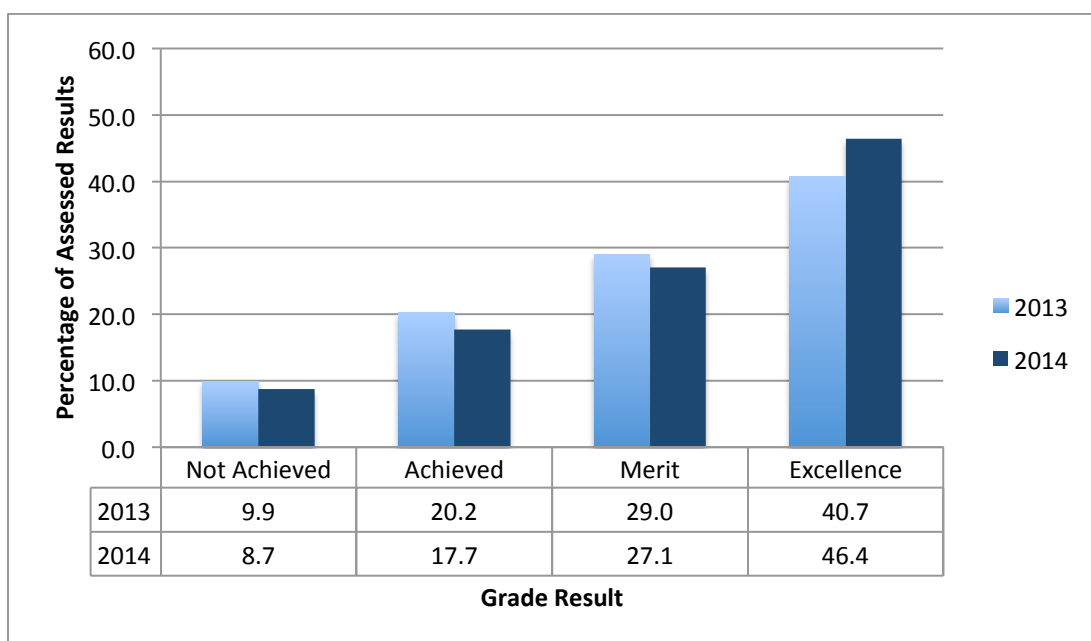


Figure 8.16. National NZQA data (decile 10 schools, male and female candidates): Distribution of results for Level 3 Chemistry AS91393 (Internal).

8.3 National NCEA results: Oxidation-reduction chemistry (decile 10)

The data collection phase of this research coincided with the period of *realignment* of Level 2 and Level 3 NCEA (see Section 2.3.4). The participant teachers and school managers were questioned about their experiences of the realignment process as part of the semi-structured interviews conducted in the case schools. In NCEA Chemistry Level 2 and Level 3, new *realigned* achievement standards were

published for implementation in 2012 and 2013 respectively. This applied to all achievement standards in the Chemistry matrix (as listed in Table 8.1 and 8.2).

One of the effects of the realignment of achievement standards for Chemistry was that student knowledge of the oxidation-reduction chemistry changed from being externally assessed to internally assessed at Levels 2 and 3. Copies of the pre- and post-realignment Level 2 oxidation-reduction achievement standards, AS90311 and AS91167 respectively, are appended (Appendices P, Q). It is the researcher's judgement that the scope of the now expired Redox standard (AS90311) is similar to that of the realigned standard (AS91167). Likewise, the Level 3 standards, both before and after realignment, were similar in their specification.

Given the espoused beliefs of participant teachers in this study with regard to assessment modes (Internal compared to External), it led to questioning of the NZQA national data:

What was the effect on result distributions when, as a result of realignment, reduction-oxidation chemistry was assessed internally rather than externally?

At Levels 2 and 3, there was an evident shift in grade distributions post-realignment in the assessment of reduction-oxidation chemistry (Table 8.9 and Figures 8.17 and 8.18).

Post-realignment, with the change from external to internal assessment of reduction-oxidation chemistry, excellence grades were 45.9 to 50.3 percent of total assessed results at Level 2. For Level 3, excellence grades were 42.3 to 50.0 percent of total results post-realignment (that is, from 2013).

Pre-realignment, that is 2010 to 2011 for Level 2, excellence grades were 12.2 to 14.2 percent of total assessed results. For Level 3, from 2010 to 2012, excellence grades were in the range 12.9 to 15.9 percent of assessed results. There was also a decrease in the percentage of not-achieved grades in the assessment of reduction-oxidation chemistry post-realignment for both Level 2 and Level 3 Chemistry.

Table 8.9

National result distributions (expressed as % of total number of results per achievement standard) for NCEA Level 2 and Level 3 Chemistry from 2012 to 2014. Data are extracted from NZQA for decile 10 schools, and both male and female students.

		N	A	M	E	# of results
		%				
Level 2						
AS90311						
External	2010	30.8	33.1	23.9	12.2	1889
	2011	25.8	30.2	29.7	14.2	1735
Realignment	AS91167					
Internal	2012	13.1	17.6	23.4	45.9	2372
	2013	11.5	17.6	20.7	50.3	2349
	2014	12.5	17.3	20.4	49.7	2541
Level 3						
AS90696						
External	2010	26.1	39.7	21.4	12.9	1330
	2011	17.2	40.2	26.6	15.9	1276
	2012	23.9	32.3	29.5	14.3	1327
Realignment	AS91393					
Internal	2013	7.1	20.8	29.8	42.3	1753
	2014	5.0	19.1	25.8	50.0	1669

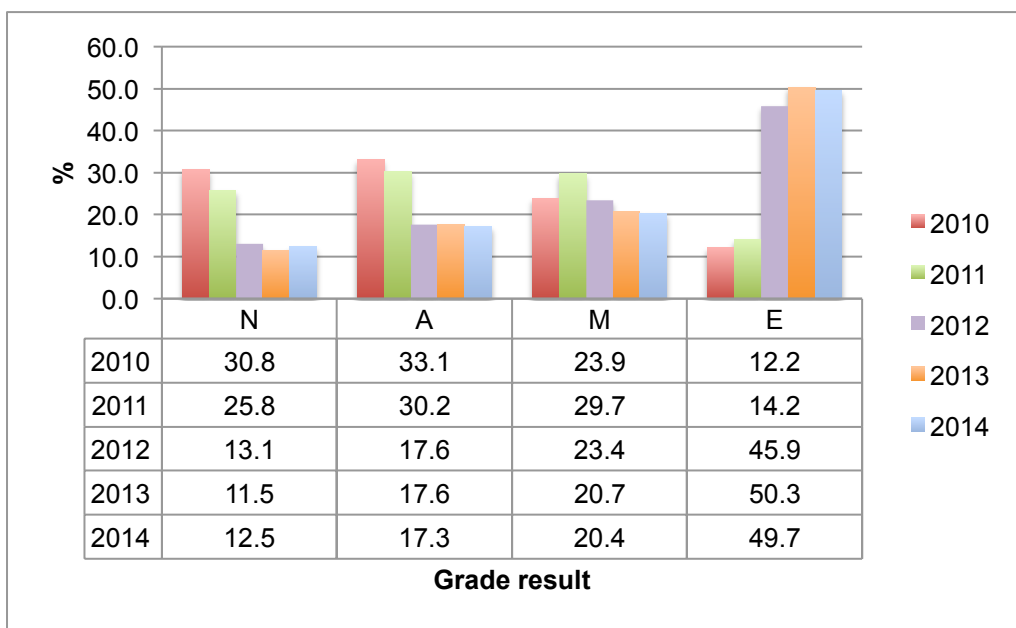


Figure 8.17. Grade distribution for oxidation-reduction achievement standards (as percentage of total results for that standard) for NCEA Level 2 Chemistry from 2010 to 2014. Decile 10 schools. Refer Table 8.9.

Notes:

N = Not achieved; A = Achieved; M = Merit; E = Excellence.

Realigned Level 2 achievement standards were implemented from 2012.

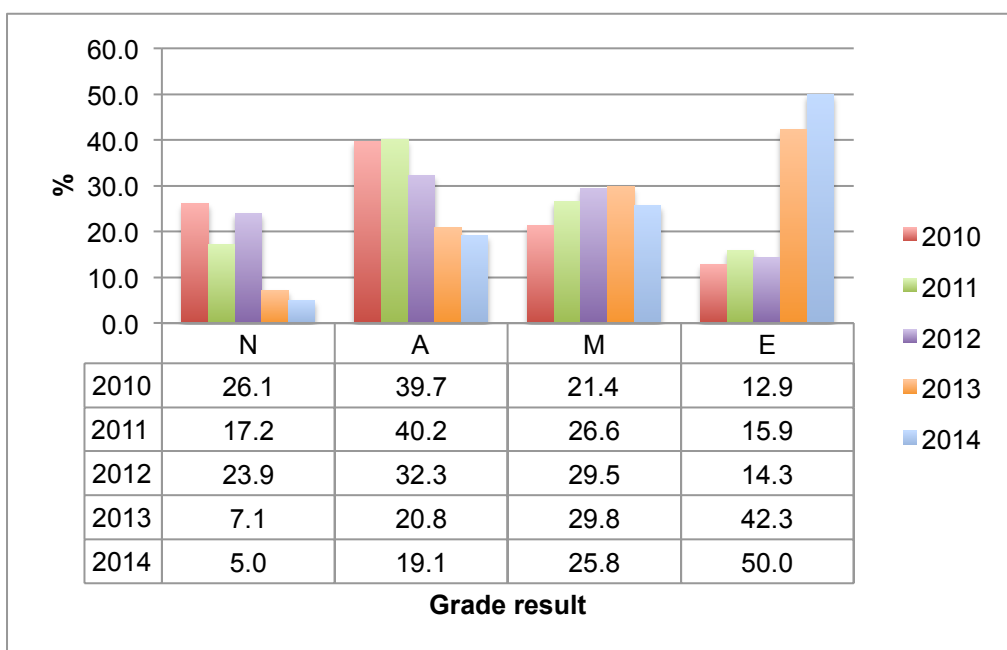


Figure 8.18. Grade distribution for oxidation-reduction achievement standards (as percentage of total results for that standard) for NCEA Level 3 Chemistry from 2010 to 2014. Decile 10 schools. Refer Table 8.9.

Notes:

N = Not achieved; A = Achieved; M = Merit; E = Excellence.

Realigned Level 3 achievement standards were implemented from 2013.

8.4 National NCEA data: Levels 2 and 3 Chemistry (all deciles)

As outlined earlier in this chapter (Section 8.1), the analysis of national NCEA results for Levels 2 and 3 Chemistry from decile 10 schools led the researcher to question if the same trends would be seen in national data for *all* deciles. Table 8.10 shows the Internal (and External) assessment as a percentage of the total number of entries for NCEA Level 2 and Level 3 nationally, all deciles, by year from 2011 to 2015. It is evident that there has been a trend of increasing percentage of internal assessment over that time period. At Level 3, internal assessment comprised 50.9 percent of the total number of recorded results compared to 29.7 percent in 2011.

Grade distributions for all Internal and External standards (Levels 2 and 3) were compiled from 2011 (Tables 8.11 and 8.12).

Table 8.10

National results NCEA Levels 2 and 3 Chemistry from 2011 to 2015, showing standard type (Internal/External) as percentage of total results. Data were extracted from NZQA for all deciles, and both male and female students.

	Internals # Results	Externals # Results	Total # Results	Internal % of Total	External % of Total
Level 2					
2011	33773	38604	72377	46.7	53.3
2012	37602	33121	70723	53.2	46.8
2013	38817	34086	72903	53.2	46.8
2014	40319	35239	75558	53.3	46.7
2015	42036	33905	75941	55.4	44.6
Level 3					
2011	10552	24987	35539	29.7	70.3
2012	11737	25083	36820	31.9	68.1
2013	20108	20630	40738	49.4	50.6
2014	20635	21160	41795	49.4	50.6
2015	22790	21997	44787	50.9	49.1

Table 8.11

National result distributions (expressed as % of total number of entries) for NCEA Level 2 Chemistry from 2011 to 2015, by standard type (Internal/External). Data were extracted from NZQA for all deciles, and both male and female students. Internal entries with no reported result included.

	# Entries	N	A	M	E
	%				
Internal					
2011	33773	9.5	14.6	24.4	50.3
2012	37602	13.9	18.5	24.4	41.5
2013	38817	13.1	17.6	23.2	45.4
2014	40319	12.2	17.5	22.6	47.2
2015	42036	11.6	16.7	22.8	48.4
External					
2011	38604	28.4	36.5	24.5	10.7
2012	33121	27.2	35.4	26.7	10.7
2013	34086	30.3	38.9	21.3	9.5
2014	35239	23.5	38.3	26.4	11.8
2015	33905	26.4	38.9	24.4	10.3

N = Not achieved; A = Achieved; M = Merit; E = Excellence.

Realigned Level 2 achievement standards were implemented from 2012.

Table 8.12

National result distributions (expressed as % of total number of entries) for NCEA Level 3 Chemistry from 2011 to 2015, by standard type (Internal/External). Data were extracted from NZQA for all deciles, and both male and female students. Internal entries with no reported result included.

	# Entries	N	A	M	E
	%				
Internal					
2011	10552	8.4	13.4	17.8	58.6
2012	11737	6.9	13.1	18.5	60.0
2013	20108	9.4	21.8	27.0	41.0
2014	20635	7.9	20.7	26.6	43.9
2015	22790	7.3	20.6	25.6	46.1
External					
2011	24987	30.4	37.7	22.8	9.1
2012	25083	33.2	36.2	21.4	9.3
2013	20630	30.7	34.7	26.5	8.0
2014	21160	26.8	36.4	26.3	10.5
2015	21997	27.8	37.8	22.5	11.9

N = Not achieved; A = Achieved; M = Merit; E = Excellence.

Realigned Level 3 achievement standards were implemented from 2013.

The data presented in Tables 8.11 and 8.12 show a trend whereby the grade distributions nationally (all deciles) are markedly different for Internal and External standards between 2011 and 2015. For NCEA Level 2 Chemistry between 41.5 and 50.3 percent of all entries for Internals were at Excellence, with between 9.5 and 13.9 percent at Not Achieved. At Level 3, data show between 41.0 and 60.0 percent of all entries for Internals were at Excellence, and between 6.9 and 9.4 percent at Not Achieved. For Externals the evident pattern in the distribution of grades were contrary to of that for the Internals. At Level 2, between 9.5 and 11.8 percent of all entries for Externals were at Excellence, and between 23.5 and 30.3 percent at Not Achieved. The Level 3 data show between 8.0 and 11.9 percent of External entries at Excellence and between 26.8 and 33.2 percent at Not Achieved.

National Certificate Endorsement statistics (all deciles) are presented in Table 8.13 for Levels 2 and 3 from 2011 to 2015. Evident in these data are the trend towards increasing percentages of both Excellence and Merit Certificate Endorsements over the period 2011 to 2015. In 2015, 41.5 percent of NCEA Level 2 Certificates were

endorsed with either Merit or Excellence, compared to 29.8 percent in 2011. Similarly, in 2015, 42.3 percent of Level 3 Certificates were endorsed with either Merit or Excellence, compared to 30.8 percent in 2011.

Table 8.13
National (all decile) NCEA Certificate Endorsement 2011 to 2015, by percentage of entries

	Year 12	Year 13
	NCEA Level 2	NCEA Level 3
Excellence		
2011	8.2	7.4
2012	11.9	8.3
2013	13.3	11.4
2014	14.3	12.8
2015	14.9	13.8
Merit		
2011	21.6	23.4
2012	26.4	24.2
2013	26.6	28.5
2014	26.8	28.9
2015	26.5	28.5

8.5 Summary

The main findings from the analysis of NCEA Levels 2 and 3 Chemistry data presented in this chapter are summarised here for clarity in relation to the questions that provoked the analysis.

- *What percentage of results (nationally) were recorded for the two types of standard (Internal and External) since 2010?*

Overall, there is a trend of results from internal assessment being a greater proportion of total results in the five year period from 2010 to 2014. There is an evident change in the period following realignment of achievement standards (2012 for Level 2, and 2013 for Level 3), towards higher levels of internal, and lower levels of external assessment.

- *In the case schools, the chemistry courses showed little variation; nationally, which standards were done?*

There are relatively low numbers of results recorded in the selected data for some Internal achievement standards: AS91163 (Technology); AS91389 (Chemical Processes).

- *The teachers in this study were clearly of the view that there were differences in grade distributions between the two types of standards (Internal and External); How do results for internally and externally assessed achievement standards compare for NCEA Level 2 and Level 3 Chemistry?*
- *Are the decile 10 data congruent in terms of trends, with the national NCEA data (Level 2 and Level 3 Chemistry) for all deciles?*

The grade distributions are higher for Internals than Externals at both Level 2 and Level 3 Chemistry, shown by more Excellence and fewer Not Achieved results for individual achievement standards. This is the case in data for all decile of schools.

- *What was the effect on result distributions when, as a result of realignment, reduction-oxidation chemistry was assessed internally rather than externally?*

At Levels 2 and 3, there was a shift in grade distributions post–realignment in the assessment of reduction-oxidation chemistry. Fewer Not Achieved, and more Excellence results were reported post-realignment; whereby the achievement standard changed from an External to an Internal.

- *How do Certificate Endorsement results over the last five years compare with the trends in percentage of Internal assessment?*

Data in Table 8.13 show that nationally the percentage of NCEA Certificate Endorsements increased in the period 2011 to 2015. In 2015, a total of 41.4 percent of all Level 2 certificates were endorsed (Merit and Excellence), while 42.3 percent of all Level 3 certificates were endorsed.

These findings are integrated with the discussion of emergent findings from the qualitative data in Chapter Nine.

CHAPTER NINE:

Cross Case Analysis and Discussion

This chapter begins with the synthesis and comparison of findings from each case school, presented as a cross case analysis. A discussion of the key findings from the case studies then follows, and for the NCEA, these are integrated with findings from the statistical analysis data as presented in the preceding chapter.

9.1 Cross case analysis

As a means of allowing the reader to more easily compare emergent findings from the data, summaries of findings from each case school are tabulated in this section. Table 9.1 comprises findings related to participant chemistry teachers' views and practices (referring to curriculum and pedagogy). Findings related to teachers' approaches to assessment are presented in Table 9.2.

Table 9.1

Cross-case analysis: Emergent findings related to teaching the content and procedural knowledge of chemistry (referring to curriculum and pedagogy)

Espoused teacher beliefs and practices related to curriculum	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
<p>NCEA</p> <p>Implementation and pedagogy</p>	<ul style="list-style-type: none"> • NCEA courses were structured to satisfy conditions for university entrance and course endorsement • manageability a concern: courses were now structured to offer fewer achievement standards; but difficult to accept leaving out AS • NCEA courses had advantages for students in terms of flexibility and accessibility • some teachers talked about emphasising pedagogy in their planning; increasing use of digital tools including google docs to encourage collaboration • teaching was to the AS and focused on assessment • NCEA students were prepared for internal assessment by rehearsal teaching strategies 	<ul style="list-style-type: none"> • subject and certificate endorsement seen as a positive change; aiming for <i>quality</i> of credits • the potential for flexible course design seen as an advantage. A multi-level course design in this school allowed extension opportunities for top students in years 11 to 12 • however, potential flexibility in course design reduced by university <i>approved subject</i> lists and stipulations re specific standards for some first year courses • at departmental level, ensuring opportunity for course endorsement was a factor in course design • school-wide data analysis directed the AS offered in each course • therefore an emphasis was including high number of internal AS in courses because of higher grade distributions in these (compared to external assessment) 	<ul style="list-style-type: none"> • DP felt that tertiary requirements are driving students subject choices and school course design • that the NCEA offered weaker students the opportunity to experience success, even if in only some AS, was a positive • flexibility of course design afforded by the NCEA also a positive aspect of the qualification • approaches to teaching include regular breaks; clear expectations for each lesson; writing model answers to questions from past papers • view that NCEA students needed more direction than IBD students • assignments comprising practice questions were useful as was building students confidence in the subject • practical work linked to students' enjoyment of a course • assessment <i>is high stakes for us as well</i> [as for students]

Espoused teacher beliefs and practices related to curriculum	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
	<ul style="list-style-type: none"> departmental focus (led by HoF) towards developing use of formative assessment strategies teachers mindful of students grade outcomes and held accountable for these 	<ul style="list-style-type: none"> teaching time was a constraint, and this impacted on the amount and type of practical work done in class digital resources used by some teachers to support student learning at home transmissive teaching approaches still evident in the department the modular design of the NCEA made it accessible for some students teachers felt accountable to senior managers for students' results (especially the percentage of course endorsements) 	<ul style="list-style-type: none"> senior manager thought it easier to monitor teacher performance in IBDP compared to the NCEA because of the single point score per subject in the DP
IBDP Implementation and pedagogy	<ul style="list-style-type: none"> available teaching hours were considered a constraint in being able to adequately cover the AHL syllabus IBDP course structure followed the IBO subject guide, which teachers found provided clear direction in unit planning IBDP thought of as a "broad course" but not all teachers felt confident in teaching the syllabus students undertake more practical work than their NCEA peers 	<ul style="list-style-type: none"> not applicable 	<ul style="list-style-type: none"> perhaps more academic students leaning towards IBDP, although <i>smart kids in both pathways</i> teacher performance (judged by results) might be more easily determined in the IBDP than in the NCEA more contextual teaching and integration of chemistry topics in the IBDP compared to the NCEA supervising Extended Essay in the IBDP had been a source of professional

Espoused teacher beliefs and practices related to curriculum	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
NCEA Achievement Standards: the default curriculum in planning courses	<ul style="list-style-type: none"> • courses were designed around the achievement standards • difficulty in knowing what to teach in NCEA courses; relying on analysing mark schemes from past examinations and TKI exemplars to clarify their interpretation of the achievement standards • teachers focused on their students attaining merit and excellence endorsements • courses were now less demanding as a result of realignment 	<ul style="list-style-type: none"> • course structures were based on AS matrix for chemistry • difficulty in interpretation of AS and preparing resources for teaching and assessment of these • doubt in teachers minds that what they were doing was <i>right</i> in terms of curriculum implementation • resources on TKI considered unreliable • realignment “a farce” and had led to a lot of work for little gain; some content lost, especially in Level 2, and led to rule-based teaching • little to no teaching done that was not assessed • fragmentation of learning a concern, and needed to teach Scholarship students to “rethink how they think” 	<p>satisfaction for some teachers; stressful for others</p> <ul style="list-style-type: none"> • aiming for top grades for students <ul style="list-style-type: none"> • assessment a key element in planning courses; guided by what is on TKI and NZQA websites • interpretation of AS left to teachers • planning based on the AS, and getting students to Excellence • thought NCEA courses “watered down” compared to what was done some years ago

Espoused teacher beliefs and practices related to curriculum	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
NCEA NZC: the missing curriculum	<ul style="list-style-type: none"> student learning of chemistry as a whole was fragmented in NCEA: “maybe students can’t link it all together” no investigation done in Year 12 & 13: senior chemistry students in case school 1 did not do AS91387 (3.1 <i>Investigation</i>) no evidence for teaching of NoS 	<ul style="list-style-type: none"> that there was fragmentation of learning due to AS structure of the NCEA; limited students’ understanding of the subject as a whole inclusion of practical work constrained by teaching time and AS type (internals were more focused on practical skills) the investigations carried out by Year 13 students were based on one of three titrimetric methods; mixed views from teachers about its merits (AS91387, 3.1 <i>Investigation</i>) 	<ul style="list-style-type: none"> dislike of the NCEA: “it has pigeon-holed my subject into chapters” NoS: research based standards not done (not seen as <i>valuable</i>) AS91387 (3.1 <i>Investigation</i>) offers students some opportunity to develop practical skills, although associated with workload issues for staff and so not done in the previous year, and optional this year overall practical work limited: focus on titration skills
IBDP Course planning	<ul style="list-style-type: none"> subject guide for Diploma chemistry offered clear direction when planning units of work was challenging to teach Diploma course; some participants were uncomfortable with teaching options and Theory of Knowledge 	<ul style="list-style-type: none"> not applicable 	<ul style="list-style-type: none"> reliance on the subject guide for course planning; detailed challenging and so more enjoyable to teach; by comparison NCEA “boring”

Espoused teacher beliefs and practices related to curriculum	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
NCEA and IBDP Professional development	<ul style="list-style-type: none"> professional development run to date by NZQA on NCEA (Best Practice Workshops) had not been helpful in implementation wish to have subject specific cluster meetings offered by MoE /NZQA collaborative planning was impacted by limited opportunities for teachers to meet as a department (NCEA and DP) google docs workshop undertaken by HoF had transformed her practice; another teacher thought upskilling in digital technologies would be useful for her IBO workshops for Diploma were thought excellent by some, and “useless” by others 	<ul style="list-style-type: none"> NCEA: Need for professional development for teachers in <i>curriculum implementation</i> noted school wide focus of professional development focus was on pedagogy, especially aimed at improving level of achievement for some Year 12 students identified as “struggling” upskilling in use of different ICT tools had been useful opportunity to undertake professional development that was chemistry specific would be valued 	<ul style="list-style-type: none"> wish to have professional development that had an NCEA implementation focus NCEA: marking for NZQA (of external examination papers) regarded as very useful professional development more allocated time for developing resources and planning was the greatest need Online Curriculum Centre (for the IBDP) useful resource, especially teacher forums online IBO workshop excellent PD for one teacher; another teacher talked about a face-to-face workshop being “completely overwhelming”
NCEA and IBDP Preparedness of students for courses in chemistry at school and university	<ul style="list-style-type: none"> in school courses: weaknesses in mathematics (including calculator skills) seen in students with NCEA Level 1 Mathematics background. entry into Year 12 Chemistry courses in School 1 required students to have Achieved in two external AS in NCEA Level 1 Science 	<ul style="list-style-type: none"> in school courses: some students’ weak skills in mathematics (especially algebra) led to them having difficulty with NCEA Level 2 Chemistry for tertiary success, several skills required: independence; sound mathematical ability; ability to work collaboratively; good communication 	<ul style="list-style-type: none"> learners going into NCEA and IBDP courses with weak maths skills from NCEA Level 1 have difficulty with some chemistry topics, such as aqueous teachers might recommend students with weak maths do not do some AS The establishment of the CIE within the school at Year 10 and 11 was aimed at

Espoused teacher beliefs and practices related to curriculum	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
	<ul style="list-style-type: none"> • tertiary-level success depended on key skills being developed by students: independent approach to learning; good time management; competence in mathematics • at tertiary level, NCEA students might be affected by fragmentation of learning from school • different NCEA course structures in schools might have implications of for students starting university courses • IBDP courses thought to offer breadth and opportunity to make <i>links</i> between concepts, including Theory of Knowledge, and practical work done (more than for NCEA) • IBDP students thought to have established good study and time management skills before leaving school 	<p>skills; strong academic literacy</p> <ul style="list-style-type: none"> • fragmentation of learning in NCEA a concern in terms of implications for students' preparation for tertiary study • thought that sound knowledge of concepts covered by external assessment was important 	<p>lifting the standard of mathematics</p> <ul style="list-style-type: none"> • IBDP course in chemistry more demanding; students with this qualification might be better prepared for tertiary studies than with NCEA, particularly in terms of practical skills • In the NCEA practical work tended to be limited to a few AS • proliferation of summer bridging courses: Perhaps indicative of weaknesses in students leaving school with NCEA? • some teachers said they had "limited" understanding of the scope of university chemistry courses

Note: AS refers to achievement standard; AHL is additional higher level; SL is standard level

Table 9.2
 Cross-case analysis: Emergent findings related to teachers' approaches to assessment.

Teacher beliefs and approaches to assessment	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
NCEA and IBDP Manageability	<ul style="list-style-type: none"> a significant concern with the NCEA was the workload for teachers and students associated with internal assessment noted that at times students are <i>overloaded</i> by assessment (NCEA and IBDP), despite the school having assessment calendars that aimed to ameliorate this NCEA: internal assessment dominated students' attention through the year, at the expense of preparing for external assessment (examinations) in chemistry NCEA: some standards are difficult to manage in terms of time and resources 	<ul style="list-style-type: none"> throughout the year, the workload associated with level of internal assessment a significant concern (NCEA) realignment of NCEA had added to workload NCEA: uneasy about the negative impacts of too much internal assessment on students: Considered to be "overbearing" high workload for teachers associated with AS91387 (3.1 <i>Investigation</i>) 	<ul style="list-style-type: none"> workload issue, especially with some internals, and some specific NCEA standards managing dual pathway led to extra workload and pressures on staff managing internal assessment for the IBDP found to be more stressful for staff than for the NCEA supervision of Extended Essay (for IBDP) in Chemistry had workload implications for teachers
NCEA Reliability and validity of assessment	<ul style="list-style-type: none"> concerns that tasks, marking and moderation of internal assessment differed between schools difficult to interpret demand of AS and reconcile with available resources on TKI; clarifications; moderator comments on tasks teachers struggling to write tasks that 	<ul style="list-style-type: none"> formative assessment used in the sense of rehearsal, such as <i>look-alike</i> tasks set prior to summative tasks that students were not attempting all papers in external examinations was concerning teachers; speculation on the reasons for this trend noted that grades for external AS 	<ul style="list-style-type: none"> that the realignment had reduced the number of papers in the external examination from four to three was considered to be a good change thought there was inconsistency in managing NCEA internal assessment (marking and processes) between schools; while grades not adjusted, then

Teacher beliefs and approaches to assessment	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
	<p>fully meet external moderator expectations: moderator reports described as <i>picky</i></p> <ul style="list-style-type: none"> • moderator feedback on tasks seen as inconsistent from one year to the next • attaining good agreement of marking to external moderator is also an ongoing concern for teachers • that the IBO selected sample for external moderation of Diploma, considered a more rigorous approach than that by NZQA for NCEA • concerned by trend in past years where a number of Levels 2 and 3 candidates did not attempt all papers in external examinations • students had a time incentive to not attempt all AS in examinations 	<p><i>substantially</i> were lower than for internal AS (links to course design)</p> <ul style="list-style-type: none"> • no correlation evident between attainment of scholarship in chemistry and excellence grades in Levels 2 and 3; selection of students for scholarship difficult • external AS regarded as <i>rigorous</i> and <i>academic</i> • feedback from external Moderator was difficult for teachers to interpret; they felt uncomfortable about knowing how to act on the feedback • students not attempting all papers in externals was a problem 	<p>differences between schools remain</p> <ul style="list-style-type: none"> • “just about every kid gets an Excellence”; it has no meaning • would like more feedback from Moderator on marking of internal assessment; HoF uncertain about processes and details of internal assessment • inconsistent feedback from NZQA Moderator one year to the next a frustration • NCEA: a significant number of Year 12 and 13 students were not attempting all papers in external examination • was now school policy that students needed to have achieved all three standards in the Level 2 externals to continue with Level 3

Teacher beliefs and approaches to assessment	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
<p>NCEA</p> <p>Impact of assessment on student learning</p>	<ul style="list-style-type: none"> thought there was a <i>credit-collecting</i> mind-set in students considered likely that students prioritised their study towards internal assessment throughout the year; with implications for subjects like chemistry with significant external assessment students' grade outcomes a key consideration for teachers teaching was to assessment and significant time was dedicated to preparing for internal assessment assessment data beginning to be used in the department to inform future teaching 	<ul style="list-style-type: none"> high grade outcomes in NCEA internal assessment considered "almost meaningless" in terms of students' overall understanding of the subject a lot of teaching time spent on preparing students for internal assessment there was an apparent tension, both within and between subjects, in terms of internal and external assessment; students often poorly prepared for external assessment internal assessment encouraged a credit-counting mindset in students with implications for their learning significant teaching time was spent preparing students for internal assessment uncertain about feedback received from external moderator on tasks little scope for learning that was not assessed statistical analysis of NCEA results were the basis for departmental goal setting 	<ul style="list-style-type: none"> limitations in the NCEA organic AS; led to rote learning and limited understanding of how organic integrates with other concepts "parents want top grades and that is what we've got to deliver" results analysis done and questions asked as to why achievement data not in the place we want it to be in such a review process some teachers can become defensive some teachers said they did not use assessment data to inform their practice

Teacher beliefs and approaches to assessment	Case School 1: NCEA & IBD	Case School 2: NCEA	Case School 3: NCEA & IBD
IBDP assessment and student learning	<ul style="list-style-type: none"> teachers' perspectives varied on merits of multi-choice paper: one teacher thought multi-choice an outdated assessment format short answer papers examined understanding across topics; integration apparent in assessment thought that portfolio approach to practical work led to deeper learning than is the case in NCEA school requirements for writing up of laboratory tasks was thought to be limiting student enjoyment of practical work 	<ul style="list-style-type: none"> not applicable 	<ul style="list-style-type: none"> noted that grade outcomes (points average) had fallen at the school in recent years; this explained (by Deputy Principal) to be a result of teacher complacency

9.2 Themes emergent from cross case analysis

The brief bullet-pointed summary tables (Section 9.1) allow for convenient comparison of findings across the case schools.

The semi-structured design of the interviews allowed the researcher to follow the direction of Merriam (2009, p. 104) and “really listen to what your participant has to share”; what was not anticipated at the outset of this research was that the participants had much more to say in the interviews about the teaching of the NCEA than the IBDP. The findings are therefore largely related to the NCEA, with comparisons made to the IBDP where they arose.

In this section, the emergent findings from the cross-case analysis are identified and discussed as themes with reference to the findings of others, and for the NCEA, integrated with findings from analysis of the NZQA statistical data. It was inevitable that findings would be inter-linked, and so it is. Despite the presentation of findings under discrete sub-headings, that there are clear connections between themes is evident. The discussion is ordered so that findings related primarily to curriculum and pedagogy come before those relating mainly to assessment.

9.2.1 Implemented curriculum: Drivers of course design.

Participant teachers and senior managers talked about their considerations in designing courses for NCEA chemistry (for Years 12 and 13) in their schools:

- using an achievement standard structure;
- to provide students with the opportunity of fulfilling the requirements for university entrance (in terms of 14 credits in a university approved subject);
- to improve student grade outcomes in Levels 2 and 3 (especially in regard to endorsements);
- to better prepare students for Year 13 chemistry (including Scholarship for the able students);
- to provide students with key skills and knowledge for continuing in this subject at tertiary level.

Certainly, in the interviews and documentation relating to the NCEA chemistry courses in the three case schools, the language of achievement standards pervaded the discourse about teaching and learning. The expression and implications of this

way of thinking about the taught curriculum is picked up later in this discussion, as part of the findings relating to *achievement standards as the default curriculum*.

The participant senior managers and teachers in this study were clear that in their schools, the majority of families had expectations that their children would leave school and go on to attend university. The senior manager with responsibility for curriculum explained that the Year 13 students in the case schools would typically be studying five subjects at NCEA Level 3, and those students and their families wanted three, four or all five of the Level 3 courses to be designed to satisfy the university entrance requirements (see Section 2.5). The chemistry courses in the three case schools all met the *university approved subject* parameters in terms of specified achievement standards and credits. In all three case schools, the chemistry courses comprised more than 14 credits, allowing for some leeway for students to not attain an achieved grade in one achievement standard but still attain the minimum of 14 credits for chemistry (for university entrance).

The course structures in the three schools in this study were indeed similar; consistent with the explanations offered by teachers with regard to the university approved subject lists and the achievement standard model of the NCEA qualification. School 2 did have two variations of Years 12 and 13 courses, reflecting their acceleration of students in “extension” classes. The rationale for the multi-level course in Year 12 for the extension classes was to give more time in Year 13 for study towards the chemistry scholarship examination. However, it is noteworthy that the identification of students for the extension classes was difficult based on NCEA results, and furthermore the Scholarship teacher remarked that she had to teach her students to “*rethink how they think*”. This was, in her view, because the integrated, higher order thinking for Scholarship was different to that demanded by Level 3 NCEA.

It was evident that participants held the view that the university entrance requirements were constraining school course designs and countering the potential for course flexibility that they felt was promised by the structure of the NCEA in its introduction (Philips, 2003). Mark, the Deputy Principal at School 2, said this:

Now, what we are finding is we are having to gradually move them back to a prescribed set of standards, in other words we are heading back to Bursary. So, it is an unfortunate consequence of the squeeze from Auckland University.

He expanded on his views, explaining that the university stance in terms of specifying what they recognised as a *subject* was an “increasing frustration” for him.

Supporting this Principal's view, is a letter from Ken Rapson (Appendix U), that details the specific achievement standards set by University of Auckland as a pre-requisite for entry into undergraduate Engineering programmes.

Innovation in course design is promoted as an ideal by Hipkins, Johnstone & Sheehan (2016), whereby teachers should strive for course coherence. However, illustrative examples provided by these authors, which were domain-blended, would not meet the university approved subject criteria, although they argued that:

Around a third of Year 13 students actually transition into university studies. Yet the structure of most courses in Year 13 curriculum has been designed to meet the need of this group to gain UE, regardless of the impact on choices available for other students. In effect, the Year 13 curriculum is held hostage by the UE regulations unless teachers are brave enough, or creative enough, to design innovative alternatives despite UE. (Hipkins et al., 2016, p. 172)

Despite Hipkins et al. (2016) challenge for teachers to be brave and creative, and find "the intellectual sophistication" (p. 163) to design such *innovative* courses, I suggest that the influence of the university admissions criteria is a strong one. Locke (2002) argued against what he saw as the potential for undermining a subject, with the NCEA course model. As it is, if the UE requirements with regard to their definitions of *subjects* are at odds with the idea of NCEA *courses* then that might be too big an ask for individual teachers or departments, or even schools to resolve. The teachers I met seemed to be taking a pragmatic view. They understood that there were obligations for their schools to meet in terms of having the majority (more than 90%) of their students attain university entrance, and they accepted that UE was a constraint on course design that they needed to plan for.

The participant teachers were also feeling accountable for student outcomes in terms of grades. In all three case schools, participant teachers believed that it was a departmental objective to have students attain high numbers of merit and excellence grades, and so high percentages of (merit and excellence) course endorsements. There was strong regard in departments for those teachers which had established a reputation for their practice leading to high student achievement (that is, high percentages of merit/excellence course endorsements per class). Senior managers talked about holding teachers accountable for results. For example, Mark (school 2) commented on his school's approach to data analysis by class and standard: "It is incredibly powerful in that it puts people under a high degree of accountability." Such positions appear aligned with school cultures focused on performativity (Codd, 2005; Wallace, 2012).

So the primary question that directed course design in the chemistry departments of the case schools appeared to be *how might we raise grades (and course endorsements)*? In the three case schools in this study, departmental goal setting and review of course design was based on a statistical analysis of NCEA results from the previous year. It was explained to the researcher that the decision might be made to drop a standard from a course if results from the year before were considered relatively low for that particular standard. That grade distributions for internal assessments are significantly higher than external assessment was put forth by the participant teachers as the rationale for including more internal assessments in recent years in the Years 12 and 13 chemistry courses. For example, the Deputy Principal at School 2, reinforced this as he talked about questioning the course structures in chemistry and physics with regard to the number of internals that were in each; higher grades in internals versus externals was the basis for his push for this change to happen in these subject areas. This approach was reiterated by the Teacher in Charge of Chemistry at that school. He explained how, some years earlier, there had been pressure from senior managers to reduce the number of external achievement standards in chemistry courses due to the relatively poor results relating to those standards.

Nationally, that an increasing proportion of credits (as a percentage of total results) are coming from internal assessment of chemistry over the period 2010–2014 (decile 10 schools), is borne out from the statistical analysis conducted in this study (Chapter Eight). Further statistical analysis showed that nationally, for all deciles, there were higher total grade distributions in internal compared to external assessment in 2010–2014. The similar trends for decile 10 and all deciles nationally are congruent with the comments made by teachers about the reasons for increasing levels of internal assessment in Years 12 and 13 NCEA chemistry courses.

The emphasis in the case schools on results analysis seems consistent with government agency reporting. *Raising achievement in secondary schools* was the title of an ERO report published in 2014, and it examined how 40 schools were using their Level 2 NCEA results, citing the government target for Level 2 attainment (85%) by 2017 as a rationale for doing so. This report emphasised NCEA results analysis, and the following is an extract from the appended *Indicator Framework* used to evaluate schools:

- There is a high-level of involvement from staff in terms of understanding the implications of NCEA analysis and knowing what is needed to improve the school's overall performance in the future
- School departments are involved in analysing NCEA results and identifying factors that supported and hindered students achieving NCEA Level 2 in their subjects
- Individual teachers understand what they need to do to contribute to the school's approach to lifting achievement (ERO, 2014, p. 27)

A new set of NZQA statistical reports entitled Principal's Reports are available for schools to access. There are three reports available in this series, two relate to UE and one to Certificate Endorsements. These reports (Appendix V) are evidently intended for use by a school's senior management, and for a given school, provide comparative decile as well as national (all decile) data.

There are two essential points to be made here. Firstly, looking at the national, all decile, data there has been a significant rise in Merit and Excellence Certificate Endorsement awards over the five years 2011–2015, for example from 7.4% Excellence in 2011 to 13.8% Excellence in 2015. Put another way, in 2011 30.8%, and in 2015 42.3%, of *all* Level 3 Certificates were endorsed. That in absolute terms seems a surprisingly high percentage, and shows a remarkable increase over that five year period. It seems unlikely that there has been a substantive shift in the learning achieved by students as implied by the change in assessment outcomes over this period. My second point is that the presentation of these Certificate Endorsement statistics by NZQA in the format of "Principal Reports" (Appendix V) have a clear agenda as a school performance indicator, and this evaluation is acting as a "powerful message system" to schools (Cowie & Penney, 2016, p. 290). How a New Zealand school is accountable with regard to assessment data was summarised:

School-wide assessment information allows schools to monitor the impact of their programmes on student learning with the information to be used to inform changes to policies and/or programmes and/or teaching practices as well as to report to school Boards of Trustees, parents, and the Ministry of Education. (Cowie & Penney, 2016, p. 289).

However, Codd (2005) was cautionary about the implications for education when it is to be measured by key performance indicators:

There is now a dominant managerialist culture within our education institutions which competes with the traditional democratic culture. This dominant culture is more concerned with what can be recorded, documented and reported about teaching and learning than it is with the educative process itself.....Managerialism, with its emphasis

on efficiency and external accountability, treats teachers as functionaries rather than professionals and thereby diminishes their autonomy and commitment to the values and principles of education. (p. 201)

The significance of these findings is that they are evidence that grade outcomes and university entrance requirements were strong drivers of NCEA course design, and so implemented curriculum, in the study schools. While the pursuit of high grade outcomes for students might be considered aspirational, seeking high grades as an end in themselves is problematic. The facility for attaining NCEA course endorsements was introduced from 2007 as a tool for fostering student *motivation* (Meyer et al., 2009). However, course endorsements in the case schools were being used as a performance indicator for teachers, departments, and schools.

The potentially negative impact on student learning is an issue that must be raised when course design is reduced to fitting the algorithm for endorsement. Teachers in this study voiced their unease about the implications of such an agenda, felt the accountability pressures, but were compliant in teaching the set programme; so to some extent they appeared to have become managed professionals (Codd, 2005; Locke, 2002).

Some teachers clearly articulated their personal reservations about the courses they were tasked with teaching. They talked about having little say in course design, and confided that they had reservations about the number of standards offered in courses. They felt they did not have the flexibility to change the timing or structure of the courses for their own classes; rather they delivered the courses as set for the department. Even teachers responsible for course designs had reservations; specifically around having sufficient time to teach for *understanding*.

What were apparently *not* factors in terms of NCEA chemistry course design in the three case schools (they were not talked about at all), were allowing for the inclusion of nature of science ideas and social or ethical aspects of the discipline. This is despite the significant place of the nature of science in *NZC*. Nor was any mention made in interviews of enacting the principles, values and competencies referred to in the front half of the *NZC*. There was no option for the individual teachers within their departments to tailor courses to their individual classes, or even vary the pace of their teaching and so the idea of learner-centered curriculum (Coll et al., 2010) seemed much compromised. These omissions are explored further in the following discussion.

It should be understood too, that the NCEA internal achievement standards relate largely to assessments of students' *procedural* understanding of chemistry such as practical skills (carrying out titrations, for example). The external achievement standards are more centered on the *substantive* knowledge and understanding of the subject. It might be claimed that such an assessment model, whereby aspects of students' procedural understanding is the focus, is in step with directions internationally in curricular reform (Duggan & Gott, 2002; Roberts, Gott & Glaesser, 2010; Tytler, Duggan & Gott, 2001).

So, what was behind the case schools' drive to include a certain number of internal achievement standards, and the apparent ambitions to report high percentages of university entrance and students being awarded NCEA course endorsements? Perhaps schools were protecting their reputations for academic excellence; brought into focus by the publication of school league tables in the general media and the availability of MoE reporting data to the public. Furthermore, that endorsement data is used by NZQA and MoE as a performance indicator for schools is clear. Students' NCEA Level 2 attainment has been explicitly linked to secondary school performance (Education Review Office, 2014).

This scenario is consistent with the idea that national curriculum reform is defined by "assessable outcomes, modular courses and ladders of qualifications" (Priestley & Sinnema, 2014, p. 51). The commentary by Australasian researchers (Codd, 2005; Klenowski & Wyatt-Smith, 2012) pointed out that the recent focus by schools on results and with it new forms of accountability have important, unintended consequences for education. This discussion point is extended in consideration of the evidence in this study of narrowing of curriculum. There are obvious links too between the adverse impacts of chasing high grade outcomes and effective pedagogy for developing deep understanding in students, as discussed later in this chapter.

As the syllabus is set for the IBD chemistry courses in all schools, issues do not arise in terms of teachers making decisions about what to include (or omit) in their teaching programme, beyond which option topic to choose (which was a concern for one teacher in School 3). It was emergent from the extent of commentary in the interviews, that decision-making related to course design was foremost an NCEA issue for the participants.

9.2.2 NCEA achievement standards: The default curriculum.

In the three case schools in this study, the achievement standards had evidently become the default curriculum documents in NCEA chemistry courses. *NZC* (Ministry of Education, 2007) did not appear to be utilised by participant teachers in their course planning. *NZC* was not mentioned in any of the interviews conducted, nor was it included or referenced in any of the course outlines or unit planning documentation reviewed during this research in the three case schools.

The bounds of each NCEA achievement standard dictated the taught curriculum by the participant teachers. They were quite clear that they were not teaching what was not assessed. Therefore, the syllogism that applied to the teaching of NCEA chemistry in the case schools might be thought of as:

- *What is taught is what is assessed;*
- *What is assessed is defined by the achievement standard;*
- *Therefore what is taught is defined by the achievement standard.*

The implemented curriculum in the case schools was modular, reflecting the achievement standard structure of the NCEA. There was evidently narrowing of curriculum as has been reported in Australia in high stakes assessment environments “as teachers teach only that which is to be tested” (Klenowski & Wyatt-Smith, 2012, p. 70).

The modular NCEA structure was seen by all of participants to have positive aspects, in terms of flexibility and accessibility for students. The achievement standard structure was also viewed as a negative in terms of impacting on the coherence of the subject.

When being interviewed for this study, the participant teachers often referred to their teaching in terms of the shorthand achievement standard numbers (2.5, 3.1, for example), rather than the topic or skills being taught in a unit of work (organic chemistry; investigation, for example). This suggests a change in thinking about curriculum, and this finding is consistent with the observations of Lundgren (2015), whereby he noted a semantics shift in discussions around the organisation and selection of content in contemporary curricula.

Perhaps surprisingly, especially given the clear dominance of the achievement standards in the design of the NCEA courses in this study, was that the majority of participants talked about being unsure of their interpretation of achievement

standards. This seemed particularly related to the internally assessed standards. The teachers in the case schools found the wording of the achievement standards (such as in-depth versus comprehensive understanding) unhelpful in terms of them being able to translate that to writing assessment tasks. Teachers considered the wording of the achievement standards *vague*, had difficulty in reconciling available exemplars with the standards, and struggled to write internal assessment tasks that met all the requirements of the external moderator (described as *picky*). Teachers talked about feeling accountable for the grades attained by their students; for attaining good agreement with the external moderation of their marking of internal assessments; and for writing tasks for internal assessments that met the standard as judged by that moderator.

The teachers explained in the interviews how they had to source the clarification notes relevant to a particular standard. They said they also used TKI exemplars as a guide, analysed mark schemes, and also utilised tasks purchased from the New Zealand Institute of Chemistry (NZIC) for school assessments. Regardless, they talked about how collating all of these sources of information together still did not lead them to feel completely clear about writing tasks, or marking, towards internal assessments. For external achievement standards, teachers commented on analysing mark schemes in order to gain clarification of what examiners were looking for. Those with experience as NZQA markers, saw advantages in their marking experience in terms of getting to know what was demanded by a particular achievement standard. When interviewed, several teachers expressed their frustration at having to work with so many elements to try and decode the requirements of each achievement standard. So, it might be said that the study teachers with experience, attained a level of *NCEA literacy*, even if they were not entirely confident in their interpretations of individual standards. The teachers used their NCEA literacy skills to guide their teaching of students.

Teachers' experiences of external moderation of internal assessment were not positive. Moderators' comments were described as *picky*. Several of the participants talked about being unhappy with the feedback received and noted how they felt there were contradictions in commentary from one year to the next. This contributed to teachers feeling uncertain about their interpretation of standards.

The participant teachers who had experience of the IBDP drew comparisons; commenting that they felt more sure of the scope of the DP syllabus (subject guide), with its learning objectives structure by topic, than they did of the NCEA achievement standards.

9.2.3 The nature of teaching and learning under NCEA and IBDP.

As already discussed, for the NCEA, the bounds of the achievement standards delineated what was taught and assessed. Teachers were quite clear that they were not teaching what was not assessed. A common course structure in the case schools in this study was a short teaching sequence of a few weeks, followed by practice and then internal assessment. The teaching sequences for external standards were several weeks longer than for internal standards. The course outline (Appendix N) shows how teaching time in one of the case schools was mapped for the year by achievement standard, with the assessments highlighted. This was similar in all of the study schools. Given a modular NCEA course structure and frequent small assessment tasks, there was no demand to revisit and consolidate students' understanding of topics. Connections between concepts were not emphasised, as that is not the way the understanding of chemistry ideas were assessed: "NCEA compartmentalises each topic" (Anna, School 1). Such modular approaches were also described by Harlen et al. (2015) with regard to compartmentalisation of learning and assessment in the tertiary environment.

The modular structure of the NCEA was concerning to all teachers in this study in that it *chopped up* the subject. Taber (2013) emphasised the importance of allowing time and opportunity for the reinforcement and consolidation of new learning in chemistry "to become better integrated and more robust (so strengthening connections between concepts and supporting economic 'chunking')" (p. 166). That the pace of teaching had implications for understanding was also claimed by Anderson and Bodner (2008), in the context of teaching organic chemistry at the tertiary level. Sevian and Talanquer (2013) have worked on building a framework to develop *chemical thinking*, and they noted the trend internationally in science education whereby students are expected to develop deep understanding of a discipline's core ideas. Childs (2009) argued that good chemistry teachers must have sound subject knowledge and an understanding of disciplinary connectedness. Thus the adverse impact of the structure of the NCEA qualification on teaching approaches reported here appears to run counter to the literature, which emphasises the importance of developing pedagogies that develop learners' integrated understanding of chemistry as a discipline.

Observed pedagogical approaches taken by teachers in this study appeared constrained by the perceived demands of assessments, and they talked about teaching to assessment. This finding of the backwash effect of assessment is consistent with those of others who have studied the NCEA and teacher practice

(Hume & Coll, 2010; Moeed, 2010; Moeed & Hall, 2011). A focus on having students master key vocabulary and phrases; write model answers to past examination questions; mark their work using mark schemes; follow teacher-directed practice of calculations and writing equations were all evident. Classroom observations in the case schools were generally consistent with findings of McRobbie & Tobin (2007), where they concluded that transmissive pedagogy predominates with teachers' goal of having their students pass examinations or other assessments. This was the case in observations of both IBD and NCEA classes, and seemed contrary to implementation of constructivist learning theory. That teachers' perspectives on the role of feedback might be related to "maximising performance on accountability testing" rather than improving learning has been reported by Brown, Harris & Harnett (2012, p. 977). The observed feedback that teachers gave to students in the case schools was linked to summative assessment. Formative assessment was effected in terms of rehearsal strategies, where teachers prepared students along the lines of what has been reported by others, that is "through repetition, teaching the language required for assessment, and providing one opportunity for a trial run to give student feedback on how to improve their grades" (Moeed & Hall, 2011, p. 101).

School-wide drives towards attaining high grades and numbers of course endorsements, led participant teachers to utilise rehearsal strategies, which they believed would result in students gaining high grades in assessments. Teachers in this study said they focused on key elements of the mark schemes and training students in mastery of the very specific (narrow) practical skills and problem-solving skills required to attain merit and excellence grades in internal assessments. The common approach recorded in this study, was to designate a set number of weeks of time for completion of an achievement standard: Teach the key skills, practise skills, set a practice task that was very similar to the upcoming internal assessment, then assess student learning shortly thereafter. Allowing students to resubmit internal assessments (allowed under the NZQA rules) was also common practice in the case schools. Further assessment opportunities (also allowed for internal achievement standards) were infrequently given in the three study schools, for reasons of manageability.

According to the stage theories of cognitive development, students in Years 12 and 13 are operating at both the *concrete operational* and the *formal operational* levels (Sjoberg, 2007). The teaching and learning towards the NCEA embodied in the interviews, observational data, and reported assessment practices are interpreted

as largely reflecting concrete operational thinking in learners. The omissions of investigation and nature of science elements (see Section 9.2.5 for elaboration), as well as courses that were aggregates of achievement standards were clearly problematic in the minds of the participant teachers in terms of *chopping up* the discipline. Such factors seem likely obstacles to students in the observed NCEA classes engaging with important aspects of the systematic thinking that is part of formal operational thinking. In comparison, the IBD chemistry syllabus and assessment design offered more scope for students to engage in formal (abstract) operational thinking: The Group 4 inter-disciplinary project; the scope of the practical work done, including investigation design; and consideration of relevant *Theory of Knowledge* issues such as ethical dilemmas and controversies in chemistry.

What was evident from the data, was the dominance of the NCEA *credit* and grades in teachers thinking, and are consistent with behaviourist learning theories. The NCEA machinery of achievement standards, credits, grades, course, and certificate endorsement evidently were drivers of course design and had implications for what was taught, or not taught, and how. For example, decisions were made in the case schools about including investigation based on the requirements for course endorsement (such as is reported in Sections 5.4.2; 6.4.2). Reinforcement in terms of students accumulating credits and grades *throughout* their NCEA courses for individual standards (structurally this qualification is quite different from the IBDP), and the reward of merit or excellence endorsements are interpreted as having significant effects as extrinsic motivation tools.

NZC is learner-centered, open-ended, and seen as congruent with constructivism (Coll et al., 2010). However, the implemented curriculum in the case schools reflected the bounds of the NCEA achievement standards, and espoused and observed practices were geared towards directing students towards high grade outcomes. To some extent teachers appeared conflicted between their own beliefs with regard to how they might teach for developing students' understanding, and how they were actually teaching in the context of an outcomes-based curriculum (and driving towards assessment grades).

In terms of teaching the IBD chemistry syllabus, the interview and observation data also pointed to content-heavy and structured methods of teaching, with assessment dominating planning and teachers feeling accountable for students attaining high point scores. There was reference to teachers using past examination papers in class to have students focus on key aspects of those assessments. The structure of the IBD chemistry syllabus was regarded by several teachers to offer breadth in the

discipline and offered the opportunity to teach in a way that made *links* between concepts for students. In the short answer examination paper (Paper 2), students' understandings are examined in a format whereby questions link topics together (such as organic chemistry, intermolecular forces, energetics). This is different from the structure of NCEA examination questions, where the questions necessarily sit within the scope of each discrete achievement standard. The demands of the practical work done in the IBD was also viewed by teachers as more comprehensive, leading to greater skill development in students than was the case for the IBD.

9.2.4 Manageability.

Nationally, there has been a trend towards more internal assessment in senior NCEA chemistry courses since 2010. Consequently, there is a greater workload through the year and therefore wellbeing issues for teachers and students. The problem is one of manageability.

By year end, the study teachers thought that some students, having prioritised their internal assessments all year, felt insufficiently prepared for the external examinations. This poor preparation, the teachers reasoned, resulted in some students having made the decision not to attempt all (external) achievement standards. The extent of the assessment regime in the case schools was evidently a factor in participant teacher workload too. Teachers believed the structure of the NCEA encouraged a student mentality of *credit-collecting*. Participant teachers believed the students they taught were very focused on their grades and credits attained for each achievement standard and attaining endorsements. This suggests the students were motivated to care about the quality of passes (Hodis et al., 2011; Meyer et al., 2009). However, participant teachers in all three case schools were concerned about the implications for student learning when students did not attempt external achievement standard papers in the final examination, which had been a trend over several years in each of the case schools. Teachers speculated on the reasons why many of their students, despite being taught the content, had not attempted all three external standards in the end of year examination. These centered on the issue of manageability (or otherwise) of assessment. The teachers were concerned that students were overloaded by the demands of internal assessment across all of their subjects throughout the year. This scenario aligns with the findings of ERO (2015) into the issues of student workload related to internal assessment in Years 11–13, and well-being.

The NCEA Level 3 internal achievement standard examining investigation (3.1) was discussed at length in each case school. It was evidently viewed by the participants as one specific standard that was particularly problematic in terms of manageability for staff. It was for this reason some schools no longer offered this standard as part of their NCEA courses. Implications of this omission is discussed further in Section 9.2.7.

There might be another reason for students not attempting a full set of examination papers. All NCEA examinations are three hours long. In the three hour chemistry examination, students sit a maximum of three papers, corresponding to three external achievement standards. There is an incentive of gaining extra time in examinations; if students attempt only two of the three papers, then they still have three hours to complete these two. Perhaps students reason this would improve their chance of Merit or Excellence grades in the two papers, than if they attempted all three papers in the examination. If students do not write on their papers at all, the paper is deemed as Standard not Attempted (SNA), and marked Void. No record of SNA or Void (or Not Achieved) grades appear on a student's Record of Achievement (ROA), a factor which might also impact on a student's decision-making processes around which papers to attempt, or not attempt, in the final NCEA examinations.

Whatever the reasons might be for the evident trend in student approaches to external assessment, the participant teachers reported being concerned by seeing students choosing to limit their studies in this way in recent years. In chemistry, with significant conceptual understanding being examined through external achievement standards this practice suggests it would lead to *significant gaps* in student knowledge of the discipline. It might be argued however, that it was only the assessment that some students were baulking at; they had been in class and learning the material during the year. Further research would be warranted in exploring to what extent this is a problem nationally.

The findings in this study around manageability of assessment suggest that scant attention was paid to the directive in NZC:

Not all aspects of the curriculum need to be formally assessed, and excessive high-stakes assessment in years 11-13 is to be avoided.

(Ministry of Education, 2007, p. 41)

One significant problem with the NCEA achievement standards becoming in effect default curriculum documents, is that of coverage, or lack thereof, in terms of

mapping to the *NZC*. Discussion of the scope of the issue and the implications for student learning are considered in next (Section 9.2.4).

Manageability of workload associated with assessment was also regarded by some teachers in this study as an issue for IBDP students. Further to this, the Head of Faculty at School 3 thought that the demands of managing the internal assessment and Extended Essay components for the IBDP was overall more stressful for staff than managing internal assessment for the NCEA. It was explained to the researcher that having the school offer alternative qualifications to their senior students undoubtedly had extra workload implications for staff.

9.2.5 Missing curriculum.

The participant teachers clearly articulated their concerns that the achievement standard structure of the NCEA model was limiting the scope for their students to develop an integrated and complete understanding of chemistry concepts and skills. There appear several aspects to this concern.

Participants considered the curriculum to have been *watered down* over time; with some further content lost in the NCEA realignment process. This was, in particular, related to the assessment demands of quantitative chemistry.

Participant teachers were clear that they were not teaching what is not being assessed. So, the taught curriculum narrowed, depending on the achievement standards that were the basis of a school's Years 12 or 13 course. Significant curricular *holes* were therefore evident in the NCEA chemistry courses, if mapped to *NZC*. The aggregation of selected achievements for a course did not cover elements such as open-ended investigation; consideration of the impact of chemistry knowledge on society; and nature of science understandings. Furthermore, the teaching to the achievements standards was not cohesive. The foundational principle of coherence in *NZC*, whereby "the curriculum offers all students a broad education that makes links within and across learning areas, provides for coherent transitions, and opens up pathways to further learning" (Ministry of Education, 2007, p. 9) seemed ignored.

These findings are central to the issue of fragmentation of curriculum, teaching and learning that arise through the structural design of the NCEA. This fragmentation problem was forecast (along with the "variability crisis") by Hall in 2000, and is what he is still flagging as a "major structural issue" of the NCEA (Hall, 2016, p. 1).

In contrast to the NCEA, the IB Diploma course requires students to study all topics of the syllabus, and complete all components of their chemistry course to be awarded a grade for the subject. The *Group 4 Project* is one component that focuses on the inter-disciplinary aspects of science and “the processes involved in scientific investigation” (International Baccalaureate Organisation, 2007, p. 33). The requirement for *theory of knowledge* contexts to be integrated into the teaching programme, while some participants said they felt daunted by these aspects of teaching the course, embed nature of science concepts in the IBDP chemistry curriculum. No participants related issues to the researcher about missing aspects of the Diploma curriculum. Some teachers observed that the expectation that students developed an integrated understanding of concepts was apparent in the style of IBDP examination questions.

What was talked about by some teachers, was that the IBDP syllabus was just too big to cover adequately in the available teaching time; this was in relation to the higher level chemistry course. One apparent way that teachers managed this was to have students study the option topics independently, with tasks set for students to study over school holiday periods. Assessment was then used as a means of monitoring the effectiveness of that independent study. The amount of time students were out of class on school sanctioned extra-curricular activities was seen as a factor adding to the difficulty of adequately covering the syllabus in School 3. Teachers at School 1 talked about the importance they placed on planning their teaching programmes, with reference to the subject guide for the IBDP, and noted that it was a challenging syllabus to teach.

9.2.6 Professional development.

The participants in the three case schools had mixed experiences of professional development. What they agreed on was that they would benefit from subject specific professional learning related to course planning and curriculum implementation. That teachers were motivated to develop further their PCK was apparent. They talked about feeling *behind* in terms of curriculum innovation and delivery.

Most had attended Best Practice Workshops in the past, but found these of limited value, and said that discussions had often been side-tracked by other participants. It was from these workshops, however, that their perceptions were formed that internal assessments were conducted differently between schools. The current offerings from NZQA are the Transforming Assessment Praxis (TAP) and Making Assessor Judgements (MAJ) workshops. However, these seem to be focused on

the processes around internal assessment, and I question if they would meet the needs of teachers as raised in this study. The MAJ are clearly targeted to the novice assessor rather than the experienced practitioner, and the scope of the workshops do not seem to address issues of course design and implementation that the teachers in this study were seeking. The demand for the TAP courses is a commitment of one and a half hours per week for nine weeks, and this extended time commitment might be a barrier for some teachers. TAP is also clearly focused on assessment related practices.

Chemistry specific professional development was also on the wish list for the teachers interviewed in this research. This wish is aligned with van Driel and Berry (2012), where they argued that “professional development programs aimed at the development of teachers’ PCK should be in ways that closely align to teachers’ professional practice, including opportunities to enact certain (innovative) instructional strategies and materials and to reflect, individually and collectively, on their experiences” (p. 27). Teaching science subjects requires teachers to keep abreast of modern practices, and also science knowledge in the specific disciplines. Appropriate resourcing along these lines would meaningfully support excellent teaching and offer scope for teachers to engage with the *teaching as inquiry* aspects of the NZC. For example, Mahaffy (2014) commented on steps forward for developing chemistry teachers in America, with extensive teaching resources now available to them through the American Association of Chemistry Teachers (AACT). As it is, teachers in these case schools felt their practice was *under-resourced*.

All participant teachers expressed concerns about their workload, largely associated with assessment, and the impact that was having in other aspects of their profession. In particular meeting time and more formal opportunities for professional development were believed to have been reduced.

In contrast to the experiences of the NCEA teachers, the IB Diploma teachers in this study had all been sent by their schools for workshop training in Australia at some time in the five years before they were interviewed for this inquiry. The three day IB face-to-face workshops cover all subject areas, and are offered in three categories for differing levels of teacher experience with the programme. Participants had different views on the quality of the workshops; some saying that as they were trained before they had taught the Diploma they were of limited value to them; others rating it as the best professional development they had had. It is a compliance requirement that all IB Diploma teachers complete IBO workshop training. The high cost of registration and travel to Australia was noted as a limitation

to New Zealand teachers being offered this type of professional development opportunity.

As yet support for the wider implementation of the NCEA, that is, with professional development opportunities beyond assessment focused training, and accessible to all teachers, is not provided by the MoE or NZQA. Nationally, teachers might benefit from a discourse on course design and a sharing of different perspectives on the issue. As teachers have gained significant experience with the NCEA, now might be thought of as the ideal time for such an initiative.

9.2.7 Reliability and validity of assessment.

Internally assessed standards were seen by participants in this study as being less rigorous and demanding than the externally assessed standards. A common belief held by the participants, was that the way in which internal achievement standards were assessed and marked was inconsistent between schools. While they felt that their schools were mindful of good practice, they believed that many other schools were less rigorous in terms of conducting aspects of internal assessment.

Issues relating to the reliability of internal assessment were the subtext to many of the interview comments made. By that, I mean that the anxiety teachers expressed around their marking; agreement rates (with the external moderator); and their experiences with the NZQA run Best Practice Workshops around improving their assessor judgement were all aspects of their practice relating to reliability of NCEA assessment.

Realignment of NCEA led to a shift in grade distributions in the assessment of reduction-oxidation chemistry. Despite the two versions of the achievement standard (pre and post alignment) being very similar in terms of the specified scope, the results are significantly higher post realignment. Why such a significant grade shift? The most obvious difference in the pre and post aligned standards is that there was a change from the standard being externally to internally assessed. It seems reasonable to consider that students might do better in internal compared to external assessment for the NCEA for several reasons: Assessment immediately follows the teaching; students are more comfortable being assessed in the familiar surroundings of their classroom and by their regular teacher; the rules of NCEA assessment allow for resubmission and one further assessment opportunity. However, in this case the grade distributions are strikingly different (Figures 8.17, 8.18), and I question if such reasons sufficiently explain the patterns on grade

distributions seen pre and post realignment. Rather, do these data point to a validity issue?

As outlined in the preceding discussion, the NCEA rules for external assessment allow for students to have three hours to complete their papers; regardless of whether papers for one, two or three achievement standards are to be undertaken. I raise these rules as evoking validity issues. In contrast, there are set time allowances for each of the three papers for the IBD chemistry examination. Grade boundaries for each component are set by the IBO with reference to statistical data. This is a means of achieving reliability of assessment:

Great care is also taken to ensure grading reliability, through the application of consistent standards supported by statistical background data, in determining grade boundaries. Grade standards are documented and exemplified, and judgments made about grade boundaries are checked by a number of statistical indicators. (International Baccalaureate Organisation, 2009, p. 13)

The IB Diploma grade boundaries are set at grade award meetings for each examination paper in each examination session. This takes place 35 days after the examination, once marking is complete.

The boundaries for internally assessed components, and externally marked non-examination components, are not revised each session. They are normally set only once, when such components have just been introduced or revised. On the other hand, new boundaries will be set for each examination paper at each session. (International Baccalaureate Diploma, 2009, p. 41)

The processes around external moderation of internal assessment in the IBDP were seen by the case school teachers as being more robust than for the NCEA. That every internally assessed component was sampled and externally moderated; that the moderation sample was generated by the IBO; and that the external moderation results meant final grades were kept the same, raised or lowered accordingly were seen by the teachers in this study as positive elements of processes for external moderation set by the IBO.

9.2.8 Preparedness of students.

The teachers in the three case schools that were participants of this study were of the view that for students to enjoy success in their senior chemistry courses (NCEA or IBDP), they had to have sound skills in mathematics. If their mathematics skills were not secure, then that would show in their difficulty with the quantitative aspects of chemistry. It is noteworthy that the participant teachers remarked that some students were not confident in using their scientific calculators. These teachers'

beliefs were aligned with the literature that linked students' success in chemistry learning to their foundational skills in mathematics (Allenbaugh & Herrera, 2014; James et al., 2008; Scott, 2012).

In terms of how well prepared their school leavers might be for tertiary level courses in chemistry, teachers expressed a range of views. Some were confident about what university courses comprise, having children of their own go through first year science courses at university. Others said they only had a basic understanding, which had been gleaned from university websites. One teacher at School 3 suggested that what she saw as the proliferation of Summer bridging courses in chemistry was perhaps indicative of weaknesses in some students leaving school with the NCEA qualification. The teachers thought it important students were independent in their approach to learning; had sound scientific literacy skills (knew how to read scientific texts and write well); and had good self-management. Teachers of both NCEA and IBD chemistry courses at School 1 believed that the IBD students were expected to work independently, an attribute that would help them at university and as Alison put it: "NCEA doesn't have that". However, *NZC does* explicitly identify *managing self* as a key competency; neglect of this capability might then be thought of as another curricular *hole* arising from the NCEA achievement standards being in effect the default implemented curriculum (see Sections 9.2.2 and 9.2.4).

In terms of chemistry understandings, the aspects teachers listed as important included having a good procedural understanding of investigation and general practical/manipulative skills. For some this included titration skills. However, given that not all schools offered the only NCEA achievement standard that assessed investigation (and what was not being assessed was not taught); the inference is that students would be arriving at university with no evidence of their competency in aspects of procedural understanding of chemistry.

Comments were made in interviews about that the comprehensive practical requirements for the IBDP, in terms of the number of practical hours that needed to be logged and the reports students were asked to write-up. The range of practical work done was regarded by the case school teachers as more comprehensive than that undertaken for the NCEA over Years 12 and 13. However, at School 1 it was said that the demand for writing-up laboratory reports in IBDP chemistry courses was reducing enjoyment students derived from doing practical work.

Participant teachers considered it necessary for students to have sound content knowledge and a connected understanding of the discipline to be successful in tertiary-level studies of chemistry (discussed in Section 9.2.2).

9.3 Cross case analysis: Summary

What emerged from the cross case analysis were several themes. These are summarised here. NCEA courses in the case schools were designed as an aggregation of achievement standards; to meet UE requirements; and a significant consideration was how to maximise student grade outcomes (by choice of standards). Little variation in chemistry course structures between schools was evident. Course endorsement data was used as a key performance indicator for teachers, departments and schools. In comparison, IBDP chemistry courses are defined by a detailed syllabus. The choice of particular option topics was a concern for some participants, who would have liked more flexibility to choose these for their own students (rather than have them set by their heads of department).

NZC was not referenced in course documentation or interviews with participants. Instead, the NCEA achievement standards defined the taught curriculum in the case schools. As such, implemented curriculum was narrowed as only material that was taught was being assessed. Despite the heavy reliance on the achievement standards, teachers felt these were *vague*.

In the context of the modular NCEA structure, teachers were clear that they were not teaching what was not assessed. The structure of the NCEA courses meant that connectedness of chemistry as a discipline was not emphasised. This contrasts with IBDP teaching, where the syllabus, and its assessment, emphasised integrated understanding of concepts and practical skills. What was observed in both NCEA and IBD classrooms was a predominance of transmission teaching strategies with a focus on grade outcomes and coverage of content.

Analysis of national data shows there has been a trend of increasing amounts of internal assessment in the NCEA over recent years, leading to issues with the manageability of assessment. Teachers reported that the NCEA encouraged students to have a *credit-collecting* mindset. A trend whereby students were not attempting all papers in the chemistry external examination concerned the participants in the three case schools. Several possible reasons for this behaviour were put forward by the teachers. These included students not feeling sufficiently prepared for their NCEA examinations because of the demands of internal

assessment through the year; and students deciding they would be better off reducing the number of papers they attempted (giving themselves a time advantage in doing so). Manageability of assessment for students across their IB Diploma was also seen as an issue. Teacher workload was a recurring thread to the interviews, including in relation to manageability of assessment.

In the case schools, the achievement structure of the NCEA was seen as leading to curricular *holes*. Achievement standards were seen as having been watered down over time, and the taught curriculum reflected the selected achievement standards in a course. When the NCEA courses in the case schools were compared to *NZC*, it was evident that courses did not include open-ended investigation or Nature of Science understandings. It is evident that the principle of *coherence* was being ignored in course design; the taught curriculum was fragmented.

The IBDP chemistry syllabus specifies all topics are to be taught, and participant teachers did not raise concerns about missing elements of the IB Diploma. Components such as the Group 4 Project required inter-disciplinary collaborative learning to be undertaken by the IBDP students.

The participants reported mixed experiences of professional development. What they did comment on was that subject specific professional development, specifically related to course planning and curriculum implementation (rather than just assessment) would be helpful in developing their practice. Subject specific professional development is an IBO requirement of programme implementation, and is audited every five years as part of IB schools' self-evaluation. So, all IBDP teachers in this study had undertaken professional development in the form of IBO workshops. There were a range of views on the usefulness of these workshops, ranging from *not very* to *the best*.

Teachers in this research had many concerns relating to the reliability of internal assessment towards the NCEA qualification. In comparison, IBO processes around the external moderation of IBD internal assessment, were regarded by the participants as more robust. Nationally, grade distributions shifted significantly for reduction-oxidation chemistry when the achievement standard shifted from being externally to internally assessed. This raises questions of validity. The NZQA rule in regard to all NCEA examinations being 3 hours long, irrespective of the number of achievement standards undertaken by a candidate (up to 3), also raises questions of validity of assessment.

There were two parts to considering the preparedness of students – firstly, the preparedness of students for the secondary school chemistry courses they were enrolled in at the case schools; and secondly, how well the students might be prepared for tertiary courses in chemistry. In both, foundational skills in mathematics were seen by participant teachers as an important factor. For tertiary success, the study teachers also thought it important students had good procedural understanding of investigation. The range of practical work done over two years towards the IBDP chemistry courses was seen as more comprehensive than such tasks done towards the NCEA. However, the comment was made that the demand for written reports on IBDP practical tasks was seen as reducing students' enjoyment of practical work. Teachers talked about it being important in their view, that those students going on to tertiary courses in chemistry had a connected understanding of chemistry as a discipline.

This chapter has presented the main findings of this study in terms of the themes of curriculum, pedagogy and assessment in teaching secondary school chemistry courses. In the following chapter, overall conclusions are drawn with regard to the research focus for this thesis and suggestions for further work are put forth.

CHAPTER TEN:

Conclusion

This chapter presents conclusions from this work in relation to the over-arching research question and the themes of curriculum, pedagogy and assessment. Data from both the three case schools and the statistical analysis of NZQA national results are the basis of these conclusions. The thesis ends with suggestions for further extensions of this research.

10.1 Key findings

The focus of the research presented in this thesis was:

In the context of NCEA and IBD chemistry courses in New Zealand secondary schools, how do teachers manage the tension between learning, teaching, and assessment?

It emerged from the interview data that the participant teachers had a lot to say about their practice in terms of curriculum and assessment for the NCEA, and much less to relate about their teaching of IBD chemistry courses. It is the researcher's interpretation that this differential in the data was due to the specific structure of the NCEA, comprising individually assessed and graded achievement standards; it was achievement standards and their implications for teaching and assessment that were uppermost in the thoughts shared by the participants.

The teachers expressed several concerns about the NCEA courses they were teaching. These concerns included: Being responsible for delivery, rather than design, of teaching programmes to meet the needs of the learners in their classes; the teaching time available in relation to the number of assessed standards being restrictive, hampering the development of deep understandings; the *chopping up* (fragmentation) of chemistry as a discipline, leading to students' comprehension of the discipline as a whole being limited and limiting the professional satisfaction they derived from their teaching; the *watering down* of curriculum, to the detriment of student learning; and the high workload, for students and staff, related to over-assessment.

The NCEA achievement structure had, in the participant teachers' view, led to fragmentation of learning of chemistry as a whole discipline. Indeed the achievement standards appeared as the default curriculum in the three case schools. The language utilised by participant teachers reflected the achievement

standards; rather than describe the topics being taught in terms of chemistry content, the abbreviated language (numbering) of standards was used in interviews and conversations, and this was also reflected in course outlines and unit plans. NCEA course designs were focused on achievement standards, rather than NZC, and key drivers of course design were university entrance requirements and improving grade outcomes. The NCEA chemistry courses in the three case schools were similar in terms of comprised achievement standards; perhaps surprising given the flexibility of the NCEA.

Teachers in this study were clear about not teaching what was not assessed. There were key elements of NZC missing from the NCEA chemistry course designs in the case schools: Investigation, Nature of Science and the principles and values of the front end of the curriculum document were aspects apparently paid little attention. These omissions must have implications for students' disciplinary understanding of chemistry and their preparedness for tertiary studies in the subject. Notably the foundation principle in NZC of coherence was not referred to in course designs. Despite the prominence of the achievement standards in their teaching programmes, difficulty in interpretation of standards was a concern of participant teachers. Such difficulties raises questions of validity of assessment.

Teachers (of both NCEA and IBDP courses) felt pressures on them in terms of having their performance judged on grade data. They felt they would face a *please explain* should student results not meet departmental targets. This perception of accountability was reinforced by the senior managers that were interviewed. The participant teachers were concerned about doing the best for the students, but felt this was not always aligned with the course designs in their departments.

These concerns espoused by teachers are consistent with the views expressed by Codd (2005), that curricular reform in this country has had a negative impact on teachers, and that schools have more of a business-like agenda than one which is education focused. For participant teachers in this study, the tensions they talked of were as described by Abiss (2014): The tension between student-centered teaching and assessable outcomes. The focus of the implemented curriculum described by the teachers in the three case schools was not one of being responsive to student needs and developing understanding of the discipline. Instead of what might be expected from modern curricular reform (Reiss & White, 2013), their focus was on improving grade outcomes for their students. Attaining high grade outcomes was a key objective driving course design in all three case schools. For the NCEA this might be best understood in the context of government targets for student

achievement at Level 2 (85% by 2017) and the reporting by NZQA of school “performance indicators” citing certificate endorsement statistics. The analysis of national statistics carried out in this study are consistent with the data collected from the teacher interviews, in that the grade distributions are higher for internal assessment, and as a result, there is a trend over recent years towards more internal assessment.

Participant teachers (of both NCEA and IBD) felt compromised in terms of their own professional development. In all three case schools, there was a paucity of time for departmental meetings and a lack of opportunity for subject specific pedagogical professional development. While the IBDP requires teachers to be trained in curriculum implementation, neither the MoE nor NZQA offer professional development opportunities focussing on curriculum that are accessible to all teachers. Instead, the NZQA resource workshops have an assessment/moderation focus.

Teacher workload (for NCEA and IBD courses) was a recurring theme in the interviews, and high workload was given as the main reason for there being less time in recent years than there once had been for chemistry teachers to meet together to discuss practice. For one teacher, her way of managing workload was to reduce her hours of work from full-time to part-time, thus reducing her teaching load by 20 percent. The demand on teachers at the two case schools that offered both the NCEA and IBDP qualifications, in terms of managing the two curricula, was noted as a workload issue.

The espoused beliefs of the teachers in this study reflected an assessment focus in their pedagogy, and from the interview data, this was more prominent in relation to the NCEA than the IBDP. Perhaps the pattern of NCEA assessment (several internal as well as external assessments in both Years 12 and 13) was a factor. No summative assessment (internal or examination) was undertaken by Year 12 IBDP students in the case schools, instead the summative assessment was set for the second year of the two-year course.

Rehearsal strategies, a focus on mark schemes and key phrasing was referred to in the interviews (and observed) as a means of improving grade outcomes. Experienced teachers may be thought of as having developed a high level of *NCEA literacy* which they used to inform their practice. The teachers interviewed were clearly dedicated, but had some misgivings about how they were teaching. They expressed how they felt constrained by the pursuit of high grade expectations as set

by their line managers; were worried about their interpretation of achievement standards; had concerns about several aspects of the NCEA course designs; and thought the timelines set by departments constrained teaching for understanding. For all that, the teachers felt powerless to change the way the NCEA was implemented in their schools. The specific design of the course they were undertaking was fixed by middle managers (Heads of Department/Faculty), with little to no opportunity for classroom teachers to amend programmes for individual classes. Teachers and students were working for NCEA grades and course endorsements based on discrete and disconnected parcels of learning defined by the achievement standards. There are parallels with what is reported at a tertiary institution that had adopted a modular course structure, whereby the “proliferation of small assessment tasks, seemed more like a ‘race for the bottom,’ with the potential for the overall quality of learning to be diminished (Harland et al., 2015).

Also a concern for the NCEA teachers in this study, was the broader impact of the amount of internal assessment on students. Teachers felt some students were struggling with the demands of internals throughout the year. Aside from student wellbeing, the high load of internal assessment, they believed, also had an adverse impact on student learning of material towards external assessment. Several teachers in this study offered the view that students were not attempting all standards in the end of year examination because by the year end they had sufficient credits. The here and the now of internal assessment in other subjects might also lead students to prioritise these throughout the year at the expense of learning the more theoretical/ conceptual content in chemistry to be assessed in the end of year examination. Other possible reasons are the incentivisation of extra time and that there is no penalty for students in terms of an NZQA record of them having not attempted a paper they were entered for. These findings raise concerns of the validity of NCEA assessment.

Managing the demands of the requisite practical hours (60 hours over the two year programme) and teaching of higher level IB Diploma chemistry with the set school timetable was seen as a challenge. It was thought by some participants that the practical programme of the IBDP meant these students were better prepared than their NCEA peers for university studies in the discipline in terms of their procedural knowledge of chemistry. There was a consensus that students need to be independent learners to do well in their tertiary studies, and that IB Diploma students were generally more self-managing than NCEA students.

Given the structure of the NCEA, many of the findings are unique to that qualification. Assessment dictated teaching practice and issues related to drivers of course design, concerns around disciplinary connectedness, missing curriculum, and reliability and validity of assessment are specifically related to the modular achievement standard design of the NCEA. Other findings were related to both the NCEA and the IBDP, such as manageability of assessment, professional development needs and the preparedness of students for university studies in chemistry.

10.2 Implications and further research

It seems quite right that Hipkins et al. (2016) have called for “new curriculum thinking to be brought to bear on NCEA’s mix of achievement standards, and the processes for course construction that these standards support” (p. 199). Given that the NCEA Level 2 and 3 achievement standards were realigned with *NZC* in 2012 and 2013 respectively, it might be argued that the teachers felt justified in working with achievement standards rather than referring to *NZC* in planning. However, there are implications of this teaching approach (as seen in the case schools in this study), both in terms of implementing the intent of *NZC* and in the coherence of teaching and learning. In the case schools, NCEA courses were taught to the achievement standards and therefore modular. The participant teachers in this study were concerned about fragmentation of learning. They said that in teaching courses comprising discrete achievement standards, little emphasis was given in their teaching as to how concepts linked together. So, the opportunity for students to develop deeper understandings of the discipline of chemistry as a whole was compromised by the NCEA course design.

Furthermore, with the model of achievement standards defining NCEA courses, depending on the selected achievement standards that comprise a course, there may be curricular “holes”, for example courses where no open-ended investigation or consideration of the impact of chemistry knowledge on society are undertaken. Hall (2016) offered specific suggestions for addressing the issue of fragmentation, including reviewing regulations to discourage students opting out of assessments; and integrating standards into larger parts as the basis for a course.

One of the positive aspects of the NCEA that was agreed on by the teachers in the case schools, was that it allowed for flexible course design. Why then were the courses in these schools so similar? School managers suggested that one conservative effect on course design was the influence of university entrance

requirements. It would be useful to explore *why* the UE requirements, and other NCEA prerequisites are set as they are. *What is the basis for the universities approved subject list? Why are universities holding to their definition of **subject**, rather than embracing the NCEA **course** concept?* It might be that implementation of NZC, and its assessment via the NCEA, would benefit from MoE led discourse around the curriculum links between universities and schools. It seems unrealistic to think that individual teachers can navigate the forces at play here.

As an extension of the findings from this research, further work examining the preparedness of students for university courses in the sciences would be warranted. A national longitudinal study to examine the transition of students from school and through undergraduate science programmes would further an understanding of the relationship between school leaving qualifications and tertiary outcomes. Inquiry into lecturers' perspectives on student preparedness for university study in the sciences, including mathematics competency, would inform those teaching in both secondary and tertiary sectors. More broadly, and as an extension of the work done here, it would seem timely to undertake research into the current perceptions of the IBDP held by university lecturers and Heads of Schools.

That students in the case schools central to this thesis were not attempting all three papers in the end of year examination was a cause for concern for all the participant teachers. It might be argued however, that it was only the assessment that some students were baulking at; they had been in class and learning the material during the year. *How significant is the problem (of students not attempting standards) nationally?* The statistics for the number of Void papers nationally would help answer this question, however the data is currently not reported. It is recommended that policy on reporting these data be reviewed. There are currently no reporting implications for students who do not attempt all papers in external assessment (standards not attempted are not recorded on their record of learning). However, students give themselves the immediate advantage of fifty percent extra time should they choose to do only two of three papers in the final three hour examination which has implications too for adding to the problem of fragmentation. The validity of results in these circumstances has to be questioned under such a system. A review of NZQA policy on examination rules in this regard is called for.

While this study has focused on teachers' perspectives, another avenue for further research would be to explore students' perspectives on the relationship between their learning and assessment. At the tertiary level, there are reports of the impact of high-stakes assessment on students' learning behaviours (Harland et al., 2014).

They reported that while internal assessment was considered a positive means of keeping learning on track, students felt stressed by the regime of continual assessment. The connection between grading, intrinsic motivation and learning would warrant further study. Exploring the motives for students to not attempt all papers in NCEA external assessments would inform our understanding of their behaviours. Is the issue one of managing their assessment workload, or is the incentive of extra time being used to improve their grades?

From this study, it may be inferred that a key driver of NCEA course design in this country is for schools to increase the number of Merit and Excellence grades attained by their students, and so increase the reported percentage of Certificate Endorsements at Levels 2 and 3. The linking by government education agencies of school performance to NCEA Level 2 grades and percentages of Certificate Endorsement appears to be driving education in secondary schools into assessment traps. The introduction of NCEA endorsements were aimed at motivating students, but use as a simplistic school accountability tool was never an intended purpose. Assessment outcomes have been taken out of context and with that, evoke unintended adverse implications for student learning. The teachers interviewed in this research were clear that they were not teaching what was not assessed, and also that they were held accountable for students' grade outcomes. In that drive towards high grade outcomes, teachers taught to the assessments and emphasised rehearsal strategies when preparing students for internal assessment. This phenomenon has also been reported by others (Hume & Coll, 2010; Moeed, 2010; Moeed & Hall, 2011), with significant implications in terms of leading to superficial learning. This process of internal assessment in the IBDP presents a contrast. Tasks undertaken by students led to a submission of a portfolio of laboratory reports for each student. Included in this portfolio were open design aspects, with little teacher direction allowed. However, the use of past examination papers, transmission style pedagogy in a drive towards high grade outcomes, was talked about and observed in preparing IBDP students for their final examinations.

There are compelling inferences to be drawn from the national grade distribution data for NCEA Levels 2 and 3 Chemistry. It is not just decile 10 schools, but schools of all deciles, that report staggering percentages of Excellence grades for internal assessment of between 41 and 60 percent for Level 3 standards since 2011. Another way of looking at this is that between 68 and 78 percent of all Level 3 candidates scored Merit or Excellence in Internal assessment. So, less than 30 percent of all candidates were attaining Achieved or Not Achieved grades. The

participant teachers were questioning the meaning of internal assessment grades in their schools, and the national statistics suggest that we should be questioning such result profiles. The national data also tell us that the amount of internal assessment has been steadily increasing since 2011. We should be questioning why this is. To what extent is the directive in *NZC* that “excessive high-stakes assessment in Years 11–13 is to be avoided” (p. 41) being followed?

10.2.1 Recommendations for policy review: Summary

Findings from this study suggest the following be a focus for further research attention and review by policy makers:

- *Attention to implementation of NZC*

Curricular *holes* need to be addressed, with the principle of coherence to be implemented – including in the taught curriculum for senior classes. Professional development opportunities with subject specific and curriculum implementation focus (and not just an assessment one) need to be accessible for all teachers.

- *The relationship between NZC and NCEA*

It was evident in the three case schools in this study, that having NCEA achievement standards stand as the default curriculum for senior secondary students was leading to issues of poor connectedness in the learning of a discipline as a whole. It is recommended that a more complete national picture of the issue is derived, and that the modular structure of the NCEA achievement standards and their mapping to NZC be reviewed. Attention should be given to the differing grade distributions of internal vs external assessments, and the implications for course designs in schools and student behaviours towards assessment; wider discourse on this issue based on national statistical data seems appropriate. It is also put forward that reporting of Void grades should be available through NZQA; such data would lead to a clearer analysis of learner behaviours in external assessment. Appropriate use of assessment data should be a consideration: NCEA course and certificate endorsements were introduced with the intent of motivating students to strive for better quality credits (at merit and excellence level). However, endorsement and Level 2 pass rates used as simplistic performance indicators for schools may be problematic in narrowing curriculum and driving grade inflation. In this research, teachers had much to say about the manageability (or otherwise) of the amount of internal NCEA assessment. Emergent concerns around the relationship between *NZC* and NCEA warrant further exploration.

- *Reliability and validity of NCEA assessment*

More explicit specification of achievement standards should be provided to teachers and learners; teachers in this research were outspoken in referring to the achievement standards as *vague*. This study clearly shows the dominant role of the achievement standard in the planned and taught curriculum in senior classes. Participant teachers and senior managers in this work were all concerned about students' approaches to assessments. Interpreting these data, and with validity issues in mind, it is concluded that NZQA examination rules need review with regard to the time allowed per examination paper. Reliability concerns related to NCEA assessment emerged from this study, and an extrapolation of this would therefore be to undertake review of moderation processes for internal assessment, with a view to improving perceptions and the effectiveness of the moderation process.

10.2.2 Directions for further research

Further extensions of this study would be to more fully explore the relationship between Certificate Endorsement and levels of NCEA internal assessment. It is suggested that government policies such as setting a Level 2 NCEA pass rate and utilising NCEA Certificate Endorsement percentages as school performance indicators, promote grade inflation and so should be reconsidered. A national study is warranted. It is a reminder of the point made by Bell and Baker (1997), that implementation of a new curriculum requires change in terms of all of the layers of curriculum, including that of the *hidden* curricula. According to our national curriculum, teachers should be empowered to interpret curriculum in response to the needs of their students, rather than simply being "managed professionals".

After the data collection phase of this study was completed, Bull (2015) published the science capabilities as "a set of ideas for teachers to think with" (p. 1). The embedding of NoS, perhaps utilising the model put forward by Bull, or arguably the more complete eight scientific practices of Osborne (2014) would, in my view, warrant attention in terms of professional learning for this country's science teachers. *How could opportunities for teachers to meet be facilitated so that they might share their thinking on NoS and curriculum design?* Teachers in this study spoke to the need for subject specific and curriculum-based professional development opportunities. It seems intuitive that resourcing of such professional development by the MoE, accessible to all teachers, would lead to gains in teacher PCK, curriculum understanding and implementation. As it is, the only professional development opportunities resourced by NZQA are assessment focused. Better

resourcing would assist in fleshing out the skeletal *NZC* and achievement standard documents, give teachers greater confidence in practice, and help resolve reliability and validity issues.

The current place of *NZC* as enacted curriculum in our schools warrants further study to inform education and assessment policy. A change of “message system” through ERO, to move away from the attainment of NCEA Level 2 as a benchmark, and towards one looking at implementation of the founding principles of *NZC* would drive more coherence into senior courses. While data on student wellbeing in secondary schools has been reported, it might be that an accountability shift for schools, away from NCEA-based performance indicators and towards one considering full *NZC* implementation is warranted. Challenges exist to work towards the principle of coherence and see full implementation of *NZC* in courses designed for students in Years 11–13; whereby curriculum and pedagogy may take their rightful place, and that is *before* assessment.

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Appendices

The IB Diploma Programme, for students aged 16 to 19, is an academically challenging and balanced programme of education that prepares students for success at university and life beyond. Students take courses in six different subject groups, maintaining both breadth and depth of study. Chemistry standard level is in group 4, experimental sciences. In addition, three core elements—the extended essay, theory of knowledge and creativity, action, service—are compulsory and central to the philosophy of the programme.

About the IB: For over 40 years the IB has built a reputation for high-quality, challenging programmes of education that develop internationally minded young people who are well prepared for the challenges of life in the 21st century and able to contribute to creating a better, more peaceful world.

The IB subject briefs illustrate key course components in the IB Diploma Programme.

- | | |
|--------------------------------|-----------------------|
| I. Course description and aims | III. Assessment model |
| II. Curriculum model overview | IV. Sample questions |

Overview of the chemistry standard level course and curriculum model

I. Course description and aims

The IB Diploma Programme chemistry standard level course combines academic study with the acquisition of practical and investigational skills through the experimental approach. Students learn the chemical principles that underpin both the physical environment and biological systems through the study of quantitative chemistry, periodicity, kinetics and other subjects. The chemistry course covers the essential principles of the subject and, through selection of options, allows teachers some flexibility to tailor the course to meet the needs of their students.

Throughout this challenging course, students become aware of how scientists work and communicate with each other. Further, students enjoy multiple opportunities for scientific study and creative inquiry within a global context. In addition, the course is designed to:

- provide opportunities for scientific study and creativity within a global context that will stimulate and challenge students
- provide a body of knowledge, methods and techniques that characterize science and technology
- enable students to apply and use a body of knowledge, methods and techniques that characterize science and technology
- develop an ability to analyse, evaluate and synthesize scientific information
- develop experimental and investigative scientific skills
- engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities
- develop and apply the students' information and communication technology skills in the study of science
- raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology
- develop an appreciation of the possibilities and limitations associated with science and scientists
- encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method.

II. Curriculum model overview

Chemistry standard level

Theory		110 hours
<i>Core</i>	80 hours of standard level instruction on 11 topics <ul style="list-style-type: none"> • Quantitative chemistry • Atomic structure • Periodicity • Bonding • Energetics • Kinetics • Equilibrium • Acids and bases • Oxidation and reduction • Organic chemistry • Measurement and data processing 	80 hours
<i>Options</i>	30 hours of instruction on two additional topics <ul style="list-style-type: none"> • Modern analytical chemistry • Human biochemistry • Chemistry in industry and technology • Medicines and drugs • Environmental chemistry • Food chemistry • Further organic chemistry 	30 hours
Practical work		40 hours
<i>Investigations</i>		30 hours
<i>Group 4 project</i>		10 hours
Total teaching hours		150 hours

III. Assessment model

Assessment for chemistry standard level

The IB assesses student work as direct evidence of achievement against the stated goals of the Diploma Programme courses, which are to provide students with:

- a broad and balanced, yet academically demanding, programme of study
- the development of critical-thinking and reflective skills
- the development of research skills
- the development of independent learning skills
- the development of intercultural understanding
- a globally recognized university entrance qualification.

Assessment for chemistry standard level (continued)

The assessments aim to test all students' knowledge and understanding of key concepts through:

- applying and using scientific methods and techniques and scientific terminology
- constructing, analysing and evaluating scientific hypotheses, research questions and predictions, scientific methods and techniques, and scientific explanations
- demonstrating both the personal skills of cooperation, perseverance and responsibility appropriate for effective scientific investigation and problem solving, and the manipulative skills necessary to carry out scientific investigations with precision and safety.

Students' success in the chemistry standard level course is measured by combining their grades on an external and internal assessment.

Even multiple-choice questions require that students know what each term or concept means in order to respond correctly, demonstrating an understanding of both basic facts and complex concepts. Calculators are not permitted in the multiple-choice examination, but students are expected to carry out simple calculations.

The internal assessment is of each student's practical or laboratory work. This includes the group 4 project, a total of 10 hours within the standard level course of 150 hours, in which students from different group 4 subjects collaborate in addressing a scientific or technological topic, allowing for concepts and perceptions from across the disciplines that "encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method".

Assessment at a glance

Type of assessment	Format of assessment	Time (hours)	Weighting of final grade (%)
External			76
Paper 1	Multiple choice	.75	20
Paper 2	Data analysis, short answer and open response	1.25	32
Paper 3	Short answer and extended response	1	24
Internal			24
Practical work	Short and long-term practicals or projects; general laboratory work and fieldwork		
	Group 4 collaborative, interdisciplinary project		

IV. Sample questions

The following questions appeared in a previous IB chemistry standard level examination.*

1. Propane, C_3H_8 , undergoes incomplete combustion in a limited amount of air. Which products are most likely to be formed during this reaction? (Paper 1)
 - A. Carbon monoxide and water
 - B. Carbon monoxide and hydrogen
 - C. Carbon dioxide and hydrogen
 - D. Carbon dioxide and water
2. Define the term *average bond enthalpy*. (Paper 2)
3. Explain the technique of reverse osmosis used to produce drinking water from seawater. (Paper 3)

* the syllabus for examinations current until 2016

Learn more about how the IB Diploma Programme prepares students for success at university by going online to www.ibo.org/universities or email us at recognition@ibo.org.

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The IB Diploma Programme, for students aged 16 to 19, is an academically challenging and balanced programme of education that prepares students for success at university and life beyond. Students take courses in six different subject groups, maintaining both breadth and depth of study. Chemistry higher level (HL) is in group 4, experimental sciences. In addition, three core elements—the extended essay, theory of knowledge and creativity, action, service—are compulsory and central to the philosophy of the programme.

About the IB: For over 40 years the IB has built a reputation for high-quality, challenging programmes of education that develop internationally minded young people who are well prepared for the challenges of life in the 21st century and able to contribute to creating a better, more peaceful world.

The IB subject briefs illustrate four key course components in the IB Diploma Programme,

- | | |
|--------------------------------|-----------------------|
| I. Course description and aims | III. Assessment model |
| II. Curriculum model overview | IV. Sample questions |

Overview of the chemistry higher level course and curriculum model

I. Course description and aims

The IB Diploma Programme chemistry course combines academic study with the acquisition of practical and investigational skills through the experimental approach. Students learn the chemical principles that underpin both the physical environment and biological systems through the study of quantitative chemistry, periodicity, kinetics and other subjects. The chemistry course covers the essential principles of the subject and, through selection of options, allows teachers some flexibility to tailor the course to meet the needs of their students.

Throughout this challenging course, students become aware of how scientists work and communicate with each other. Further, students enjoy multiple opportunities for scientific study and creative inquiry within a global context. In addition, the course is designed to:

- provide opportunities for scientific study and creativity within a global context that will stimulate challenge students
- provide a body of knowledge, methods and techniques that characterize science and technology
- enable students to apply and use a body of knowledge, methods and techniques that characterize science and technology
- develop an ability to analyse, evaluate and synthesize scientific information
- develop experimental and investigative scientific skills
- engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities
- develop and apply the students' information and communication technology skills in the study of science
- raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology
- develop an appreciation of the possibilities and limitations associated with science and scientists
- encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method.

II. Curriculum model overview

Chemistry higher level

Theory		180 hours
<i>Core</i>	80 hours of instruction on 11 topics <ul style="list-style-type: none"> • Quantitative chemistry • Atomic structure • Periodicity • Bonding • Energetics • Kinetics • Equilibrium • Acids and bases • Oxidation and reduction • Organic chemistry • Measurement and data processing 	80 hours
<i>Additional higher level</i>	55 hours of instruction on five topics <ul style="list-style-type: none"> • Atomic structure • Periodicity • Bonding • Energetics • Kinetics • Equilibrium • Acids and bases • Oxidation and reduction • Organic chemistry 	55 hours
<i>Options</i>	45 hours of instruction on two additional topics <ul style="list-style-type: none"> • Modern analytical chemistry • Human biochemistry • Chemistry in industry and technology • Medicines and drugs • Environmental chemistry • Food chemistry • Further organic chemistry and conservation 	45 hours
Practical work		60 hours
<i>Investigations</i>		50 hours
<i>Group 4 project</i>		10 hours
Total teaching hours		240 hours

III. Assessment model

Assessment for chemistry higher level

The IB assesses student work as direct evidence of achievement against the stated goals of the Diploma Programme courses, which are to provide students with:

- a broad and balanced, yet academically demanding, programme of study
- the development of critical-thinking and reflective skills
- the development of research skills
- the development of independent learning skills
- the development of intercultural understanding
- a globally recognized university entrance qualification.

The assessments aim to test all students' knowledge and understanding of key concepts through:

- applying and using scientific methods, techniques and terminology
- constructing, analysing and evaluating scientific hypotheses, research questions and predictions, scientific methods and techniques, and scientific explanations
- demonstrating both the personal skills of cooperation, perseverance and responsibility appropriate for effective scientific investigation and problem-solving and the manipulative skills necessary to carry out scientific investigations with precision and safety.

Students' success in the chemistry higher level course is measured by combining their grades on external and internal assessment.

Even multiple-choice questions require that students know what each term or concept means in order to respond correctly, demonstrating an understanding of both basic facts and complex concepts. Calculators are not permitted in the multiple-choice examination but students are expected to carry out simple calculations.

The internal assessment is of each student's practical or laboratory work. This includes the group 4 project, a total of 10 hours within the higher level course of 240 hours, in which students from different group 4 subjects collaborate in addressing a scientific or technological topic, allowing for concepts and perceptions from across the disciplines that "encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method".

Assessment at a glance

Type of assessment	Format of assessment	Time (hours)	Weighting of final grade (%)
External			76
Paper 1	Multiple choice	1	20
Paper 2	Data analysis, short answer and open response	2.25	36
Paper 3	Short answer and extended response	1.25	20
Internal			24
Practical work	Short laboratory practicals and long-term practicals or projects; general laboratory work and fieldwork		
	Group 4 collaborative, interdisciplinary project		

IV. Sample questions

The following questions appeared in previous IB Diploma Programme chemistry higher level examinations.*

1. Which compound can exist as optical isomers? (Paper 1)
A. $\text{H}_2\text{NCH}_2\text{COOH}$
B. H_3CCONH_2
C. H_3CCHBrI
D. HCOOCH_3
2. The molecular formula, $\text{C}_3\text{H}_4\text{Cl}_2$ represents several isomeric compounds. Some isomers are cyclic and some are unsaturated. (Paper 2)
 - (a) Draw the structures of two cyclic compounds that are structural isomers and state the names of both isomers.
 - (b) Two of the non-cyclic compounds have geometrical isomers. Draw the structures of these compounds and their geometrical isomers.
3. Describe aerobic respiration of glucose in the human body, with reference to oxidation and reduction. (Paper 3)

* the syllabus for examinations current until 2016



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

SCHOOL PRINCIPAL INFORMATION SHEET

Researcher: Michelle Tewkesbury, School of Education Policy & Implementation, Victoria University of Wellington

I am writing to invite you and your school to participate in my doctoral research project. The primary focus of this PhD study is the exploration of teachers' perspectives of chemistry teaching and learning in the context of the IBD and NCEA qualifications. Data about the perspectives and practice of chemistry teachers will allow the researcher to determine how teachers manage the tension between learning, teaching and high-stakes assessment. The University requires that ethics approval be obtained for research projects involving human participants.

As part of this study, I am inviting Principals of selected schools that offer IBD and/or NCEA to participate. Participation is voluntary. If you do agree to participate in this research, you will be asked to:

- Participate in one hour long interview;
- Allow access to demographic information about your school;
- Pass on the information sheets to chemistry teachers in your school.

The purpose of the interview is to collect relevant contextual information relating to science curriculum and qualification/s in your school. It is envisaged that the interview would take up to an hour and would be scheduled at a time that is convenient to you. The interview would be digitally recorded (audio only). You may withdraw from participation in this project at any time before the data is transcribed and analysed, that is within two weeks of the interview being conducted.

Interview responses will be kept confidential to the researcher, the research supervisors and the person who transcribes the audio recordings of our interview. Electronic and hardcopy files will be kept in password protected computer drives and offices. Five years after the completion of the research, the audio recordings and transcripts will be destroyed.

Responses collected will form the basis of my research and will be reported on a confidential basis (pseudonyms are to be used and identifying details removed), and so not associated with

the names of the participants or the school. Research findings will be put into a thesis and available for access through the university library and it is intended that one or more articles will be submitted for publication in academic journals and presented at conferences.

If you have any questions, or would like to receive further information about the project, please contact my supervisors:

Dr Azra Moeed
School of Education Policy & Implementation
Victoria University of Wellington
(azra.moeed@vuw.ac.nz)
ph +64 4 463 9643

Dr Jenny Horsley
School of Educational Psychology & Pedagogy
Victoria University of Wellington
(jenny.horsley@vuw.ac.nz)
ph +64 4 463 9643

If you have any ethical concerns about the research, you should contact Dr. Alison Kirkman, Chair of the Victoria University of Wellington Human Ethics Committee (alison.kirkman@vuw.ac.nz).

The research has been approved by the Faculty of Education Human Ethics Sub-committee under delegated authority from the Victoria University Human Ethics Committee. (Approval #SEPI/2013/43 RM19895).

Michelle Tawkechury

Signed:

APPENDIX D: School Principal consent form



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

SCHOOL PRINCIPAL CONSENT FORM

This consent form will be held for a period of five (5) years

I agree to participate in one 60 minute interview under the conditions described in the Information Sheet.

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time. I understand that I may withdraw myself (or any information I have provided) from this project at any time before the data is transcribed and analysed, that is within two weeks of the interview being conducted, without penalty of any sort.

I understand that any information I provide will be kept confidential to the researcher, the supervisor and the person who transcribes the recording of our interview. The published research findings will not use my name or that of the school. I understand that the audio recording of the interview will be deleted 5 years after the completion of the research.

I give consent for my school to participate in this research. Yes No

I am willing to participate in an interview. Yes No

I am willing to provide demographic information about this school Yes No

I am willing to pass on the information sheet to the Chemistry teachers. Yes No

I would like to receive a summary of the results of this research when it is completed. Yes No

Signature:.....Date:.....

Full name – printed:.....School:.....

Email:.....



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

SCHOOL TEACHER (CHEMISTRY) INFORMATION SHEET

Researcher: Michelle Tewkesbury, School of Education Policy & Implementation, Victoria University of Wellington

The primary focus of this PhD study is the exploration of teachers' perspectives of chemistry teaching and learning in the context of the IBD and NCEA qualifications. Data about the perspectives and practice of chemistry teachers will allow the researcher to determine how teachers manage the tension between learning, teaching and high-stakes assessment. The University requires that ethics approval be obtained for research projects involving human participants.

As part of this study, I am inviting teachers of senior chemistry courses of selected schools that offer IBD and/or NCEA to participate. Participation is voluntary. Your participation in this research will involve:

1. An interview
2. Discussion of any documentation that informs your lesson planning
3. Allow the researcher to observe a sequence of lessons (up to four lessons)

You may withdraw from participation in this project at any time before the data is transcribed and analysed, that is within two weeks of the last classroom observation being completed.

It is envisaged that the interview would take up to 90 minutes and would be scheduled at a time that is convenient to you. The interview would be digitally recorded (audio only).

Interview responses and classroom observation sheets will be kept confidential to the researcher, the research supervisors and the person who transcribes the audio recordings of our interview. Electronic and hardcopy files will be kept in password protected computer drives and offices. Five years after the completion of the research, the audio recordings and transcripts relating to the research will be destroyed.

Responses, observations and document analysis from teachers will form the basis of my research findings and will be reported on a confidential basis (pseudonyms are to be used and identifying

details removed), and so not associated with the names of the participants or the school. Research findings will be put into a thesis and available for access through the university library and it is intended that one or more articles will be submitted for publication in academic journals and presented at conferences.

If you have any questions, or would like to receive further information about the project, please contact my supervisors:

Dr Azra Moeed
School of Education Policy & Implementation
Victoria University of Wellington
(azra.moeed@vuw.ac.nz)
ph +64 4 463 9643

Dr Jenny Horsley
School of Educational Psychology & Pedagogy
Victoria University of Wellington
(jenny.horsley@vuw.ac.nz)
ph +64 4 463 9643

If you have any ethical concerns about the research, you should contact Dr. Alison Kirkman, Chair of the Victoria University of Wellington Human Ethics Committee (alison.kirkman@vuw.ac.nz).

The research has been approved by the Faculty of Education Human Ethics Sub-committee under delegated authority from the Victoria University Human Ethics Committee. (Approval #SEPI/2013/43 RM19895).

Michelle Tewkesbury

Signed



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

SCHOOL TEACHER (CHEMISTRY) CONSENT FORM

This consent form will be held for a period of five (5) years

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time. I understand that I may withdraw myself (or any information I have provided) from this project at any time before the data is transcribed and analysed, that is within two weeks of the last classroom observation being completed, without penalty of any sort.

I understand that any information I provide will be kept confidential to the researcher, the supervisor and the person who transcribes the recording of our interview. The published research findings will not use my name or that of the school. I understand that the audio recording of the interview will be deleted 5 years after the completion of the research.

I agree to participate in this study under the conditions specified in the information sheet.

1. I agree to be interviewed Yes No
2. Discuss any documentation that informs my lesson planning Yes No
3. Permit the researcher to observe a sequence of lessons (up to four lessons) Yes No

I would like to receive a summary of the results of this research upon completion. Yes No

Signature:.....**Date:**.....

Full name – printed:.....

School:

Email:

APPENDIX G: Principal: Indicative interview questions



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

PRINCIPAL: INDICATIVE SEMI-STRUCTURED INTERVIEW QUESTIONS

During this interview I seek contextual information and your views of issues around curriculum and qualification/s in your school. Published results will not use your name or that of your school.

- What senior qualifications does your school offer students?

NCEA schools:

- What are positive aspects of implementation of the NCEA (Level 2, 3) in your school?
- What are the challenges of implementation of the NCEA (Level 2, 3) in your school?

Science Curriculum

- What drives decision-making at your school around science curriculum and:
 - Student outcomes
 - Enrolments
 - Student course selection
 - Staffing
 - Resourcing
 - Strategic development
- How is assessment data used to inform teaching and learning at your school?

Dual pathway (NCEA and IBD) schools only:

- What are positive aspects of implementation of the IBD in your school?
- What are the challenges of implementation of the IBD in your school?

NCEA / IBD schools:

Is there anything else you wish to say about curriculum / qualification pathway/s at your school?



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

INDICATIVE: CASE SCHOOL – CHEMISTRY TEACHER INTERVIEW SCHEDULE

During this interview I ask for your perspectives of teaching senior chemistry (NCEA and/or IBD).

Background:

1. Can you tell me about your background as a chemistry teacher?
2. How many years of secondary teaching experience do you have?
3. What experience do you have of different secondary school qualification systems?
4. What is your current teaching load?
5. Does your school offer alternative qualification pathways? If so, how are teaching allocations determined?
6. What departmental responsibilities do you have?

Teaching content and procedural knowledge of chemistry

1. What have been the highlights of your teaching over the last two years?
2. How are senior chemistry courses planned in your department; can you describe the process? Who is involved?
 - a. What source / reference materials guide your course / unit planning?
3. How involved are you in the course planning process?
4. Overall, what are the main considerations in course planning?
 - a. Possible elements from NZC
5. In practice, what are the key considerations for you in teaching a unit of work?
6. What teaching strategies work well for your students; how do you know?
 - a. Think about your Yr 12 Chemistry class, what approaches did you use to teach organic chemistry?
7. To what extent is practical work part of your teaching units?
8. How much of the practical work done over the year is open-ended investigation?
9. What teacher professional development have you undertaken that has been relevant to your teaching of senior chemistry courses?
10. What type of professional development opportunities would be most useful to you in the future?

11. What opportunities exist for you to discuss curriculum and pedagogy developments with other chemistry teachers?
12. What aspects of NCEA / IBD do you like the most?
13. What aspects of NCEA / IBD do you like the least?

Approaches to assessment

1. How would you describe your approaches to assessment in chemistry?
2. Over the course of the school year, what proportion of teaching time is dedicated to assessment / preparation for assessment?
3. Of the topics that are taught, which are being attempted by students in external examinations?
4. How confident are you in marking internal assessments in NCEA / IBD?
5. What are your experiences of external moderation of internal assessment in NCEA / IBD?
6. IBD only: can you describe your experience with EEs in chemistry?
7. In the chemistry course you teach, what scope is there for learning that is not assessed summatively?
8. In your department, how is assessment data used to inform teaching and learning?
9. NCEA only: Do you have any comments that you would like to make on the realignment of standards?
10. Do you have any other comments you would like to make related to assessment of the course you teach?

Preparation of students for university

1. What do you think are the key skills and competencies that students need to be able to successfully go on to university courses in chemistry?
2. How well do you think that the NCEA / IBD course prepares students for university courses in chemistry?

Michelle Tewkesbury
School of Education, Victoria University of Wellington

APPENDIX I: Class observation



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

INDICATIVE: CLASSROOM OBSERVATION AND RUNNING RECORD

Purpose: *To record teaching practice in senior chemistry class (NCEA or IBD), so as to allow interpretation of relationships between curriculum, pedagogy and assessment*

Date: 11/7 Day: Thurs Period: 3/4 (double)
Year Level: 12 Course: NCEA Number of students present: 29

Lesson Overview: (topic, objectives)

Redox (int) 'Redox Reactions Circus'

Start of lesson:

- Visual organizer used
 - Purpose of lesson outlined to students
 - Links made to previous lesson
 - Other:
- Looking at colour changes for reactions
• Identifying oxidant/reductant
• Writing eqns
- ^{to} Link (to assessment)

Running record: to be completed and appended

Post- Observation Notes

(framework based on Tyler, 2009)

Encouraging active engagement with ideas and evidence	
Challenging students to develop meaningful understandings	Questions of students about balancing...
Linking science with students' lives and interests	Ref to hypochlorite ions in bleach.
Catering for individual students learning needs	
Embedding assessment within the science learning strategy	Questions ✓ Focus on prep ⁿ for internal assessment.
Representing the nature of science and its different aspects	
Linking science with the broader community	
Exploring learning technologies for their learning potentialities	

Students very focused on learning activities throughout and teacher efficient in directing activities.

11/07
P3
(double)

YHANCE

10:30 Start P3 Redox

T: We are doing a prac today...

Has handout for reaction prac on ^{projected} whiteboard

Assignment due in terms

0:45

T: Handing out cards for students.

Review of requirements for prac...

Tomorrow: go over equations...

Demo:

hypochlorite ion OCI⁻ (not on p. 56)
found in Janda

What is oxidation number of
Cl in this ion?

T: Goes through this.

Then demo, and shows students how to carry out
reaction, and record colour changes.

Sets students task... balancing eqns

T: At whiteboard, checking balancing $\frac{1}{2}$ eqns.

Further instructions... about

②

T: Having ops of students chemicals required. for
Exp B ...
C ...
reagents
(as per
boards)

Students carrying out reagents @ benches.

T: Safety-gear under benches, 'get your glasses on!'

S - quietly on task.

T - circulating, working @ students to help write
eqns.

(Students from accelerated class last year, not
working on anything)

T: Questioning students.

morning tea break.

Shortened period due to extended morning
tea.

T: Quickly gets students underway / rotates
to next station in circuit activity.

Students really focused on task - silent work

2:05pm (only 10 min remaining of period)

Students recording colour changes, teacher
on laptop @ front (50%)

3

T circulating to group, giving advice.

T: 'another minute... then change'
- reminder about wearing safety glasses.

working c table group of 3 to explain observations / linked to species.

Raise + table / change.

Prac continues c students largely on task.

12:07

T returns to laptop
Some students off task. (ignored by T)
T - looking for materials / back to laptop.

2:14

Some students quietly discussing reactions and observations, generally (except for very focussed and off-task 3) on-task.

2:15 T working c go a front of class, helping c writing of eqns / explaining species.

ditto.

'We are out of time' - raise + tables

& put away
call for coloured cards. A Duo turn

④

Students move, clean up, rinse + tubes, pack up
quietly & leave.



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

STUDENT INFORMATION SHEET

My name is Michelle Tewkesbury and I am studying to do a PhD in chemistry education. The primary focus of this PhD study is the exploration of teachers' perspectives of chemistry teaching and learning in the context of the IBD and NCEA qualifications. Data about the perspectives and practice of chemistry teachers will allow me to determine how teachers manage the tension between learning, teaching and high-stakes assessment.

As part of this study, I am inviting teachers of senior chemistry courses of selected schools that offer IBD and/or NCEA to participate. Your chemistry teacher has agreed to take part in my research. As part of my data collection your teacher has agreed to be interviewed and for me to observe your class for up to four lessons. The focus of my observation is how your teacher teaches chemistry. Your participation in this research will involve:

- Allowing me to observe the teaching in your chemistry class.
- Audio record the lesson.

You may withdraw from participation in this project at any time before the data is transcribed and analysed, that is within two weeks of the last classroom observation being completed. Five years after the completion of the research, the audio recordings and transcripts relating to the research will be destroyed.

Responses, observations and document analysis from teachers will form the basis of my research findings and will be reported on a confidential basis (pseudonyms are to be used and identifying details removed), and so not associated with the names of the participants or the school. Research findings will be put into a thesis and available for access through the university library and it is intended that one or more articles will be submitted for publication in academic journals and presented at conferences.

If you have any questions, or would like to receive further information about the project, please contact my supervisors:

Dr Azra Moeed
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Dr Jenny Horsley
School of Educational Psychology & Pedagogy
Victoria University of Wellington
(jenny.horsley@vuw.ac.nz)
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If you have any ethical concerns about the research, you should contact Dr. Alison Kirkman, Chair of the Victoria University of Wellington Human Ethics Committee (alison.kirkman@vuw.ac.nz).

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Michelle Tewkesbury

Signed



A comparative analysis of the National Certificate of Educational Achievement and International Baccalaureate Diploma chemistry courses: Curriculum, pedagogy and assessment.

STUDENT CONSENT FORM

This consent form will be held for a period of five (5) years

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time. I understand that I may withdraw myself (or any information I have provided) from this project at any time before the data is transcribed and analysed, that is within two weeks of the last classroom observation being completed, without penalty of any sort.

I understand that any information I provide will be kept confidential to the researcher, the supervisor and the person who transcribes the recording of our interview. The published research findings will not use my name or that of the school. I understand that the audio recording of the classroom observation will be deleted 5 years after the completion of the research.

I agree to participate in this study. Yes No

I agree to the researcher observing my chemistry class. Yes No

I agree to audio recording of the lesson. Yes No

I would like to receive a summary of the results of this research when it is completed. Yes
No

Signature:.....Date:.....

Full name – printed:.....

School: Email:

APPENDIX M: List of codes

List of codes

C_Teachers' and DPs' perspectives and implementation of curriculum

1_Evaluation of curricula

NCEA

a_AS structure has led to fragmentation of subject

b_Students' focus on credits vs learning a concern

c_Impact of the re-alignment process

d_Implications for student selection by universities

IBD

e_Challenging to teach

f_Professionally satisfying to teach

Scholarship:

g_Professional satisfaction derived from extension / scholarship teaching

h_Selection of scholarship candidates

2_Planning courses

NCEA

a_Time for curriculum planning

b_Working collaboratively with colleagues

c_Using dedicated school time: not enough of it

3_Resources used in planning

NCEA

a_Utilisation of NZQA AS / TKI/ texts and resources published by NZIC

b_Reliability issues with resource material

IBD

c_Subject guide and other OCC resources

d_Modifying available resources to suit instruction time

4_Alternative curricula

IBD/NCEA

a_Rationale for offering IBD

b_IBD alignment with existing school culture

c_Lifting school results

d_Selection of qualifications by students

e_Managing perceptions of two qualifications

f_Consulting staff about teaching loads

NCEA

g_Intentions re split of vocational and academic curriculum

5_Clarity of curriculum

NCEA

a_Insecurities around interpretation of AS

b_Uncertainty re criteria and marking

c_Scholarship: wanting more information from MoE re Schol

IBD:

d_Explicit curriculum statements referred to

6_Course selection

NCEA

- a_University impact on school course selections and design
- b_Student course selections changing over time

7_Course design

NCEA

- a_Maximising credit offerings in courses
 - b_Reservations (T) about course design
 - c_Inclusions of all external AS
 - d_Quality of passes
 - e_Aiming for course endorsements / improved results overall (trend towards more internals)
 - g_Flexibility and accessibility in course design are positives
 - h_Inclusions of all external AS in courses questioned by SM
- IBD*
- i_Options are engaging contexts for students

8_Preparedness of students

- a_Maths skills of students going in to Yr 12 chemistry
- b_for university chemistry courses

A_Teachers approaches to assessment

1_Workload

NCEA

- a_Staff being under pressure with workload issues
- b_Trend towards more internal assessment has workload impacts
- c_Students being under pressure with internals throughout the year
- d_Realignment

2_Internal assessment

NCEA

- a_Seeing impacts on learning behaviours
 - b_Focus on attaining high grades
 - c_Rehearsal
 - d_Being uncomfortable with experiences of external moderation
 - e_Perceived inequity with marking between schools
-
- f_Planning / writing internal assessments not supported with time allocation
 - g_Under-resourced
 - h_Trend towards more internal assessment
 - i_Grade expectations
- NCEA / IBD*
- j Internally assessed components meeting needs of students

3_External assessment

NCEA

- a_Speculation on reasons for poor (and SNA) results

NCEA/IBD:

- b_Teachers feeling accountable for results of students (data analysis)
- c_Senior management directing departments to meet result expectations in individual subjects

4_Formative assessment

NCEA/IBD:

- a_Planning for AtL
- b_Marking work and giving feedback

5_Teaching to assessment

NCEA

- a_Working back from assessment to plan teaching programme
- b_Emphasising rehearsal with similar tasks prior to summative assessment task being set
- c_Teaching time impacted by amount of assessment

P_Pedagogical approaches utilised by chemistry teachers

1_Practical work

NCEA/IBD

- a_open-ended investigation
- b_practical work done (all types)

2_Reflective practice

NCEA/IBD

- a_Teaching practice being amended in response to student outcomes
- b_Identifying students who are struggling and initiating interventions
- c_Using data to inform teaching

3_Favoured learning strategies

NCEA/IBD

- a_Including practical work, demonstrations
- b_Using models
- c_Variety of teaching approaches to suit different learners
- d_Use of ICT
- e_Teacher-led instruction
- f_Encouraging students to work collaboratively in small groups
- g_Teaching strategies compromised by time constraints

4_PD

NCEA

- a_participation in cluster groups
- b_PD run by other schools
- c_Desire for PD related to AS delivery

IBD

- d_Subject specific training workshops

IBD/NCEA

- e_School-wide focus on pedagogy
- f_Upskilling with use of ICT in practice

g_Preparing new digital resources

h_Within departments: opportunities for professional dialogue with colleagues

Also:

T comments about student motivation

Allocation of departmental responsibilities

APPENDIX N: Teaching planner: Case school 2

TERM 1 13 CHEM

k	DATE:	Monday	Tuesday	Wednesday	Thursday	Friday
1	29/1- 1/2		Yr10-13 staggered	Yr 9 Orientation	C 3.7 Redox	
2	4/2-8/2			WAITANGI DAY		
3	11/2-15/2					
4	18/2-22/2					
5	25/2-1/3					Int-Assess Test
6	4/3-8/3	C 3.4 Bonding				
7	11/3-15/3					
8	18/3-22/3					
9	25/3-29/3					GOOD FRIDAY
10	1/4-5/4	EASTER MONDAY				
11	8/4-12/4					Ext-Test
12	15/4-19/4	C 3.6 Aqueous				

TERM 2

Wk	DATE:	Monday	Tuesday	Wednesday	Thursday	Friday
1	6/5-10/5					
2	13/5-17/5					Teacher only day (L3)
3	20/5-24/5					Teacher only day (L3)
4	27/5-31/5					
5	3/6-7/6	QUEENS BIRTHDAY				
6	10/6-14/6					Ext - Test
7	17/6-21/6	C 3.1 Invest				
8	24/6-28/6					
9	1/7-5/7					Due : Mon 5 th Aug
10	8/7-12/7	C 3.5 Organic				

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TERM 3

Wk	DATE:	Monday	Tuesday	Wednesday	Thursday	Friday
1	29/7-2/8					
2	5/8-9/8					
3	12/8-16/8					
4	19/8-23/8					
5	26/8-30/8					
6	2/9-6/9					Ext - Test
7	9/9-13/9				Senior Exams	Senior Exams
8	16/9-20/9	Senior Exams	Senior Exams	Senior Exams	Senior Exams	Senior Exams
9	23/9-27/9					

TERM 4

Wk	DATE:	Monday	Tuesday	Wednesday	Thursday	Friday
1	14/10-18/10					
2	21/10-25/10					
3	28/10-1/11	LABOUR DAY				
4	4/11-8/11					
5	11/11-15/11			Junior Exams	Junior Exams	Junior Exams
6	18/11-22/11					
7	25/11-29/11					
8	2/12-6/12					
9	9/12-10/12					



National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TĀEA

Alignment of the Chemistry Standards with the New Zealand Curriculum (2007)

August 2011

The Ministry of Education, in association with the New Zealand Qualifications Authority and subject associations, is working to align the standards with *The New Zealand Curriculum* (NZC). The scope of this project includes all standards that are linked to the curriculum outcomes at curriculum levels 6-8.

Purpose

The purpose of this project includes:

- developing L1-3 standards aligned with the outcomes from curriculum levels 6-8
- addressing any duplication of standards issues
- addressing any credit parity issues.

Process

The process has been guided by:

- the direction of the NZC – in particular the values, principles and key competencies
- the Principles for Standards Review
(<http://www.nzqa.govt.nz/news/releases/2008/170608.html>)

The principles guiding the standards review can be summarised as:

- A standard must be derived from a curriculum or established body of knowledge.
- A standard must have a clear purpose.
- A standard must allow valid and reliable assessment.
- Grade distinctions (between A, M and E) must be based on qualitative differences in achievement. Grade distinctions should not be based on the candidate being required to acquire and retain more subject-specific knowledge.
- Credit Parity - one credit should reflect a notional 10 hours of learning, practice and assessment for an average candidate.
- Standards should not duplicate one another. Duplication occurs when the central knowledge/skills, understandings, and competencies specified for a standard are all largely similar to those of another standard.

In addition to this, decisions have been made that give effect to:

- All standards derived from learning areas in the NZC will be achievement standards (and not necessarily limited to 24 credits per level).
- The numbers of standards assessed in an external time bound written examination at any one level will be limited to three per subject. Independent advice from assessment experts clearly indicates that for valid assessment in such examinations a candidate needs a minimum of one hour for each standard.

Current curriculum based unit standards that are below NZC level 6

If the unit standard no longer links to the NZC or its links are below curriculum level 6 and does not duplicate another standard but is well used in the wider education sector, it may be recommended to NZQA the standard be retained. Any such unit standards that NZQA determines warrant retention will be reviewed and the curriculum link removed.

Development of Level 3 Chemistry Standards

The Level 3 Chemistry Achievement Standards have been developed to align the outcomes with level 8 of the Material World strand of the Science Learning Area of the NZC and, where appropriate, the Nature of Science (NoS) strand.

The intention of the Achievement Aims of the Material World strand is that all three achievement objectives along with NoS objective regarding the use of language, symbols and conventions would be integrated in each context explored in a chemistry teaching programme. This would encourage students to use their understanding of the structures and interactions of the particles that make up a substance to explain observations of the properties of that substance. They would represent particles and reactions using appropriate symbols and equations and they will relate their knowledge of chemistry to authentic human contexts e.g. biological, historical, economic and environmental.

AS Chemistry 3.1 *Carry out an investigation in chemistry involving quantitative analysis.*

Curriculum Links: Material World L8 AO1 - Investigate and measure the chemical and physical properties of groups of substances.

Relationship to current standards

- Is a modified version of previous achievement standard AS3.1
- Is still internally assessed and data collection is done individually.
- Title does not include "Develop" as this is inherent in "carrying out" the investigation.
- Explanatory notes for Merit and Excellence only list the additional requirements to those for the lower levels of achievement.
- The requirement in the current AS3.1 to investigate a possible trend has been extended to include a pattern. Investigating a possible trend is dependent on being able to measure the independent variable. Adding a pattern allows a wider range of choice of independent variable where the variable needs to be able to be described but not necessarily measured.
- Consumer testing/quality control is still not acceptable at this level.

- A clearly identified purpose is required. Students will select their own purpose but the context can be limited by the school/teacher.
- Valid conclusion has been replaced for Merit by a conclusion based on the processed data relevant to the purpose of the investigation.
- Checks for reliability of procedure have been removed to reduce the time needed for this assessment and because it has limited meaning statistically. Instead reliability should be inherent in the evaluation which explains why the data should be trusted.
- For Excellence it is now expected that the purpose is linked to background information i.e. background information helps define the reason. Relevant background information must be included for Merit.
- Log book remains central to assessment – it is a working document that shows evidence of the ongoing process.
- Control of significant variables has been moved up to merit as part of a procedure to develop quality data.
- Merit now has discussion of procedure and reliability of data because there is a connection between these two – requires recognition of the effect of the procedure on reliability of data.
- The investigation is guided by the teacher. See moderator newsletter August 2008 for advice regarding guidance.

AS Chemistry 3.2 *Demonstrate understanding of analytical techniques in chemistry*

Curriculum Links: Material World L8 AO1 - Investigate and measure the chemical and physical properties of groups of substances. AO3 - Apply knowledge of chemistry to explain aspects of the natural world and how chemistry is used in society to meet needs, resolve issues, and develop new technologies.

Relationship to current standards

- This is a new standard developed to meet the need to retain a practical assessment as well as the investigation in Level 3 AND to respond to sector feedback that modern techniques in chemistry are introduced at this Level.
- While some aspects of the standard are similar to the previous AS3.2 there is no credit parity with the old standard. The new standard is 3 credits which equates to 30 notional hours which would usually be mean 3-4 weeks of teaching.
- Internally assessed.
- Two aspects of chemical analysis are assessed - qualitative and quantitative.
- The quantitative technique assessed is a back titration involving oxidation reduction or complexometric reactions. This provides a considerable step up from Level 2 (AS2.1). A blank titration is required so that students need to collect two sets of titration data.
- The level of accuracy in the titration determines Achievement (i.e. greater accuracy is not required for M and E). Accuracy of calculations using the collected data determines Merit and Excellence.
- There are three qualitative techniques that could be assessed. Only one is needed for Achievement. At this level students are able to interpret the

- spectra of simple organic molecules and have a basic knowledge of how the technique works.
- For Merit students are required to link data from at least two different spectroscopic techniques to the structural features of given molecules.
 - For Excellence they will be required to solve the structures of simple organic molecules using data from at least two different spectroscopic techniques.
 - A wide range of possible functional groups is given to allow for a variety of assessment contexts. The number of carbons is limited to 5 to keep the data manageable.
 - Tables will be provided for interpretation of data e.g. fragments (mass spec), characteristic absorptions (ir) and shifts (nmr).
 - A portfolio would be an appropriate way to assess this standard as aspects of it may be taught and assessed at different times in the teaching programme.
 - Examples of integrated problems:
<http://orgchem.colorado.edu/hndbksupport/spectprob/problems.html>

AS Chemistry 3.3 *Demonstrate understanding of the role of chemistry in the world around us*

Curriculum Links: Material World L8 AO3 - Apply knowledge of chemistry to explain aspects of the natural world and how chemistry is used in society to meet needs, resolve issues, and develop new technologies.

Nature of Science L8 AO 1- Understand that scientists have an obligation to connect their new ideas to current and historical scientific knowledge.

Nature of Science L8 AO2 - Develop and carry out investigations that extend their science knowledge, including developing their understanding of the relationship between investigations and scientific theories and models.

Nature of Science L8 AO3 - Use accepted science knowledge, vocabulary, symbols and conventions when evaluating accounts of the natural world and consider the wider implications of the methods of communication and/or representation employed.

Relationship to current standards

- This is a new standard.
- It is not intended that this be a research based standard. Information is to be provided by the teacher for students to process and interpret to make connections between a recent discovery or development in chemistry and the related chemical principles or processes.
- Information could be from a list of websites or written material.
- The use of correct formulae and balanced equations where appropriate is implicit in the requirement that chemistry vocabulary, symbols and conventions are used.

AS Chemistry 3.4 *Demonstrate understanding of properties of particles and thermochemical principles*

Curriculum Links: Material World L8 AO1 - Investigate and measure the chemical and physical properties of groups of substances

Material World L8 AO2 - Relate properties of matter to structure and bonding. Develop an understanding of and use the fundamental concepts of chemistry (for example, equilibrium and thermochemical principles) to interpret observations.

Relationship to current standards

- Retains all aspects of the current AS3.4.
- Emphasis at Merit and Excellence is on links between the properties of particles, the properties (now defined) of the substances they form.
- The concept of entropy has been introduced so that it can be considered alongside enthalpy in discussions of spontaneity of reactions. Entropy calculations are not included.
- Writing equations and correct use of formulae has not been specified as it is implicit in the requirement that chemistry vocabulary, symbols and conventions are used.

AS Chemistry 3.5 *Demonstrate understanding of structure and reactivity of organic compounds*

Curriculum Links: Material World L8 AO1 - Investigate and measure the chemical and physical properties of groups of substances.

Material World L8AO2 - Relate properties of matter to structure and bonding. Develop an understanding of and use the fundamental concepts of chemistry (for example, equilibrium and thermochemical principles) to interpret observations.

Relationship to current standards

- Retains most of material from current AS3.5.
- Esters are now introduced at this level as one of the carboxylic acid derivatives.
- Major and minor products of elimination are now included.
- Reduction of aldehydes using LiAlH_4 has been introduced to give more scope for reaction pathways and provide reversal of some oxidation reactions.
- Emphasis at Merit and Excellence is on links between structure, functional groups, physical properties and the reactivity of organic compounds.
- Writing equations and correct use of formulae has not been specified as it is implicit in the requirement that chemistry vocabulary, symbols and conventions are used.

AS Chemistry 3.6 *Demonstrate understanding of equilibrium principles in aqueous systems*

Curriculum Links: Material World L8 AO1 - Investigate and measure the chemical and physical properties of groups of substances

Material World L8 AO2 - Relate properties of matter to structure and bonding. Develop an understanding of and use the fundamental concepts of chemistry (for example, equilibrium and thermochemical principles) to interpret observations.

Relationship to current standards

- Retains all aspects of current AS3.6.
- Writing equations and correct use of formulae has not been specified as it is implicit in the requirement that chemistry vocabulary, symbols and conventions are used.

AS Chemistry 3.7 *Demonstrate understanding of oxidation-reduction processes*

Curriculum Links: Material World L8 AO1 - Investigate and measure the chemical and physical properties of groups of substances.

Material World L8 AO2 - Relate properties of matter to structure and bonding. Develop an understanding of and use the fundamental concepts of chemistry (for example, equilibrium and thermochemical principles) to interpret observations.

Relationship to current standards

- Retains material from current AS3.7 but is now assessed internally.
- The decision to keep this as a separate achievement standard rather than incorporating it into one of the three external standards was based on sector feedback.
- Electrolysis has been moved from Level 2 to Level 3 where it is more appropriate to consider it alongside electrochemical cells.
- The major emphasis of this standard is on electrochemical cells and the application of these in understanding the spontaneity of chemical reactions and relative strength of oxidants and reductants.
- There is scope for practical work to be part of the assessment.
- Writing equations and half equations has not been specified as it is implicit in the requirement that chemistry vocabulary, symbols and conventions are used.
- Emphasis at Merit and Excellence is on links between links between oxidation-reduction processes, observations, equations and calculations.
- Knowledge of preferential discharge in electrolytic cells is not required.
- 'State' has been removed from the required knowledge of oxidants and reductants as it is implicit in 'appearance'.
- CO has been removed from the list of reductants because not practical is to use it in school laboratories.
- Sulfite and hydrogensulfite have been bracketed with SO₂ for completeness
- Appropriate calculations for this standard include those using electrode potentials and the relationship between oxidation numbers and equation stoichiometry.
- A written test would be an appropriate way of assessing this standard.

Achievement Standard

Subject Reference	Chemistry 2.7		
Title	Describe oxidation-reduction reactions		
Level	2	Credits	3
		Assessment	External
Subfield	Science		
Domain	Chemistry		
Registration date	20 October 2004	Date version published	20 October 2004

This achievement standard involves describing oxidation-reduction reactions.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
<ul style="list-style-type: none"> Describe oxidation-reduction reactions. 	<ul style="list-style-type: none"> Apply oxidation-reduction principles. 	<ul style="list-style-type: none"> Discuss oxidation-reduction processes.

Explanatory Notes

- This achievement standard is derived from achievement objectives 7.1, 7.2 and 7.3 in *Chemistry in the New Zealand Curriculum*, Learning Media, Ministry of Education, 1994, p. 23.
- Knowledge of appearance and state of the following reactants and their products is required. Oxidants are limited to: O_2 , I_2 , Cl_2 , H^+ , Fe^{3+} , H_2O_2 , MnO_4^- (aq)/ H^+ , $Cr_2O_7^{2-}$ (aq)/ H^+ . Reductants are limited to metals, C, CO, H_2 , Fe^{2+} , Br^- , I^- , SO_2 (HSO_3^-). Appropriate information relating to any other oxidants or reductants will be provided.
- Aspects of oxidation-reduction include:
 - determine oxidation numbers
 - write balanced oxidation-reduction equations
 - identify oxidants and/or reductants
 - recognise the ability of halogens to act as oxidants in reactions with other elements, water or halide ions.
- Oxidation-reduction reactions may be assessed in the context of simple electrolytic cells. Knowledge of preferential discharge is not required.

5 Terms:

- *Describe* requires the student to identify, name, draw, give characteristics of, or an account of.
 - *Discuss* requires the student to show understanding as to how or why something occurs by linking chemistry ideas/principles. It may involve students in justifying, relating, evaluating, comparing and contrasting, analysing.
-

Quality Assurance

- 1 Providers and Industry Training Organisations must be accredited by the Qualifications Authority before they can register credits from assessment against achievement standards.
- 2 Accredited providers and Industry Training Organisations assessing against achievement standards must engage with the moderation system that applies to those achievement standards.

Accreditation and Moderation Action Plan (AMAP) reference

0226

Achievement Standard

Subject Reference	Chemistry 2.7		
Title	Demonstrate understanding of oxidation-reduction		
Level	2	Credits	3
		Assessment	Internal
Subfield	Science		
Domain	Chemistry		
Status	Registered	Status date	17 November 2011
Planned review date	31 December 2014	Date version published	17 November 2011

This achievement standard involves demonstrating understanding of oxidation-reduction.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
<ul style="list-style-type: none"> Demonstrate understanding of oxidation-reduction. 	<ul style="list-style-type: none"> Demonstrate in-depth understanding of oxidation-reduction. 	<ul style="list-style-type: none"> Demonstrate comprehensive understanding of oxidation-reduction.

Explanatory Notes

- This achievement standard is derived from *The New Zealand Curriculum*, Learning Media, Ministry of Education, 2007, Level 7. The standard is aligned to the Nature of Science achievement objectives and the Material World achievement objectives, and is related to the material in the *Teaching and Learning Guide for Chemistry*, Ministry of Education, 2010 at <http://seniorsecondary.tki.org.nz>.
- Procedures outlined in *Safety and Science: a Guidance Manual for New Zealand Schools*, Learning Media, Ministry of Education, 2000 should be followed.
- Demonstrate understanding* involves describing, identifying, naming, giving an account of oxidation-reduction and describing oxidation-reduction reactions. This requires the use of chemistry vocabulary, symbols and conventions.

Demonstrate in-depth understanding involves making and explaining links between oxidation-reduction reactions, observations and equations. This requires explanations that use chemistry vocabulary, symbols and conventions.

Demonstrate comprehensive understanding involves justifying, evaluating, comparing and contrasting, or analysing links between oxidation-reduction reactions, observations and equations. This requires the consistent use of chemistry vocabulary, symbols and conventions.

- 4 *Oxidation-reduction* is limited to:
- oxidation numbers
 - electron transfer in reactions
 - oxidants and/or reductants
 - observations for reactions
 - balanced oxidation-reduction half equations
 - overall balanced oxidation-reduction equations.
- 5 Knowledge of the appearance of redox reactants and their products includes a selection from, but is not limited to:
- oxidants include a selection from, but not limited to: O_2 , I_2 , Br_2 , Cl_2 , OCI^- , H^+ , Fe^{3+} , Cu^{2+} , H_2O_2 , MnO_4^-/H^+ , $Cr_2O_7^{2-}/H^+$, concentrated HNO_3 , IO_3^-
 - reductants include a selection from, but not limited to, metals, C , H_2 , Fe^{2+} , Br^- , I^- , H_2S , SO_2 , SO_3^{2-} , HSO_3^- , H_2O_2
- 6 Conditions of Assessment related to this achievement standard can be found at www.tki.org.nz/e/community/ncea/conditions-assessment.php.
-

Replacement Information

This achievement standard replaced unit standard 8947 and AS90311.

Quality Assurance

- 1 Providers and Industry Training Organisations must have been granted consent to assess by NZQA before they can register credits from assessment against achievement standards.
- 2 Organisations with consent to assess and Industry Training Organisations assessing against achievement standards must engage with the moderation system that applies to those achievement standards.

Consent and Moderation Requirements (CMR) reference

0233

<p>Comments A Grade boundary too broad</p> <p>Observing impacts (advers) of internals not by students sacrificing learning</p> <p>Valuing down of chemistry</p> <p>Missing links / no realising</p> <p>Objecting to internal assess in chemistry</p> <p>In demand for results (being unrealistic) (from school)</p> <p>Feeling pressure to have students attain Es in internals</p> <p>Assessment to learn</p> <p>Giving 'formatives' (in use of practices)</p> <p>Feeding back to students</p> <p>Creating digital resources for home use</p> <p>Providing opportunities for students to succeed in summatives</p>	<p>458</p> <p>459</p> <p>460</p> <p>461</p> <p>462</p> <p>463</p> <p>464</p> <p>465</p> <p>466</p> <p>467</p> <p>468</p> <p>469</p> <p>470</p> <p>471</p> <p>472</p> <p>473</p> <p>474</p> <p>475</p> <p>476</p> <p>477</p> <p>478</p> <p>479</p> <p>480</p> <p>481</p> <p>482</p> <p>483</p> <p>484</p> <p>485</p> <p>486</p> <p>487</p> <p>488</p> <p>489</p> <p>490</p> <p>491</p> <p>492</p> <p>493</p> <p>494</p> <p>495</p>	<p>I was an employer and I had someone come in with an A. I think that the internal assessment is overbearing in some aspects and that it encourages students if they get enough credits to not focus on externals in some of those topics, and some of those topics in chemistry are so important, and because they've got the credits they don't need to get the credits somewhere else and they will sacrifice that learning for that. This is my personal opinion. I have a feeling that my subject is being watered down, in that the knowledge that the students used to have is being diluted. I go back to the mole. When that became an internal and we got rid of things like % composition, and doing empirical formulae different ways, that seemed too hard, and we got rid of it. We don't talk about the mole outside of the mole internal, I don't like that. I find that very difficult to justify from a chemical point of view. I can see how it suits quite well for some other subjects, Drama and so on, where you would want internally assessed stuff, that's fine. But, in my subject, I have a problem with it. I have a problem with where it is going. I don't think all students need or are capable of doing chemistry to a level where... We are at the stage now where everybody is able to take Yr 12 Chemistry and they should be able to get Es and so on.</p> <p>I believe there is a bell curve and I am going to try and get my kids into the top of the bell curve. But, the pressure in internals for them all E's because it makes the school look good, is false and I think we are mis-educating the children.</p> <p><i>How would you describe your approaches to assessment in chemistry (Yr 12 & 13)?</i></p> <p>32m 44s</p> <p>I like to think of assessment to learn, I've always done that before it came out as a saying. So, my formative testing is really important to me. Giving the kids little quizzes, having assessments – little formative tests which I mark. I like giving feedback to the students as to where they are and also now with the internals there. A lot of things that I wrote last year on Youtube, they can go home and check the answer to a problem that we did in class. That is where I see assessment, as helping them get to the point where they can do the summative assessment and do really, really well, be confident in that.</p>	<p>A1b ✓</p> <p>A2i</p> <p>C1c ✓</p> <p>A2i</p> <p>A4a ✓</p> <p>A4b</p> <p>P3d</p> <p>A4a</p>
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19 June 2013

Michelle Tewkesbury
PhD student
Victoria University of Wellington Faculty of Education
C/- School of Educational Policy and Implementation
Donald Street
Wellington

Dear Michelle

RE: Ethics application SEPI/2013/43 RM 19895

I am pleased to advise you that your ethics application '**A comparative analysis of the National Certificate of Educational Achievement and the International Baccalaureate Diploma courses in chemistry: Curriculum, pedagogy and assessment**', with the required changes, has been approved by the Victoria University of Wellington Faculty of Education Ethics Committee. Please note that the approval for your research to commence is from the date of this letter.

Best wishes for your research.

Yours Sincerely

Dr Sue Cornforth

Co-Convener
Victoria University of Wellington Faculty of Education Ethics Committee

APPENDIX T: Ethics SEPI/2013/53 Addendum



FACULTY OF EDUCATION
PO Box 17-310 Wellington 6012, New Zealand
Website www.victoria.ac.nz

12 July 2013

Michelle Tewkesbury
PhD student
Victoria University of Wellington Faculty of Education
C/- School of Educational Policy and Implementation
Donald Street
Wellington

Dear Michelle

RE: Ethics application SEPI/2013/53 Addendum to SEPI/2013/43 RM 19895

I am pleased to advise you that your ethics application addendum to 'A comparative analysis of the National Certificate of Educational Achievement and the International Baccalaureate Diploma courses in chemistry: Curriculum, pedagogy and assessment', with the required changes, has been approved by the Victoria University of Wellington Faculty of Education Ethics Committee. Please note that the approval for your research to commence is from the date of this letter.

Best wishes for your research.

Yours Sincerely

Dr Sue Cornforth

Co-Convener
Victoria University of Wellington Faculty of Education Ethics Committee

SCHOOLS PARTNERSHIP OFFICE

Ken Rapson
MSc (Hons) Dip Tchg
Director

The HOD Science/Physics



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Dear HOD Science/Physics

We hope the following information will help you to develop Level 3 Physics courses for next year.

The University of Auckland Engineering Faculty has considered the revised Level 3 Physics standards for implementation in 2013 and has changed the entry requirements for Engineering.

Please note that from 2014 students intending to study Engineering at The University of Auckland are required to have at least 16 external credits in Physics. (This is a change from the 2013 entry requirement of 18 credits in Physics). 20 or more credits in Physics is preferred.

The standards required are:

- AS 3.3 Demonstrate understanding of wave systems
- AS 3.4 Demonstrate understanding of mechanical systems
- AS 3.6 Demonstrate understanding of electrical systems

These Achievement Standards cover the most essential content in terms of student preparation for the study of Engineering. Students with high rank scores and at least 18 credits in Physics without all of the required achievement standards may still be considered for places in Engineering but the three required standards will be the first consideration when selecting students for the Bachelor of Engineering (Honours) degree.

(The Mathematics requirements have also changed to at least 17 external credits in Calculus (ie all of AS 3.5, 3.6, 3.7, 20 or more credits preferred).

If you have any questions about these entry requirements for Engineering at The University of Auckland please contact me.

Yours sincerely

Ken Rapson

APPENDIX V: NZQA Principal's Report

NZQA

New Zealand Qualifications Authority
Mana Tohu Matauranga O Aotearoa

Qualify For The Future World
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Principal's Report -

This new set of reports compares your school's last five years of student achievement against the national figures as well as giving comparisons with schools within the same decile band. A number of performance indicators are detailed including NCEA Levels 1, 2, 3, and University Entrance (UE) by school years 11, 12, and 13.

New UE requirements came into effect from 1 March 2014 and were informed by a wide ranging NZQA-led review in 2010. The overall purpose of the changes (most notably the requirement to achieve NCEA Level 3; requirement for 14 credits from each of three approved subjects; increased literacy requirements) was to tighten the UE standard.

The change in UE attainment is in line with expectations, given the changes to requirements.

Overall Achievement in NCEA and UE - Participation Based

- [Overall Achievement in NCEA and UE](#) (PDF)
- [Overall Achievement in NCEA and UE](#) (Excel)

Overall Achievement in NCEA and UE - Roll Based

- [Overall Achievement in NCEA and UE](#) (PDF)
- [Overall Achievement in NCEA and UE](#) (Excel)

Literacy and Numeracy

- [Literacy and Numeracy](#) (PDF)
- [Literacy and Numeracy](#) (Excel)

NCEA Certificate Endorsement

- [NCEA Certificate Endorsement](#) (PDF)
- [NCEA Certificate Endorsement](#) (Excel)

**NCEA Certificate Endorsement:
PR4 - Current Year Results by Percentage**

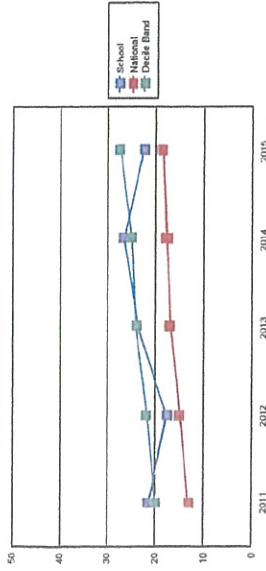
Decile 8-10

Academic Year	Year 11			Year 12			Year 13		
	NCEA Level 1	NCEA Level 2	NCEA Level 3	NCEA Level 1	NCEA Level 2	NCEA Level 3	NCEA Level 1	NCEA Level 2	NCEA Level 3
Excellence									
2011	21.3	12.7	8.3	13.3	8.2	7.4	20.0	12.3	10.3
2012	17.6	20.3	12.5	15.1	11.9	8.3	21.9	17.1	11.1
2013	23.8	20.5	14.7	17.1	13.3	11.4	24.0	18.7	14.5
2014	26.5	24.4	13.2	17.8	14.3	12.8	25.0	19.6	16.1
2015	22.4	26.7	19.5	18.6	14.9	13.8	27.5	21.8	17.6

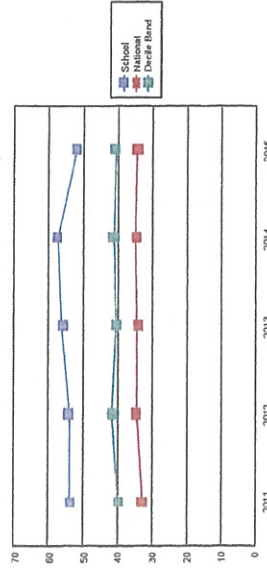
Merit

2011	53.9	40.5	26.7	33.0	21.6	23.4	39.8	28.1	29.2
2012	54.1	43.2	33.3	34.7	26.4	24.2	41.6	33.1	30.3
2013	56.2	45.2	47.1	34.4	26.6	28.5	40.5	33.4	34.5
2014	57.5	42.2	38.2	34.9	26.8	28.9	41.2	33.2	34.8
2015	52.0	47.8	47.1	34.5	26.5	28.5	40.7	33.8	34.4

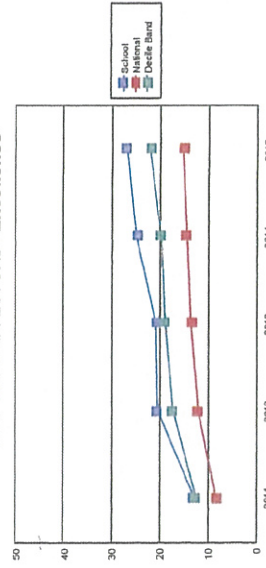
Year 11 NCEA Level 1 - Excellence



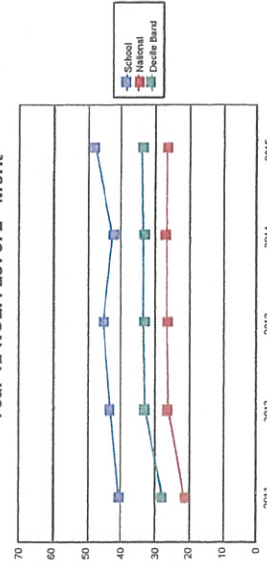
Year 11 NCEA Level 1 - Merit



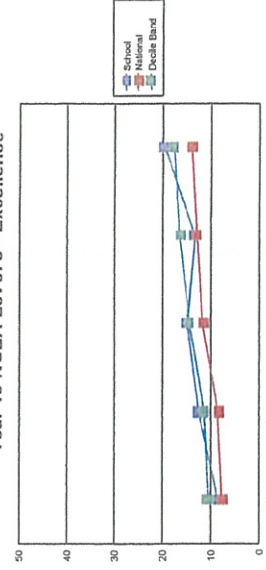
Year 12 NCEA Level 2 - Excellence



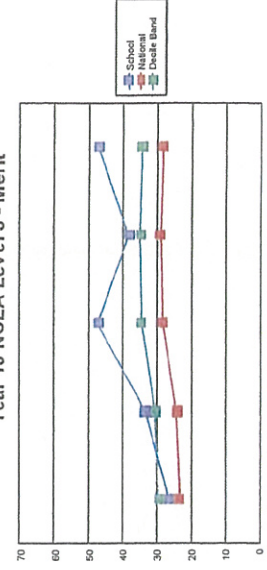
Year 12 NCEA Level 2 - Merit



Year 13 NCEA Level 3 - Excellence



Year 13 NCEA Level 3 - Merit

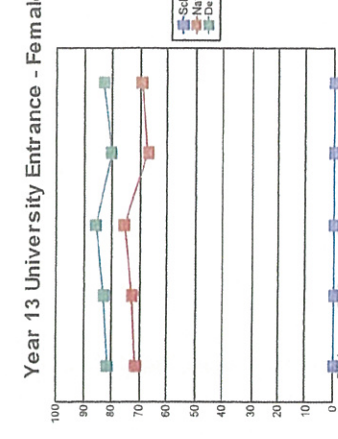
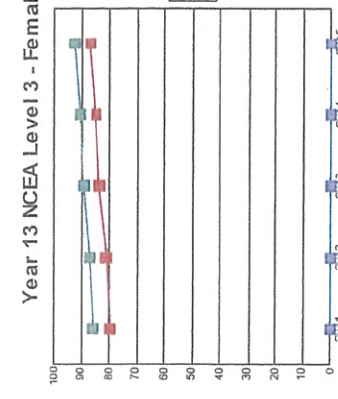
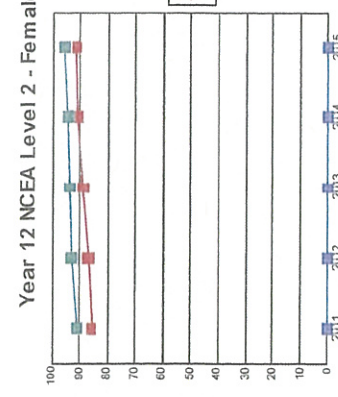
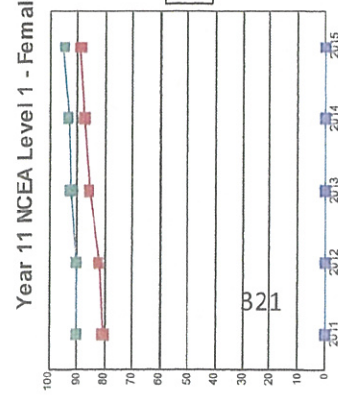
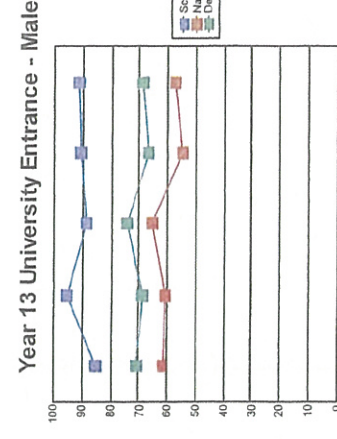
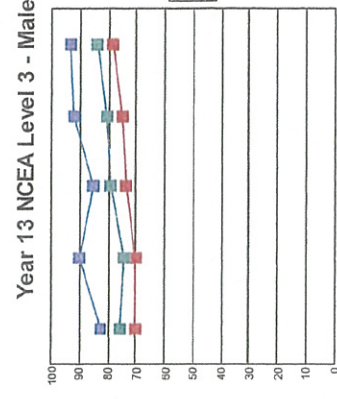
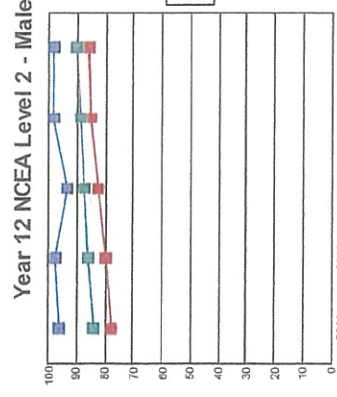
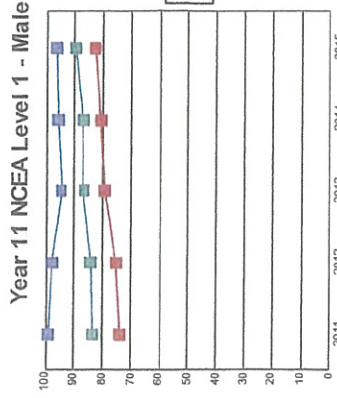


Achievement in NCEA and UE:

PR1 - Participation-Based Current Results by Gender

Generated 6/30/2016

Academic Year	National				Decile 8-10			
	Year 11 NCEA L1	Year 12 NCEA L2	Year 13 NCEA L3	Year 13 UE	Year 11 NCEA L1	Year 12 NCEA L2	Year 13 NCEA L3	Year 13 UE
Male								
2011	98.9	96.3	82.2	84.9	73.8	77.8	70.4	61.7
2012	97.7	97.4	90.0	95.0	75.6	80.0	70.0	60.8
2013	94.6	93.6	85.0	88.8	79.4	82.4	74.0	65.2
2014	95.8	97.8	91.9	90.4	81.0	85.2	75.3	54.7
2015	96.1	97.8	93.5	91.4	82.6	85.7	78.1	57.1
Female								
2011					80.8	85.6	79.6	70.9
2012					82.2	87.0	81.0	72.6
2013					85.7	88.8	83.6	75.1
2014					87.3	90.9	84.7	66.8
2015					88.5	91.3	86.8	68.8



Achievement in NCEA and UE:

PR1 - Participation-Based Current Overall Results

Generated 6/30/2016

Academic Year	National				Decile 8-10			
	Year 11 NCEA L1	Year 12 NCEA L2	Year 13 NCEA L3	Year 13 UE	Year 11 NCEA L1	Year 12 NCEA L2	Year 13 NCEA L3	Year 13 UE
2011	98.9	81.9	75.4	66.8	86.8	87.4	81.3	76.5
2012	97.7	83.6	76.0	67.3	87.4	89.3	81.2	76.5
2013	94.6	85.7	79.2	70.6	89.3	90.4	84.4	80.2
2014	95.8	88.1	80.4	61.3	90.2	91.6	85.9	73.7
2015	96.1	88.5	82.8	63.4	92.1	92.8	88.4	76.3

