Contents

Introduction

This dissertation compares the types of Level 2 science courses delivered in three New Zealand secondary high schools to ask about the consequences of the types of courses for students' progression in science subjects. The large body of longitudinal national research describing changes in the New Zealand high school science curricula since the restructuring of the New Zealand Curriculum (NZC) in 2007, is presented in chapter one to provide an overview of the issues involved concerning the course types available to students. That chapter also provides an overview of the re-structuring including an account of the introduction of the National Certificate in Educational Achievement. The sociological concerns raised in the research prompted me to compare different types of Level 2 science courses in terms of the opportunities they provide to students. Some Level 2 science courses advance to Level 3 subjects and enable students to proceed to tertiary study including vocational courses and university academic study. Other Level 2 science courses have no progression, and ultimately less career options for the student.

To understand why some science subjects enable students to progress while others inhibit progression, the concepts of knowledge structures and pedagogy developed by Bernstein (2000) are used to compare the characteristics of the courses. Bernstein developed his concepts to explain how schools as institutions reproduce socioeconomic class structures in society. According to Bernstein the knowledge structures and pedagogy that characterise student learning environments either encourage or diminish student opportunities for 'enhancement', 'inclusion' and 'participation' in society. The aim of this research study was to see if Bernstein's theory can be applied to the types of science courses that I investigated. Did the type of knowledge in the respective courses encourage or diminish students' opportunities to progress with their science studies? Were courses that did not enable students to progress more likely to be offered to certain socioeconomic or ethnic groups?

The research conducted for this dissertation involved interviewing five teachers from three different high schools in a medium sized city in New Zealand. All three schools had student populations of around 1500 pupils. The decile rankings of the schools ranged from medium (decile six) to high (decile nine). The teachers who agreed to be interviewed each taught a year 12 science subject. Three teachers taught academic subjects. These were either Year 12 Physics and or Year 12 Chemistry. The other two teachers taught non-academic subjects: Year 12 Horticulture and Agriculture, and Year 12 General Science. Each of the Year 12 science subjects were classified according to the knowledge types and pedagogy that characterised the course. The classification typology I developed (see Table 2, page 39) as the analytical methodology was developed from Bernstein's theory of knowledge structures (2000). Accordingly academic subjects such as physics and chemistry are characterised by vertical and non-contextualised features while the less academic and more practical subjects are structured horizontally and are more context dependent. The type of knowledge structure affects the pedagogy used. This is included in the classification typology.

The study of the science courses is located within the wider context of restructuring of the New Zealand science curriculum and the concluding discussion in this dissertation theorises the unintended consequences of that restructuring. It considers the specific effects of the two types of science courses on students' opportunities to continue with science and examines the wider sociological effects of the relationship between students' socio-economic class location and their access to certain knowledge types.

Chapter 1: Restructuring of the New Zealand curriculum

Intentions

In 2004 the New Zealand Qualifications Authority introduced the National Certificate in Educational Achievement (NCEA) assessment certification for Level 1 (Year 11) through to Level 3 (Year 13). The Certificate was supported by a new version of the New Zealand Curriculum published by the Ministry of Education in 2007. The new assessment introduced criterion referenced standards with the purpose of increasing student motivation, raising school leavers' attainment and creating a seamless transition between school and other vocational and academic providers (Meyer, McLure, Walkey, Weir, & McKenzie, 2009). It also involved redefining student success as competency in pre-defined standards. Success was no longer limited to a set number or percentage of students but to any student that met the criteria. Under the former norm based systems, only the highest achieving students experienced success. Norm based assessment involved ranking students from first to last and failing the bottom fifty per cent of students in each subject. If a student failed too many subjects the student's options were to leave school or repeat the year. Norm based assessment had the effect of lowering the motivation of less able students (Meyer, McLure, Walkey, Weir, & McKenzie, 2009). In contrast, criterion referenced standards allow any student who gains competency in a standard to gain an 'Achieved' grade in that standard. Most subjects are composed of seven or eight standards so a grade of 'Not Achieved' in one standard does not prevent the student achieving the other standards in that subject.

Apart from creating more assessment opportunities for student success, the criterion referenced standards allow schools to create pathways or combinations of subject options that allow all students at all levels to be included in education. Hipkins (2013a) describes the "foundational intent of the NCEA" as "learning for all" (p. 75). By acknowledging and including vocational and academic knowledge all students are able to have a pathway or "a journey from early childhood through secondary school and, in many cases on to tertiary training in one of its various forms" (New Zealand Curriculum, 2007, p. 41). The Ministry of Education has identified Level 2 NCEA as the "minimum qualification that will keep learners' future career pathways open" (Hipkins, 2013a, p. 5) and has set a specific target for 85% of school leavers to attain Level 2 NCEA by 2017 (Hipkins, 2013a).

Curriculum Restructuring

Science has been a secondary school subject in New Zealand since the middle of the 20th century (Bull, Gilbert, Barwick , Gilbert, & Baker, 2010). Following the 1944 Thomas Report's recommendation that New Zealand introduce a national core curriculum, the first science syllabus was included in the first post primary school curriculum in 1959 (Bell, Jones, & Carr, 2008). Regular curriculum reviews were undertaken every decade, for example The Curriculum Review in 1987 recommended that there should be a common curriculum for all schools up to Form 5 (Year 11), with an emphasis on a broad and general education (Bell, Jones, & Carr, 2008).

Traditionally New Zealand school subjects were developed or recontextualised directly from university subject equivalents by the University Examination Board (UEB) which set the University Entrance and University Bursary Examination. The UEB was dismantled in 1989 when the New Zealand Qualifications Authority was established and further science curriculum development was contracted out (Bell, Jones, & Carr, 2008). Science teachers became the main contributors to science curriculum writing, although business people were consulted through the Ministerial Task Group Reviewing Technology and Science Education. Feedback from the commercial sector noted that "problem solving skills and communication skills [had been] neglected in favour of the acquisition of knowledge" (Bell, Jones, & Carr, 2008, p. 84). These views were influential in the restructuring of the New Zealand science curriculum.

Schools' science curricula must be based on the New Zealand Curriculum (2007) which is a self-described framework curriculum that "gives schools direction for teaching and planning… rather than a detailed plan" (Ministry of Education, 2014). The curriculum seamlessly progresses across eight levels for Years 1 to 13. The expectation is that most students transitioning to senior school in Year 9 are meeting level four or level five criteria (New Zealand Curriculum, 2007). The curriculum is divided into Values, Key Competencies and Learning Areas. This places Values such as 'Excellence', and Key Competencies such as 'Participating' and 'Contributing', on an equal footing with Learning Areas such as Science. By encouraging teaching professionals to reflect on more than just subject content and on how that content is delivered to the learner, the NZC (2007) shows its commitment to equity and the citizenship purpose of the curriculum. However, the question of what should be taught, is left unanswered and the word ‘knowledge’ is conspicuously absent from the New Zealand Curriculum (2007) document. Other Ministry of Education reports vaguely define knowledge as a combination of skills and traditional canon content (Bolstad, 2011), a position which supports the logic behind dividing the Science Learning Area of the New Zealand Curriculum (2007) into five strands: Physical World, Material World, Living World, Earth and Space, and Nature of Science. Nature of Science and Developing Skills and Attitudes are identified as the unifying or integrating strands that incorporate skills and values whereas the other four strands contain the traditional canon content. Each strand contains a number of Learning Objectives for each Year Level which gives schools a broad platform from which to create their own science curricula. Although the system delegates curricula design to schools all senior science curricula are ultimately dictated by the New Zealand Qualifications Authority assessment for certification (Torrance, 2011) named the New Zealand Certificate of Educational Achievement (NCEA).

Since the introduction of the New Zealand Curriculum (2007) and NCEA assessment (2004), schools are offering an increasing number of new science courses to senior students. Schools no longer follow a prescribed science curriculum designed by a "community of practitioners" (Young, 2010a, p. 21) but are able to create science curricula to meet their local student needs. This flexibility is possible because criterion referenced standards allow individual school departments to decide the content and assessment of courses (New Zealand Curriculum, 2007, p. 41) by splicing together internal and external Achievement Standards and Unit Standards across Year levels and subject boundaries (Pilcher & Philips, 2007; Alison, 2005). Thus individual teachers act as curriculum designers (Ormond, 2013), creating curricula “for tacit or explicit social, political or economic ends” (Bull, Gilbert, Barwick , Gilbert, & Baker, 2010, p. 4).

This learner centred approach to curriculum development (Boud, 2000) aims to meet different students’ needs which are defined as utilitarian, pre-professional training, intellectual or citizenry (Bull, Gilbert, Barwick , Gilbert, & Baker, 2010). Bell, Jones and Carr (2008) conclude “both aims (“science for all” and “science for future scientists”) were included in the New Zealand Curriculum to please the different lobby groups within science education" (p. 88). This was to be achieved with the modularisation of criterion referenced standards assessment. According to this approach modularisation supports learner centred approaches by providing students with clearly defined learning outcomes. New Zealand was not alone in the shift to modularisation. The use of criterion referenced standards in modularised assessment follows an international trend towards defining what students should know or what students can do (Phillips, 2010; Raffe, 1994)

Unexpected consequences, the New Zealand Center for Educational Research studies

The New Zealand Centre for Educational Research (NZCER) has conducted nationwide research over ten years using surveys and interviews with students, principals, trustees, teachers and parents from 124 schools (Hipkins, 2007; Hipkins, 2013a; Hipkins, 2013b; Hipkins & Vaughan, 2012; Hipkins, Vaughan, Beals, & Ferral, 2004). The research has been used to report on NCEA implementation, subject choice availability and demographics as well as perceptions of NCEA. One report is focussed entirely on the impact of Level 1 NCEA on the teaching of mathematics and science (Hipkins & Neill, 2003). A brief summary of some concerns raised by the research is presented here.

According to Hipkins (2013a) teachers of mathematics, science and technology were most likely to state that the target for 85% of students to gain Level 2 NCEA is not realistic, that it is in fact undesirable. Teachers from the anonymous interviews commented: "It is meaningless. If it is achieved universities will simply raise the bar for university entrance and other measures are taken to ensure there is an ample supply of under qualified school leavers available to employers for unskilled work" (Hipkins, 2013a, p. 71). "Like all assessments of student achievement that also are used to rank a cohort, inflation of the number of achievements devalues the system and another measure will be found to separate out the groups of individuals. It is likely that lifting the achievement rate of students at level 2 will result in the search and use of a ranking system other than NCEA" (Hipkins, 2013a, p. 71).

The concerns of the teachers quoted above are part of larger concerns about the value of the inclusion into school science of non-academic subjects and pathways and the meaning of success (Alison, 2005). However these educators' concerns are not given credence by the Ministry of Education and the New Zealand Council for Educational Research. For example, Ministry of Education researchers explain that the system does not identify any intrinsic distinction between pathways. Vaughan describes it in this way:

> Now, the term "pathways" is an attempt to recognise success as something more than just academic achievement in schools. Other, non-academic pathways are as valid as the academic ones. You can see this in the way the status and profile of non-academic pathways has been raised, in the past year in particular. For example, Industry Training Organisations are now recognised as Tertiary Education Organisations alongside polytechnics and universities. (Vaughan, 2003, p. 2)

In this passage Vaughan explains how the effect of restructuring the education system has been to socially (and financially) acknowledge more commercially orientated tertiary organisations. Obviously some students have always moved on to vocational training post-secondary school. However this dissertation considers how vocational training displaces academic knowledge within schools. This displacement is made possible by changes to school curricula and assessment that assign equal value to trainability and critical thinking. Beck (2002) defines trainability as "fostering of receptiveness to whatever set of objectives and contents comes along next" (p. 624) and is used to reduce the separation between education and production. Thus Vaughan's comment shows the shift to a more strongly instrumental or utilitarian notion of the purpose of education that characterises the neoliberal period of the post-1970s. Education is no longer to be 'the great leveller' that offers citizens of all backgrounds the same rights to "enhancement, inclusion and participation in society" (Bernstein, 2000, p. xx),

The main NZCER researcher, Rosemary Hipkins (2007, 2013a) implies that the reason for the low achievement of some students lies with the traditional academic subjects themselves and that the new pathways equivalence approach will overcome the hurdle set by academic subjects. Accordingly, “The thought that with the appropriate *curriculum support* [emphasis added] greater numbers of students could raise their achievement levels… confronts the view of these subjects (foundational subjects; Math, English, Science, History)… as gatekeepers of academic quality” (Hipkins, 2013a, p. 75).

However, in contrast to the researchers, teachers do distinguish between pathways. Teachers are aware that failure to meet prerequisites for future academic subjects will limit the student’s tertiary options. The intention to equalise academic and non-academic success is based on the faulty premise that there is no selection criteria at the tertiary level. In contrast this dissertation explains why selection criteria increase at each level of academic education due to the nature of knowledge at that level. In Hipkins’ Report (2013a) only fifty nine percent of teachers as opposed to ninety one percent of principals thought the school provided enough direction to ensure students keep their pathways open (p. 33). This reveals the potential rift in focus between senior management and teachers created by the system as senior management focus on meeting Ministry of Education target rates of achievement and classroom teachers focus on the practical job of adding real value to student achievements. One teacher from Hipkins’ Report (2013a) states: “The value of Level 2 NCEA qualification is highly dependent on the subjects taken and the usefulness in future employment or courses of study. There are too many fun type courses/classes that are really not worth much… they don’t lead to proper jobs” (p. 72). A principal cited in the Report (Hipkins, 2013a) also acknowledged that the consequences of equalising pathways between academic and non-academic subjects are not the intended ones of raising achievement. Instead the standards to be achieved are lowered. “The target leads to schools offering low level courses to help students gain Level 2. We do not believe it is the right target. Gaining success in academic courses is more valid” (p. 72).

Hipkins (2013a) summarises this chapter in the research report with the observation that the “pre-existing judgements of the lesser value of more practical learning” (p. 77) has been facilitated by the division of assessment into unit standards and achievement standards. Achievement standards allow a form of ranking because students achieve to different extents: not achieved, achieved, endorsed with merit or endorsed with excellence whereas unit standards use a binary achieved, not achieved assessment. The Report (Hipkins, 2013a) recommends these “tacitly held” judgement values need to be “shifted” by “professional learning” for teachers (p. 77). The problem is understood to be the teachers themselves rather than the academic and non-academic equivalence problem identified by the teachers and principals who are cited in the Report (Hipkins, 2013a).

These citations from the interviews with teachers and principals show that these educators acknowledge that different assessment types contain different knowledge types. However the Report itself (Hipkins, 2013a) uses the interview material to argue that the teachers’ views about the non-equivalence of academic and non-academic subjects demonstrates their tacitly held value judgements; judgements that the Report writers recommend changing through professional learning. The Report’s (Hipkins, Vaughan, Beals, Ferral, & Gardiner, 2005) recommendation that the more practical courses assessed by the unit standards be conflated with the academic courses assessed by the achievement standards indicates that the difference in knowledge types is not to be recognised. Indeed the comment that teachers value the knowledge in the academic courses differently from the knowledge in the unit standards and that this valuation requires ‘shifting’ shows a clear preference by the Report writers for the conflation of knowledge types based on the assumption that there is not (or should not be) a differentiation. At the very least the Report assumes that if there are different knowledge types, then these are imposed onto the knowledge by the teachers’ value judgements and the value differential should be removed. It is necessary to note at this stage that such assumptions about the nature of knowledge types is crucial for the analysis in this dissertation. Chapter two uses the theories of Basil Bernstein to argue that the knowledge types are ‘real’ concepts and not value judgements imposed onto the knowledge.

Teachers also expressed concern that NCEA assessment has changed knowledge within traditional academic courses as knowledge is translated from the general achievement objectives in the NZC (2007) to highly specific statements in NCEA modules. This has the effect of reducing the volume of knowledge in academic courses in an effort to ‘rehearse’ that knowledge. Hipkins’ (2013a) reported an increase in the proportion of principals, teachers and trustees who saw NCEA driving the curriculum as a “major issue facing their school” (p. iv), and observed junior classes being taught the same content as senior classes in an effort to prepare and practise for assessment (Hipkins, 2013).

The discrepancy between broad curriculum objectives in the NZC and narrow assessment objectives in NCEA standards particularly affects the knowledge contained in the Nature of Science strand. Although the NZCER recognises the value of this epistemic knowledge and has encouraged teachers to continue developing Nature of Science in their practice (Hipkins, 2013), NCEA assessment limits its relevance to curricula. Despite being identified in the NZC (2007) as the "overarching unifying" strand (p. 28), Nature of Science is only assessed within one internal Achievement Standard for Biology, Physics, Chemistry or Earth Science. Some have criticised these singular internal Achievement Standards as too simple, and focussing only on fair testing. Linear sequential thinking is fostered in place of reiterative cyclical thinking (Moeed & Hall, 2011). A chicken and egg scenario has developed with teachers being criticised for failing to embrace the unifying Nature Of Science (NOS) methodology encouraged by the NZC (2007) (Bull, Gilbert, Barwick , Gilbert, & Baker, 2010). On the other hand teachers accuse the realigned NCEA standards of failing to "capture the intent" of the NZC especially in the Science Learning Area (Hipkins, 2013a, p. 24). Consequently teachers have reported that without the development of Nature of Science knowledge throughout the year, unifying theories that link concepts are omitted (Alison, 2005), leaving a disparate collection of isolated facts lacking authentic thinking experiences (Gilbert, 2004).

The objective of the 2013 NZCER Report to realise the equivalence of all knowledge types in the interests of social equity has been implicit in the reports intermittently released during the decade long research undertaken by the NZCER for the Ministry of Education under the leadership of Rosemary Hipkins. The earlier 2007 Report 'Course Innovation in the Senior Curriculum' adopted the term 'course innovation'. This phrase was coined by Marshall (1999) pre-NCEA to study how schools "coped with issues of course provision and student retention" (Pilcher & Philips, 2007, p. 153). In Hipkins' 2007 Report course 'innovation' post NCEA is separated into four types which are paraphrased below:

1. Innovating curricula by recombining units from traditional academic courses within one Learning Area

For example a Level 2 course could be titled 'General Science' and include achievement standards about Waves from Physics, Genetics from Biology and Aqueous Chemistry. This 'Citizens' Science' course may aim to enable young people to make better decisions about issues regarding communications or genetic modification.

2. Innovating curricula by recombining units from traditional academic courses from different Learning Areas

For example achievement standards from Geography, Maori and Biology could be combined to create a 'Maori Ecology' course. Local sites could be explored and student knowledge extended to include cultural and scientific perspectives.

3. Innovating curricula by recombining achievement standards and unit standards from one Learning Area

For example Plant Biology, Plant Propagation and Forestry could be combined to create a 'Horticulture' course. Students could gain a theoretical understanding of the different plant structures as well as practical skills to grow plants.

4. Innovating curricula by recombining components from different levels

For example Level 2 Ecology could be combined with Level 2 Statistics and Level 1 Diving to create a 'Marine Biology' course. The student would gain diving proficiency and perhaps collect data or have an appreciation of how data is collected. The data could be analysed using statistics and applied to an ecological theory.

Three years earlier the 2004 Learning Curves Report (Hipkins, Vaughan, Beals, & Ferral, 2004) had identified three core curriculum pathways being practised within eight secondary schools: 'traditional discipline', 'locally redesigned' and 'contextually focussed'. The Learning Curves research described the differences between the course types with language that was to change significantly by the 2007 course innovation Report (Hipkins, 2007). The 2004 research still characterised the Level 2 science courses using terms from Bernsteins' (1971) "typology of subject types" (Hipkins, Vaughan, Beals, & Ferral, 2004, p. 70). By 2007 the language of course innovation shows the significant shift in approach from acknowledging academic and non-academic subject types to the course innovation approach which conflates the two types into one knowledge type. In that year, 17 percent of schools had created alternative or innovative versions of Year 12 sciences (Hipkins, Course innovation in the senior secondary curriculum: A snapshot taken in July 2007, 2007). Innovated courses were advertised as offering an alternative pathway crossing over traditional academic subject boundaries to focus on “real world” science (Hipkins, Course innovation in the senior secondary curriculum: A snapshot taken in July 2007, 2007, p. vii).

However, as the interviews in the 2013 Report (Hipkins, 2013a) show, teachers retained the idea of academic and non-academic knowledge types despite the researchers recommending that teachers shift away from such differentation through professional development designed to alter their “tacitly held” (Hipkins, 2013, p. 77) judgements about the higher value of academic courses.

The comparison between the three core curriculum pathways described in the Learning Curves Report (Hipkins, Vaughan, Beals, & Ferral, 2004) and the integrated pathways of the 2013 Report shows a significant shift by influential researchers (Hipkins, 2013a) to conflating academic and non-academic knowledge. The Learning Curves Report (Hipkins, Vaughan, Beals, & Ferral, 2004) gathered empirical data from six secondary schools and identified three core curriculum pathways “Traditional Discipline, Locally Redesigned and Contextually Focussed” (p. xvii) which I have paraphrased below:

1. Traditional Discipline

Strongly classified subjects that have “the boundaries between the individual disciplines… closely guarded and carefully maintained” (Hipkins, Vaughan, Beals, & Ferral, 2004, p. 70). These subjects were assessed only by achievement standards with the maximum number of achievement standards; for example a chemistry course containing only chemistry achievement standards. The organisation of these courses “reflect traditional ways of thinking about the structure and content of each discipline or subject within the school curriculum” (Hipkins, Vaughan, Beals, & Ferral, 2004, p. xvi). A year later, The 2005 Learning Curves Report (Hipkins, Vaughan, Beals, Ferral, & Gardiner, 2005) showed the influence of social equity beliefs on the shift to conflating academic and non-academic subjects by splicing together the two types using the pathways approach. The 2005 Learning Curves Report stated that “Päkehä students were more likely to be taking traditional-discipline versions of these “core” curriculum courses” (Hipkins, Vaughan, Beals, Ferral, & Gardiner, 2005). The underlying assumption is that social equity is to be achieved, not by raising the standards of students of other ethnic groups who were under-achieving, but by altering the academic subjects so that more students can succeed. Maori and Pacifica students tended to take a contextualised version of mathematics (Hipkins, Vaughan, Beals, Ferral, & Gardiner, 2005). The following two recommended changes to the core curriculum pathways show how this change to academic subjects is to be achieved.

2. Locally Redesigned

Weakly classified subjects assessed with a mix of achievement and unit standards with less content coverage and variations in pacing possible; for example schools had developed physical sciences courses with achievement standards from chemistry, physics and science (Hipkins, Vaughan, Beals, & Ferral, 2004, p. 97).

3. Contextually Focussed

Weakly framed courses that have "the power to select, organise, and pace students' learning" (Hipkins, Vaughan, Beals, & Ferral, 2004, p. 70) shared between teacher and student. These courses were likely to be assessed internally only via unit standards with a reduced number of credits offered. Content in the courses had explicit links to future employment, skills and everyday life (Hipkins, Vaughan, Beals, & Ferral, 2004, p. 180). For example schools offered training in National Certificates in occupations such as Electronics, Agriculture and Forestry (Hipkins, Vaughan, Beals, & Ferral, 2004, p. 106).

The empirical data from the 2004 Learning Curves project was analysed by Ferral (2005) to identify clusters of subject choice for different ethnic groups. Five clusters or subject groupings were identified for Level 2 NCEA. This following table is adapted from p.19:

Table 8: Year 12 cluster characteristics

Overall descriptions of subjects which characterise the clusters

Cluster 1 n = 165	Cluster 2 n = 91	Cluster 3 n = 77	Cluster 4 n = 62	Cluster 5 n = 163
Traditional English	Traditional English and Maths	Alternative English and Maths	Alternative English	Traditional English and Maths
Alternative Maths	All 3 traditional Sciences	Alternative Science	Traditional Maths	Accounting
Other practical	Other academic	Electronics	Science	Science
Arts subjects		Other practical	Accounting / IT	Other Academic
				Other Practical

The predominant cluster(s) that were identified by ethnicity were highlighted in Table 9 as:

- Asian: cluster 4
- Maori and Pacific Islander: cluster 3
- European: clusters 1, 2 and 5

Ferral (2005) concluded that the results did not have predictive powers but “interesting patterns” (p. 29) emerged. Strong relationships between differences in subject choice and gender and ethnicity were evident but Ferral observes that these effects were compounded by the school that the student attended. Because individual schools have their own organisational culture (Barth, 2002) and decide their own curricula, students’ choice of school essentially determines their subject choices. Student school choice is complicated by compulsory zoning which constrains the majority of students within their socioeconomic grouping. These ethnicity patterns continue to be identified by NZCER and other research that show how subject versions effectively stream students into career pathways with this streaming having an inequitable ethnic dimension (Pilcher & Philips, 2007).

In the 2005 Learning Curves Report Hipkins describes the “hardening of the academic/vocational divide by producing active compliance with the sorting of students into strongly differentiated courses”. Some pathways have no opportunity for further academic study in that field and essentially “fizzle out”

(Hipkins, Vaughan, Beals, Ferral, & Gardiner, 2005, p. xiv). By 2013 Hipkins, (2013a) acknowledged that the situation is unlikely to change because the recent NCEA course endorsement changes will likely “sharpen the divisions” between courses with Achievement Standards and Unit Standards (p. 3). Thus the current system is rather confused because while it insists all credits are equal, some credits are more equal than others because they can be endorsed. Subject endorsement is possible for students who gain 14 credits at Merit or Excellence level in that subject. Level I, II or III endorsement is possible if students gain at least 50 credits at Merit or Excellence in that level. Universities have begun to offer scholarships to students with Level III endorsement and so course endorsement is used as a *de facto* ranking system by universities. Despite this evidence the NZCER has continued to encourage subject innovation and equivalence of pathways. It is an approach that rejects the distinction between knowledge types as ‘tacitly held’ value judgements.

The effect of the equivalence pathways is to stimulate student achievement while limiting that achievement to non-academic forms. This non-academic achievement can confuse students and parents especially from low decile backgrounds in navigating pathways to university (Jensen, McKinley, & Madjar, 2010). Parents with little education themselves are most dependent on school educators to direct students into a pathway that leads to further opportunities as they are unaware of the type of knowledge required to proceed to advanced study in that subject. One Maori parent of a Year 11 student explained:

> She [daughter] chose them [subjects], and then told me what she was doing – I didn’t think it was a good idea if she wanted to be a lawyer. So I made her go back and re-discuss it… I’m hoping that having gone back and re-discussed it, that those people in that role have enough understanding to help her make better choices. (Jensen, McKinley, & Madjar, 2010, p. 41)

This chapter raises the philosophical questions which underpin the research study: Can poor academic achievement of particular social groups including low socioeconomic groups and Maori (Phillips, 2010) be addressed by ‘innovating’ the science curriculum to create non-academic science subjects that lack academic progression? Can increased educational outcomes for all be defined as ‘success’ if *relative* differences in opportunities between socioeconomic groups remain fixed? According to the literature (Hipkins, 2013a; Hipkins, Vaughan, Beals, & Ferral, 2004), despite the equitable intentions of the New

Zealand Curriculum (2007) and NZCER's promotion of course innovation, school subjects have experienced a 'hardening' between vocational training and academic learning. My research seeks to add to this literature by investigating how the 'hardening' between academic and non-academic courses is occurring in Level 2 science courses. I use a conceptual methodology that addresses the type of knowledge characterising the course, the pedagogy associated with the course, the disciplinary identities formed within each course and the opportunities for progression – defined by Bernstein as: individual enhancement, inclusion and participation (Bernstein, 2000, p. xx).

Chapter 2: Background sociology and research questions

The discussion of the New Zealand Centre for Educational Research longitudinal study (Hipkins, 2007; Hipkins, 2013) along with Feral's (2005) analysis reveals contradictions in the design of science courses following the 2004 assessment changes and the 2007 curriculum re-structuring. These contradictions centre around the question of whether traditional academic science subjects are structurally different from traditional practical science subjects. The purpose of the assessment and curriculum re-structuring was to reject such differentiation as one imposed by teachers' tacit value judgements and find a way to conflate the two types of courses into 'innovated' subjects. It is worth noting that earlier research (Hipkins, Vaughan, Beals, & Ferral, 2004) contradicted this position by also including references to the different knowledge types in a way that appeared to recognise their validity.

In addition, the two Reports (Hipkins, 2007; Hipkins, 2013a) and other studies (Ferral, 2005; Pilcher & Philips, 2007) show that the intended new pathways were not in fact different from the former differentiated courses despite official policy promoting the innovated pathways. The "hardening of the academic vocational divide" (Hipkins, Vaughan, Beals, Ferral, & Gardiner, 2005) and its reflection in socio-economic class division suggest that little if anything has changed as a consequence of the re-structuring. If that is the case then the justification for the re-structuring requires critique – a critique that occurs in the final discussion chapter of this dissertation.

This chapter discusses Bernstein's (1999) differentiation between vertically structured knowledge and horizontally structured knowledge (Bernstein, 1999; Hoadley & Muller, 2009) to characterise the type of knowledge structures used in academic and non-academic Level 2 science courses in order to ask if the attempts to conflate the two types of courses in the assessment and curriculum re-structuring of 2004 and 2007 failed to recognise that different types of knowledge do exist. The difference is the result of the way in which scientific concepts are structured and build into increasingly advanced systems of meaning.

Knowledge types characterised by academic and non-academic courses

According to Bernsteinian theory (Bernstein, 2000), vertical and horizontal knowledge are differentiated by the way the knowledge is structured and how the knowledge is recontextualised to be taught at school. The way knowledge is structured in a science course affects the pedagogy employed by the teacher. Horizontal knowledge is structured so that it is embedded in its context and tends to lack the concepts and integration of concepts that enable students to understand deeper systems of meaning. For example, innovated horticultural courses training in tissue culture propagation alone does not provide the student with the knowledge needed to understand the genetic variation which explains the reasons for propagating in certain ways and not in others. Nor does this form of limited training in 'hands-on' cultivation work enable students to locate the cultivation of plants within the food production economic sector although the idea behind the course is to train students for employment in the horticulture sector.

Knowing about the commercial relevance of plants requires scientific knowledge about asexual and sexual reproduction in plants. The ability to grow other crops or to increase the disease resistance of a crop also requires the deeper scientific knowledge that is not acquired by working with plants physically. That practical experience may well be useful as a pedagogical strategy but the students require conceptual knowledge in order to understand the meaning of their practical work. It is for this reason that horizontal knowledge is described as segmented because no generalising unifying concepts allow the knowledge to be transferred to new situations.

In Bernstein's terms non-academic science subjects are 'weakly classified' if they are characterised by horizontal knowledge. Horizontal knowledge is not unique to the school subject, the student has access to the same knowledge from other non-academic sources or from other school subjects. To use the same horticultural example as above – the student may well acquire this knowledge from working in a garden centre during the school holidays or helping in the garden at home. There is no distinction or 'insulation' between the subject knowledge and other knowledge, and everyday language is sufficient to communicate the knowledge.

Non-academic subjects have no standard content. The Achievement Standards can be a mix of Learning Areas and strands which varies between schools. These subjects have no obvious progression between year levels within school or to an academic programme of study in a tertiary institute or university.

In contrast, vertical knowledge is systematically structured. This means that it is acquired through developmental concepts which build one upon the other in sequenced steps. A student must learn the initial stages of the subject's principles and concepts before moving to a more advanced level. For example, an understanding of particle theory allows the student to understand kinetic theory which is the basis for collision theory with chemical reactions and change of state with physical reactions. In this way the acquisition of advanced principles requires mastery of lower order principles and scientific language.

Academic school subjects containing vertical knowledge are 'strongly classified' because the knowledge is unique to that subject. The knowledge is usually not available to the student outside of school or from another subject. This distinct knowledge is mediated via the language of the subject and as students master the language, rules, and concepts they are able to progress to higher stages in the subject.

Academic subjects are recontextualised or altered from the disciplines into school subjects. This process requires a teacher who has had academic training in the subject. Academic and pedagogical expertise is needed to organise the material developmentally and to practise the specialised language of the discipline. The school subject will have an obvious progression at each year level in school and enable further progression to university level.

Academic science subjects such as Biology, Chemistry, and Physics are characterised by vertical knowledge while non-academic subjects such as Horticulture, Aquatics, General Science and Sports Science may have all or some aspects of knowledge horizontally structured. Because academic courses are characterised by subject specific knowledge and language, the student can form a specific subject identity and be initiated into the objective knowledge of the discipline. This idea of subject identity becomes important in understanding the link between the type of knowledge studied at school and socio-economic class location. For example, the act of participating in a drama class confers on the student an identity as an actor, and the possibility of initiation into an arts discipline. The act of experimenting in a science class confers on the student an identity as a science student and the possibility of initiation into a scientific discipline. Conversely, the act of being placed in a general course confers upon one the identity of a non-specialist with no possible initiation into a discipline.

Bernstein (2000) asserts that power relationships are transmitted in society through the maintenance of identities. A dentist, a mechanic, and a pilot all have occupations with strong identities. We associate these occupations with very specific knowledge, responsibilities and opportunities. "Identity… signals a broad set of domains that may be evoked and socially constructed in the moment, yet depend on shared assumptions, sociocultural categories, and knowledge" (Brown, Reveles, & Kelly, 2005). Bernstein explains that a group must be sufficiently different or 'insulated' from other groups in order for members of the group to form a strong identity. Only once a group has an identity can the group exert power within society, and individuals accepted into the group gain power by association. If a senior science course does not provide the student the opportunity to form an identity as a science student and to link to the scientific community, the student gains no social power or status by association.

Pedagogy characterising academic and non-academic subjects

Bernstein (2000) distinguishes between two different pedagogies; the regulative and the instructional, with which the school as an institution, consciously or unconsciously controls students. The regulative pedagogy is the dominant controlling pedagogy because it defines the school culture, who gets to do what, where, when and how. Other researchers agree that 'Institutional processes' such as timetabling and streaming are aspects of student life that influence the kind of knowledge available to students (Hallinan & Kubitschek, 1999) and reinforce a student's place in the learning hierarchy (Barth, 2002). For this study I focussed on the instructional pedagogy as I interviewed teachers and did not observe teaching or analyse department timetabling or pathways. The instructional pedagogy is defined as the content selection, sequencing, pacing and evaluation within each course.

Bernstein describes the teacher's role as expert subject specialist and pedagogue (Young, 2010a). The teacher is not just a reservoir of specialist knowledge, but models their disciplinary identity and uses disciplinary language to stimulate interest and confidence in the subject. Vygotsky explained that learning takes place in the ‘Zone of Proximal Development’. The teacher is required to ‘scaffold’ learning, or create a bridge between students’ experience and academic knowledge. The process is not didactic, it is a “two-way pedagogic process” (Young, 2010b, p. 16) requiring student engagement. It is not simply an extension of student’s knowledge but a transformation of the student. The student becomes initiated into the codes of the discipline, transforming their identity and language and uses the teacher as a benchmark of their progress by gauging their mastery of the subject by their ability to communicate with the teacher.

In contrast recent student centred pedagogies have reclassified the teacher’s role as a ‘facilitator of knowledge’. This is a neutral role where the teacher does not impose knowledge, but rather the student selects relevant knowledge when they discover a need for it (Brandes & Ginnis, 1996, p. 15). In order to realise the goal of motivated self-actuating students, this student centred pedagogy inherently needs to be supported by clearly defined learning goals (Stiggins, 2005). Therefore the assessment criteria play the crucial role in directing and evaluating progress rather than the teacher.

Future opportunities characterising academic and non-academic subjects

School subjects may not seem the ultimate determining factor in a student’s career. However Bernstein asserts that schools can institutionalise student rights to enhancement, inclusion and participation to ensure equitable outcomes for society (Bernstein, 2000).

Bernstein defines enhancement as the “right to the *means* of critical understanding and to new possibilities” (Bernstein, 2000, p. xx). Science curricula that promote every day, vocational or cultural knowledge in place of objective scientific knowledge can mean that the student loses the right to the best (Young, 2010b) knowledge available and the opportunity to advance in the subject.

“Inclusion” is described as the right to remain autonomous yet be included socially, intellectually, culturally and personally (Bernstein, 2000, p. xx). Some assert success in a subject is still success, regardless of the content knowledge offered by a science curriculum (Bishop, 2012). But science curricula that replace scientific knowledge with every day, vocational or cultural knowledge serve to exclude students from disciplinary communities. Without access to “generative principles of disciplinary knowledge, they (students) are not able to transcend the particular context” (Wheelehan, 2007, p. 649).

Bernstein defines “participation” not as discourse but as practice. The student must be given the right to “participate in procedures whereby order is constructed, maintained and changed” (Bernstein, 2000, p. xxi). The opportunity for students to have some control selecting and sequencing content, setting the pace of lessons and evaluating learning is described by Bernstein as weak framing. The pedagogical possibilities offered by weak framing have obvious curricula implications but need not change the kind of knowledge offered in the curricula. School subjects can still be strongly classified or distinct from other subjects and offer vertical or disciplinary conceptual knowledge even if students are given some control over its delivery.

Based on the contradictory assumptions about the types of knowledge offered in science courses identified in the NZCER’s Report (Hipkins, 2013a) described in chapter one and identified using Bernstein’s theory of knowledge structures in the curriculum discussed in this chapter, the chapter concludes with the research questions used in the case studies described in chapter three.

Research Questions

A: Does the knowledge taught in the traditional discipline course differ from that taught in the non-academic course?

B: Does the difference in the type of knowledge affect the pedagogy, including the language used by the teacher?

C: Does the student experience or develop a sense of identity due to the knowledge that is included in the course?

D: Does the type of knowledge offered in the course progress the student? Is the student **enhanced** – “given the means to critically understand” at an individual level? Is the student **included** – introduced to the scientific community? Is the student able to practise **participation** in “procedures where order is constructed maintained and changed?”i.e. at a political level (Bernstein, 2000, p. xx).

Chapter 3: Case study

A qualitative case study comprised semi-structured interviews with five teachers from three state secondary schools. Two pairs of teachers taught at the same school, one taught a Level 2 traditional academic subject such as Physics or Chemistry and the other a non-academic science.

Current department documents from the participating schools were used to acquire "first-hand information" about the NCEA standards offered in each course (Robinson & Lai, 2006, p. 86). This was verbally confirmed during the interview process.

Table 1: Level 2 science courses in three New Zealand secondary schools

Level 2 science	Credits available from Internal Achievement Standards	Credits available from External Achievement Standards	Credits available from Internal Unit Standards
Academic			
School A Jill	11	13	0
School B Jessica	8	13	0
School C James	4	16	0
Non-academic			
School A Jack	0	0	Variable up to 18
School C John	0	0	Variable up to 21

Jill Level 2 Chemistry teacher at state school, student population: >1500

Jill teaches Level 2 and Level 3 Chemistry at a large state school. She has a confident and approachable personality. Jill is achievement focussed and talking with her I get the impression that her pedagogy has been shaped by her years of extracurricular coaching experience. She knows her subject is difficult for students to grasp and expends much energy on encouraging, praising and goal setting. This strategy depends on her having plenty of formative assessment data so that she can provide personalised feedback and feed forward to students.

> *I suppose the most important thing is to be encouraging, giving lots of praise. Knowing where each student is, seeing if someone's struggling and going and asking what can I do to help? Do you want to come back at lunchtime or do you need more of these types of questions to practise?"*

Jill uses anecdotal stories such as methanol poisoning, and the failed contraceptive pill that caused facial hair growth, to spark students' interest.

> *So it's selling it to them and making it interesting and getting them to have success often. When they start failing or finding it too hard then they turn off. If they do little chunks and find they can do it they think wow this is not so bad and I can do it and it's fun doing the practical stuff…The concepts are really hard so you have to start each topic with a real passion and introduce it in a way that relates to them, so they see the relevance of why they have to learn it.*

Jill describes how many students taking Level 2 Chemistry already have a career mapped out before them. For example there are always students who wish to be vets or doctors. Although she describes her chemistry students as the more academic students she still views her role as essential. She explained that although students could access all this information online or from books, for certification purposes students need to know which material to focus on. It is her knowledge of chemistry and assessment criteria that control the pace and environment of the class. Her role includes telling them what is needed to pass and what is considered to be achieved merit or excellence, as well as celebrating each successful event.

Jill is very certain about which essential concepts the students must enter the course with and the foundational chemistry that must be acquired at this year level. Students must already understand the difference between an atom and ion and be comfortable with ionic bonding before they can contrast that with covalent bonding and the concept of a molecule. Jill believes a particular sequence of Achievement Standards is essential. 'Organic chemistry could not be taught before structure and bonding because all organic compounds are molecules. Likewise structure and bonding energies could not be taught before quantitative chemistry because energy calculations require mole energies.

Likewise Jill thinks the acquisition of specialist language is essential and spends time teaching students how to remember the key words. Chemistry terminology is reinforced with glossaries, flashcards, internet games, and puzzles.

> *Certain words and terminology you would never hear in ordinary everyday language. Things like dipoles cancelling or intermolecular forces, oh just lots of specific wording – even for one particular topic in chemistry. So it's really important to focus on that and get students comfortable with the words, without that they're going to struggle to answer the questions. It takes a while to do this.*

The pace of the class is set by Jill. She starts a topic as a class (one lesson) and then progresses through achieved, merit and excellence concepts and questions (two lessons) in group settings. The pace means the more able students can work on 'excellence' level material while other students continue with the 'achieved' and 'merit' level work. Jill finds that the pace does not allow for the development of key scientists theories, rules and careers. Students learn about Saytzeff's Rule and Markovnikov's Rule but don't learn about the development of the rules.

Jill believes each achievement standard is relatively independent and students may pass one without too much knowledge of another. She states that students must understand the interrelatedness of each topic only if they aim to be endorsed with excellence in Level 2 chemistry or achieve at Level 3 chemistry.

James Level 2 Physics teacher at state school, student population > 1500

James is an experienced physics teacher whose enthusiasm for his subject is palpable. Throughout our interview he is constantly prompting me with questions about the physical environment "Why did you hear that car out the window?" "Why would you rather I throw this softball to you than this rock?" And so I have direct evidence of James' beliefs that students come to the classroom armed with an array of experience and intuition upon which the teacher can draw.

> *Physics is what's out there… They [students] have a huge amount of knowledge. It's important not to overcomplicate it. Most of the concepts are very simple but the concepts have to be linked together… Everybody has their own preconceived ideas of how things are linked. Either you're right or you will have to modify your concepts as you go. I subconsciously teach it this way– bringing out students internal knowledge...redirecting and linking their knowledge.*

James needs to test for prior knowledge before experiments and direct student thinking beforehand to ensure the right knowledge is reinforced.

> *Although half of the boys will enjoy doing an experiment they don't think about it too much. They'll see something happen but they won't have an idea why. We've done Hook's law cold. They can get the results and graph the data, the brighter ones put the spring constant and gradient together but others do not… and need the theory first. In another experiment they have to find the relationship between image and object distance and focal length. There is always discrepancy between practical and theory.*

James can easily identify the essential concepts a student must have grasped before Year 12 and the concepts that must be acquired during Year 12. According to James, students should have some Year 11 knowledge about what causes motion to change, the concept of energy and its relationship to work and the links between energy, forces and motion. James spends time pre-testing and providing formative assessment before each topic especially for the electricity standard because students from alternative Year 11 courses have not done any electricity since Year 10. James makes the comment that he observes many students moving cities and schools and that with such a highly mobile population maybe NZ needs a more prescriptive curriculum.

James insists that the main concepts of Year 12 are so interlinked, "the concepts don't work in isolation" that he preferred teaching integrated physics before it was separated into achievement standards.

> *A good teacher will link all the topics. We used to have integrated physics when NCEA first started at this school. The concepts don't work in isolation. The links between those concepts is what makes the world go around. We keep taking out concepts.*

His department has tried various combinations of achievement standard teaching sequence and have found the best order is Mechanics Energy then Waves.

> *I try to teach my trigonometry before the mathematicians… they [students] don't transfer the maths very easily [between subjects].*

To advance in this subject James thinks students need to have good algebra and number sense. They should be able to solve algebraic equations and understand order of magnitude. Increasingly, James finds students more reliant on calculators and data loggers to produce data. The top students who are very good at maths are the students that rely on him the least.

James believes it is vital that students are exposed to predigital models and equipment that teaches them first principles. "(With) original machines you can see everything working" he tells me as we play with the biggest dynamo I have seen. He also spends time relating scientific issues with social issues. For instance when he teaches nuclear physics, he discusses Einstein's nuclear involvement, and also has students research the truth of this statement: "NZ is a nuclear free country" (but we use radioactive Cobalt in hospitals).

James thinks key language is vital to physics and mentions two barriers to student acquisition of physics terminology.

> *We are a bit lax with our language; we should say 'net force causes acceleration'. We talk about a force causing a change in motion but it's not true. We dumb it*

down a little. There is a fear of terminology… If you say order of magnitude they might not know what it is… the meaning of a lot of words has changed. If you use 'disturbance' [as in chemistry equilibrium] they will interpret it as 'trouble'. To try and use things in a scientific way is difficult. For instance mass versus weight – you wouldn't go to a butcher and use Newtons.

James explains that assessment dates are rigid. The internal deadlines and benchmark exams are set before the year begins. However one of the achievement standards in Level 2 physics requires students to produce a portfolio of investigations so James sets up 4 or 5 independent research opportunities in the year and students can choose which three to complete with a full lab write-up.

Jessica Level 2 Chemistry teacher at state school, student population > 1500

Jessica is a younger teacher with a strong disciplinary and pedagogical identity. She thinks deeply about her role in society and in the classroom.

More and more I'm using a student centred approach, it means students understand and retain information... They feel dependent; I like to teach them to be independent. Often they ask me to tell me something again and I'll say – I'll tell you again but it won't make a difference you won't remember it. I give them the time space and skills as well as opportunities to learn via different ways, for instance; talking, doing, answering questions, taking notes. I teach them to take responsibility – to figure out the best way that they can learn… The work is tailored, but I need them to help me tailor it to their needs.

She goes on to relate an experience about a Year 12 Chemistry class who had no teacher for half the year but managed to get better results than the other classes because they realised they *had* to teach themselves. But Jessica realises the limitations of student-centred learning.

Students are encouraged to engage in discussion but they don't know if the other person in the group could be putting them wrong.

Although there is little flexibility in the course timetable which is set before the school year begins, Jessica personally schedules student research and presentation into two external achievement standards. All groups research 'Le Chateliers' for rates and reactions and each group researches a different functional group for organics. Jessica found that generally students did not like researching topics and preferred a didactic approach. However her student centred approach is balanced with conscientious commitment to students' learning and she describes how student research is used as a way into the concept.

> *I want the students hungry for it and ready to learn it. They need to take a journey themselves and then I can feed into that. I believe learning takes place outside of your comfort zone. Students need that chance to extend themselves within the safety net of the teacher's help.*

Jessica thinks her students are focussed on credits and not interested in historical discoveries such as Mendeleev's periodic table which she considers essential to a chemistry education. "They want to look forward not backward". However Jessica maintains it is vital to expose students to the theories that espouse scientific knowledge. She teaches structure and bonding with Valence Shell Electron Pair Repulsion theory and tells the students to "Say it out loud! Valence Shell Electron Pair Repulsion… Make these words your friends!" This is why her "…department dropped one Year 12 internal so that we "have more time to make them into scientists not just NCEA passes."

Jessica is very clear about which pre-requisite knowledge is required to enter Year 12 chemistry and the concepts that must be acquired during the year. Students must have learnt the difference between ions and atoms in Year 11 and need to grasp the difference between metals and non-metals, solids and molecules in Year 12. This development from the macroscopic to the microscopic is supported with molymod models and the development of the particle nature of matter is related back to experiments in Year 9 and Year 10.

Jessica believes the topics covered in each achievement standard are very interrelated but finds the modularisation of assessment works against this principle:

When I'm teaching, I will say something like remember in redox we learnt… but especially if that standard was an internal they have shut it off… But learning must regress.

The department has experimented with the order of teaching achievement standards. "Some concepts naturally follow on from each other." But there is a trade-off between following a natural progression and having students opt out of the standard at the end of the year. Jessica explained that although organics should be taught after particle nature in structure and bonding, "The first year we had organics last, students gave up and opted out". Although Jessica knows that the conceptual sequencing is wrong she identifies the constraints that justify the department's assessment practices. Organics is such an important part of chemistry that students need more time to acquire the knowledge and practise writing assessments. This practice can be achieved if organics is taught earlier in the year, albeit out of sequence.

Jessica explained how even the smart kids can become despondent at the difficulty of Level 2 Chemistry and her strategies for keeping students motivated.

If I can, I point out the relevance [of the topic]. For instance for organic groups I talk about how wine oxidises to vinegar… and we make superball polymers from PVC in year 12. I use anecdotal concepts from their everyday life and then extend from there. Like when I teach ions in solution I use an example of going to the ball. You go with someone to the ball but when you get there it's a free for all - you dance with anyone.

Jessica stimulates interest with anecdotal information and links chemistry knowledge to other scientific disciplines but emphasises how this can impair student acquisition of specialised language.

I relate polar bonds to force vectors in physics. But students can get confused and they do latch on to your words and repeat them. I will never say like dissolves like again because they will write that in a test and get marked wrong.

Specialist language is so important that it is her chosen area for professional learning this coming year. She plans to use posters with key language and more exercises to match the word to the definition.

The key language must be revisited and students need feedback about whether they are using words in the right context.

The degree of language specialisation in each achievement standard can be a matter of moderation for NCEA markers. Jessica has been involved in NCEA marking before and describes it as very useful professional development.

> *There are some prescribed answers but every year NCEA steps it up a notch as teachers get better at teaching it from marking schemes. For example in structure and bonding you can't say the molecule is symmetrical you must say the bond dipoles are arranged symmetrically around the central atom. Now you have to name the central atom and state the bond angle.*

Jack Level 2 General Science teacher at state school, student population > 1500

Jack is an experienced teacher who teaches senior biology as well as the Level 2 General Science course. It is evident that Jack's concern for students is what prompted him to create this alternative science course. He explained to me that the students enrolled in his course have not met the pre-requisites for the other Level 2 sciences; chemistry, physics and biology and this is the only alternative science course at Level 2 in the school.

The course is a mixture of internal unit standards across three different Learning Areas; science, technology and core. Some of the unit standards are NCEA Level 1 and others NCEA Level 2. The standards include: plant propagation, first aid, biology of fin fish, excel spread sheets, and career options, but depending on the cohort, some years he may not finish all these standards.

The standards Jack chose to put in the course have a relevance to the students' physical and cultural environment.

In our local district fishing is a big commercial interest and hobby. We learn about commercial fishing quotas and how recreational quotas are reduced when fish stock gets too low.

Jack explains that the purpose of his course is to give students a 'taster' of many different industries so that they can make some tertiary training decisions, thus there is no relationship between the knowledge learnt from one standard to the next, and no specific teaching order to the year. "There is some overlap in skills… just getting them understanding [about how] to pass tests."

The students in Jack's innovated course come from a range of ethnic groups. He described how he united the class with communal lunches by eating the fish from the fish biology lessons. "Many cultures use food as an icebreaker", so sharing food was a way to build relationships.

Jack believes the relationships with students are as important as the knowledge itself. His role is to make knowledge relevant to students, but this requires that he know each student well.

To get anywhere with them you need a relationship with them; you can't come in waving a big stick telling them to work and do this and that… They need to see you're interested in them and they will respond to you. In the beginning they come in with a negative attitude so you need to spend time being interested in them as a person. Ask what they do in the weekend… These students were pretty unmotivated they needed to see the relevance to their lives. They wanted the credits but didn't want to do any work.

The knowledge taught in the standards is secondary to the social purposes of keeping students involved in some kind of training.

We try to give them incentives it's true at school and in life. If you put in the work you'll be rewarded. That was the broad aim. I did that with cake days and we gave them a carrot – if you did this much work you can get this.

There is a high truancy rate amongst the students in the course. Generally Jack found that students were less likely to truant his science class due to his relationship building efforts but still found absences a major factor limiting the pace and cohesion of the class.

There is no pre-testing before each standard but there are some concepts that need to be learnt; for instance during the basic plant propagation standard students need to understand "why different plants soft or semi hardwoods require different techniques of propagation". However the concepts and comparisons between asexual and sexual reproduction are not introduced and scientific language is not tested.

Students have the opportunity to practically test their knowledge. Throughout the year, students go into the school gardens and monitor the cuttings they have grown. A field trip to a commercial forestry nursery reinforces the learning. "The instructor uses the same terms to describe how they take cuttings."

John Level 2 Horticulture teacher at state school, student population > 1500

John is an experienced Head of Science who has trained student teachers. He is well spoken and has a calm presence that commands respect.

This course titled Level 2 Horticulture is composed of standards entirely related to plant propagation and biology and follows on from a Level 1 Horticulture course. John explains that the Level 1 Horticulture course is assessed by achievement standards and is reasonably academic whereas the Level 2 course is assessed by unit standards and is only recommended to students who did not meet the pre-requisites for a Level 2 academic science. Students with achieving grades who have an interest in horticulture are not admitted into the Level 2 course but directed into academic science courses. This is because "Industry is requiring highly skilled intelligent people with management capability". Here John acknowledges that commercial businesses require people with critical thinking ability rather than nuts and bolts skills and that there is no opportunity to develop critical thinking ability in the unit standard course.

> *All of the unit standards in this course require a "demonstrated knowledge of" as opposed to "demonstrated understanding" for an achievement standard. This means most of the assessment questions are "describe type questions, [with a]*

limited number of explain questions. Students must be able to demonstrate skill and explain why they did it. It does require retention and memorisation of skills… There are some big concepts like transpiration.

John describes his role in the classroom as a facilitator meaning "I don't do the learning – they do the learning" but describes students as "heavily dependent" on him. His main role is "man management" trying to intersperse all the theory with practical work. His disciplinary identity and pedagogical skill modify the highly specific nature of the knowledge in the unit standards. John introduces experiments and knowledge that relate to the standard and give students a sense of scientific identity.

The Demonstrate knowledge of structure and function standard doesn't require [use of the] scientific method but I teach it anyway to give the course validity. For example fresh and dry weight, just like in field trials and industry. However this is not assessed.

Even though there is no need to link knowledge between standards it is second nature to John.

A certain order of teaching… allows units to link up. I teach practical plant propagation first… so students know how to grow plants. Students soon realise different plants have different requirements, due to belonging within a group of plants. For instance, if it looks like a cabbage it will probably need the same care as a cabbage. [Then when I teach] plant nomenclature – although there are different cultivars of a species, propagation is the same. So plant nomenclature can be associated with propagation of species. Structure and function is a harder unit so students can now learn about respiration and photosynthesis after they've learnt the reproduction – sexual and asexual.

John enriches the plant nomenclature unit standard by introducing some history of Greek and Maori horticulture. Students practise the skill of naming plants in an assignment where they

collect 30 native plants within 100 meters of school and identify them; common name, Maori name and botanical name… [it's] actually not part of assessment but it is an assignment I give them. Plant nomenclature is covered in another standard

(849), but assessment doesn't require students to name any plants, but they have to understand how a plant is named and how to find out the name of a plant.

Scientific language is not a priority but John supports key language by writing key words in a specific place on the whiteboard.

I do introduce Latin words in class but they are not required or assessed. On field trips to commercial operations the Latin name is not used, not even the cultivars, just barcodes… [But] by using the language all the time I hope it sinks in and becomes part of their language.

Students have some guided research opportunities, where they can choose to learn about the cloning of a specific plant. The tempo of the class is not set in stone;

> with different cohorts I get through different amounts of the course. There are a lot of credits on offer so sometimes students choose to miss assessments."

John believes the course would be better if he could teach horticulture full time. A full time horticulture teacher would have the time to concentrate on building up projects and resources specific to subject. He describes how he would prefer to teach the course from the ground up as a planting out project. The creation of a reserve would start with collecting seeds, and the learning would build from there.

Chapter 4: Methodology

The methodology takes into account the aim of the case study which was to contribute to what Bernstein (2000) has identified as the main problem in the sociology of education. This is how institutions such as schools manage to reproduce sociocultural inequalities. The case study provided an empirical illustration of Bernstein's idea that the way knowledge is structured and taught is related to socio-economic class allocation. According to Bernstein, this is how institutions such as schools manage to reproduce sociocultural inequalities. Specifically he drew attention to how pedagogic practices "directly or indirectly relay the distribution of power and principles of control" (Bernstein, 2000, p. xxi).

The empirical data from the interviews was analysed using a conceptual methodology that recognises the 'real' nature of concepts and their subsequent power to explain events and processes observed empirically, such as the teachers' interpretation of their pedagogies and curriculum choices in my case study (Popper, 1978). This realist methodology connects the empirical data to the theoretical meaning. The data is analysed in terms of its 'best fit' to the concepts, and acknowledged as a 'provisional truth' used to clarify and crystalise concepts. In this case the concepts are Bernstein's types of knowledge classifications and pedagogical framing. From the concepts a typology (Table 2, p. 39) was developed, which was used firstly to produce the semi-structured research questions (Appendix A) and secondly, to analyse and explain the data.

In this dissertation, the explanation is conceptual and enables sense to be made of the empirical data acquired in the case studies. The use of Bernstein's concepts as explanatory tools contrasts with the interpretivist approach which reports participant voices as the explanation. The participant concerns quoted in the interpretivist studies in chapter two (Hipkins, Vaughan, Beals, & Ferral, 2004; Hipkins, 2007) are reported in a way that monitor the participant reactions and compliance to education policy. The amassed data is sorted into themes but the nature of the problems, the underlying issues are not questioned, or addressed. Subjectivity is a given and readers must co-construct their own meaning from the data in true post-modernist style (Macdonald, 2003; Kauffman & Sasso, 2006). Similarly the empirical approach used in Ferral's (2005) subject cluster study does not attempt to explain the reported patterns and trends. In contrast the realist methodology used in this study can explain patterns and trends in the empirical data by relating them to Bernsteinian concepts which are ‘real’ in that they serve as explanatory tools. The advantage of a realist methodology which works from concepts is it does not lack imaginative creativity as is the case where meaning is drawn from the empirical data itself nor does it anchor data within one context as occurs with Interpretivism.

Table 2: Methodological typology used to develop Research Questions

Science Course	
Strong Pedagogical Framing	Weak Pedagogical Framing
Teacher as subject specialist: 1. Subject specific language used and introduced by teacher 2. Subject specific language encouraged from students 3. Content chosen by teacher 4. Pace of the lesson prescribed in teacher's lesson plan 5. Sequential learning as prescribed in teacher's lesson plan	Teacher as subject facilitator 1. Everyday non-scientific language used to explain concepts 2. Language specific to local common knowledge is encouraged from students and accepted by teacher 3. Content of lesson co-constructed with student 4. Students determine own pace 5. Students determine own learning sequence
Teacher as pedagogic expert: 1. Teacher elicits prior knowledge or concepts from students 2. New concepts are taught explicitly 3. Experience may be used to illustrate new concepts 4. Students' 'research' or 'investigation' scaffolded by sufficient expert information e.g. Suggested academic readings 5. Whole class teaching main method of instruction	Teacher as pedagogic facilitator 1. Teacher does not try to connect prior learning to current topic 2. No differentiation between experience and other ideas or concepts 3. Students 'research' without structure often using internet 4. Group and individual 'co-construction' approach favoured as teaching method
Strong Knowledge Classification	Weak Knowledge Classification
1. Scientific theory or concept explicit i.e. vertical knowledge used 2. Historical context explained 3. Concept related to previously introduced concepts and reference made to concepts in the next part of the sequence 4. Generalisations made from particular case (unifying knowledge from specifics)	1. Local problem or specific issue the basis for the learning i.e. horizontal knowledge used 2. No historical context of scientific concepts provided 3. Specific issue not identified as related to other cases 4. Dependent on, or reduced to, specific context. No other contexts discussed

Chapter 5: Analysis of Interviews

In this chapter the typology adapted from Bernstein's concepts of knowledge classifications and pedagogical framing in Table 2 is used to analyse the characteristics of the five Level 2 science subjects from the case study.

Knowledge Classification

According to Bernstein academic subjects will be characterised by strong classification and strong framing. If school subjects are not sufficiently insulated from 'others' they experience a 'pollution'. Bernstein (1971) states "Any attempt to weaken or change classification strength (or even frame strength) may be felt as a threat to one's identity and may be experienced as a pollution endangering the sacred" (as cited in Beck 2002, p.619). Insulation endows the subject with a 'sacredness' that subsequently can inspire subject loyalty and identity.

The chemistry and physics teachers in my case study could clearly describe the concepts taught in the course. Those teachers acknowledged that sequential development of concepts is desirable which indicates that the knowledge is vertically structured in these subjects. As Jill explained a good understanding of the subject, as evidenced by an endorsement grade, is only possible when links between the concepts are developed by the student.

However the chemistry and physics teachers valued the linking of concepts differently. James insisted that he would much rather teach integrated physics than NCEA physics because achievement standard modules disrupt the integrity of the subject. He adds that a good teacher is obliged to break down those assessment barriers to aid student understanding. Jessica also believed that knowledge is very 'interrelated' but students had adapted to the system which 'compartmentalises' knowledge. Jessica had also adapted to the un-sequencing of achievement standards due to the department's need to reduce the number of students opting out of a difficult standard. At the other end of the spectrum Jill was more focussed on student achievement, and because achievement did not require any linking between achievement standards it should not be the focus of teaching in her view. Regardless of the value each teacher placed on linking concepts across standards, all of their statements show that modularisation of assessment has the effect of disconnecting vertical knowledge structures.

The physics and chemistry teachers' attitudes to nature of science knowledge also reveal how subject loyalty and student identities may be forming in their classrooms. Phil used historical figures to enliven discussions around modern day issues such as nuclear free zones. He believed his use of simple machines allowed students to build deep conceptual understandings rather than reliance on data produced from a device/application. Jessica insisted on introducing students to theories that produced knowledge even though the theories themselves are not assessed. Jill found no need to focus on this type of information because it would not be assessed. Hence some teachers of traditional academic subjects tried to instil subject loyalty by giving the student a deeper, 'humane connection' (Beck & Young, 2005) to the knowledge whereas others focussed on achievement success.

The non-academic courses were both 'contextually focussed' by NZCER definitions (Hipkins, Vaughan, Beals, & Ferral, 2004), but with distinctly different knowledge structures from each other. Both were assessed only by unit standards which assess 'demonstrate knowledge of processes' rather than 'demonstrate understanding of processes'. However, unlike Jack's taster course all of the standards in John's course were based on one topic. This allowed John to use his considerable subject experience and pedagogical expertise to modify the highly specific and unrelated achievement objectives to give the course a coherent theme. This linking and sequential development of concepts planned by John meant that some knowledge was structured vertically. Hence the course was not as weakly classified as expected from the lack of concept progression in the assessment criteria. Students in John's Horticulture course were able to link plant processes with plant production to develop some deeper understandings about plant growth and behaviour even if that knowledge was not assessed. Similarly the teacher's regular use of Latin names and scientific terminology and methodology (that were not prescribed in the standards) modelled subject expertise to the students. His expertise allowed students to develop a sense of subject expertise and therefore subject loyalty and identity. Interestingly John is unsure exactly what identity the course offers students. John explains that the horticulture and agriculture industries are looking for people who are capable of critical thinking, and students who have demonstrated these abilities in the Level 1 Agriculture and Horticulture course would be funnelled into Level 2 academic courses instead.

In contrast the taster course developed by Jack is weakly classified. If some concepts were developed they were not progressed any further, or moved beyond the local context. Life cycles of commercial fish were taught but these were not extended to population studies in New Zealand or other countries. The internal standards were not related by topic so there could be no linking or development of concepts. Students formed a loyalty not to the subject but to the teacher who was primarily interested in getting them to stay in school and experience success. Jack's description of his role identifies him as a subject facilitator rather than a subject specialist. The knowledge and language taught in the course was secondary to the aim of fostering relationships and gaining success (as defined by assessment standards) for the students.

Clearly two types of knowledge are being taught in two types of courses. The traditional courses are more strongly classified than the non-academic courses because they are characterised by vertical knowledge or interlinking concepts of a hierarchical nature. Some innovated courses have more coherence than others and offer students a sense of identity as a subject practitioner, but overall that identity may not be valid as it has no progression in the school system or compatibility with industry roles.

Pedagogical Framing

Hoadley & Muller (2009) explain how knowledge structures influence instructional framing. "The verticality of a particular knowledge structure places limits on its progression, sequencing and pace. This is the link to pedagogy: the more hierarchical a particular discipline, the more restriction on these dimensions of framing" (p. 76). The teacher is unable to slow the pace in an academic course because any concepts that are left out may jeopardise the student's achievement further into their study. This is confirmed by the case study data, as all of the academic courses had the internal assessment and benchmark exam dates set before the year started. Thus teachers and students have very limited control over the content, sequence, pacing or evaluation of any part of the course. The exception is an internal physics assessment that requires students to produce a portfolio of investigations. James is able to set up four or five independent research opportunities in the year and students can choose which three to complete with a full lab write-up.

Interestingly the physics and chemistry teachers act as pedagogic experts in the classroom, even though two teachers described their role in the class as facilitators. The fact that teachers describe themselves as facilitators even when they behave as a subject specialists and pedagogical experts reflects the successful rebranding of the teacher's role by the Ministry of Education. In fact the physics and chemistry teachers all explained how they must take the time to skilfully introduce new concepts to students. The teachers carefully pick their examples so that they can draw out students' prior knowledge and experiences in order to link them to difficult concepts. Jessica does expect students to grapple with some of the knowledge from unfamiliar sources first but she limits and controls the research process and oversees the final note taking process.

Likewise the chemistry and physics teachers explained that modelling of disciplinary language is vital to students' knowledge. Understanding of concepts is not enough the disciplinary language must transform the student (Young, 2010b) to become part of the student's repertoire. The chemistry and physics teachers could describe the activities they used to support this literacy component of the learning.

Although the non-academic courses were characterised by horizontal knowledge they still needed to be taught by pedagogical experts who organised the knowledge for the students. Like the teachers of the academic courses, the teachers of the innovated courses also acted more like pedagogical experts not facilitators. This is not surprising because both Jack and John are experienced teachers of academic subjects. Overall Jack's course was more weakly framed than the other courses but Jack only partially fit the description of a subject facilitator. Even though the standards in the taster course were not linked and did not allow concepts to be sequentially developed, Jack deliberately organised the order of standards to allow for variations in the pacing and so that field trips would hold the students' interest throughout the year. Jack taught with a whole class method before assigning teams to work, and research was directed by specific research questions and conducted within a set time frame. Jack described his students as “quite dependent” on his knowledge, and the class had near 30 students with a wide range of abilities so it took considerable effort and planning for Jack to allow students some flexibility in pacing. Yet Jack ensured the pace of the course was “flexible” because there was no point rushing through the material “as no one would achieve anything”.

John also described his students as “heavily dependent” on his knowledge. Although John had made booklets so that the students could work independently they usually worked as a class. Like Jack, John was able to shift course deadlines so that the pace of the course was flexible. In both non-academic courses computer research was controlled by teachers who directed students to specific websites, in effect reducing the research scope to a literacy exercise in unfamiliar text. Overall the case study showed that even when a teacher of a non-academic course was not a subject specialist of some of the knowledge in the course, the teacher still controlled the knowledge and therefore could not be defined as a facilitator.

In conclusion the case study data showed that academic Level 2 science courses were characterised by strong classification and strong framing whereas the non–academic Level 2 science courses were characterised by varying degrees of weak classification and weak framing.

Chapter 6: Concluding the Analysis

This conclusion discusses the case study analysis in relation to the original research questions developed from Bernstein's concepts within the larger context of epistemological understanding of knowledge in the curriculum.

Relativists assert that all knowledge is subjective, that it is constructed within a cultural context. The language used in NZCER research such as 'equity of pathways', and 'teachers tacitly held value judgements' (Hipkins, 2013a; Hipkins & Vaughan, 2012) and other Ministry of Education documents indicates an underlying relativist epistemology (Matthews, 1993). From this perspective all knowledges are legitimately produced in various social contexts (Bishop, 2012) and are to be valued equally so as to acknowledge and validate all social groups. Because science as a subject is considered to be produced from within a subculture of western culture (Aikenhead, 2008) it naturally advocates a historically white bourgeois male perception of the world, effectively alienating particular social groups. Standpoint theorists working from a relativist position assert that because the language and behaviours used in traditional subjects are especially unfamiliar to students from minority cultural, religious or ethnic groups (Banks & McGee, 2010) they are better served by curricula with no explicit subject boundaries, or in Bernstein's terms, subjects that are weakly classified. According to this position the problem of class reproduction in schools can be solved by adapting curricula to include and thus validate knowledge from all social groups. "The challenge to curriculum developers is… to neither undermine pupils' confidence in their own abilities to make sense of learning experiences, nor grossly misrepresent scientific ideas" (Driver & Oldham, 2008, p. 110).

On the other side of the debate Realists or Universalists flatly reject the relativity of knowledge that has been imposed into modern science curricula, and identify this post-modern constructivist view of science as 'anti science' (Harding & Hare, 2000). Realists assert that the relativity approach confuses 'knowledge of the powerful' with 'powerful knowledge' effectively exacerbating class distinctions (Young, 2010a). As physicist Roger Newton (1997) stated:

> Science stands or falls on the validity rather than the origins of its large structure of ideas. Those who, in light of the turbulent social currents in which we are all

immersed, claim that the content of these ideas is of little rational relevance can be fairly accused of engaging in what the philosopher Larry Laudan calls "the most prominent and pernicious. . . anti-intellectualism in our time." Operating most successfully at universities, they are robbing rational thought of all intellectual and cognitive value, leaving its expression a hollow rhetorical shell. This, ultimately, is why scientists, who value rationality above all else, are deeply offended by a misrepresentation that claims their work has as much epistemic value as the invention of fairy tales. (p. 3-4, quoted in Harding and Hare, 2000 p. 227).

Central to Rationalist or Universalist epistemology is the independence or separation of what is known from the knower, and the understanding that although scientific knowledge is produced within a social setting, it is a "product with its own materiality" hence is distinct from its producer (Rata, 2012, p. 54). From a Rationalist approach the science curricula may compare *rather than* include multiple world views of the natural world in order to explain how "testable, predictive and explanatory" knowledge (Siegel, 1994, p. 806), or falsifiable hypotheses (Popper, 2005) elevate humans from the "tyranny of traditional culture" (Rata, 2012; Rata, 2014, p. 1). In practice this means more than teaching science with practical demonstrations or training students to use equipment, and write up experiments. Students need authentic practise with the scientific method to understand the "theoretical tentativeness and the practical truthfulness" of scientific theories (Harding & Hare, 2000, p. 228). Authentic student investigations give students confidence in the objective nature of scientific knowledge, showing how the "small scale practical level" produces certainties which support overarching scientific theories (Matthews, 2000; Bencze & Hodson, 1999; Harding & Hare, 2000, p. 228).

Although the language and behaviours of scientific disciplines may be more difficult for students of different socioeconomic groups to grasp, without proficiency in them students cannot progress in the sciences. Realists assert that this access issue remains a pedagogical issue not a curricula issue. Social realism is a new movement drawing on Bernstein's work (2000) that recognises the importance of pedagogical techniques while at the same time defends student access to the vertical knowledge structures that promote their disciplinary identities and protect their democratic rights. Protecting the traditional subject boundaries remains the best way to provide all students with: the most reliable knowledge available in a particular field, a clear bridge between everyday knowledge and theoretical concepts, and an identity as a science student (Young, 2010b).

Knowledge in Level 2 science courses

The knowledge types in the traditional academic and innovated Level 2 science courses are clearly separated into the categories prescribed by the topology I developed from Bernstein's concepts of vertical and horizontal knowledge. Using the typology, some non-academic subjects were more weakly classified than others. The Level 2 Horticulture course maintained a coherent plant theme whereas each unit standard in the Level 2 General Science course was unrelated. The content of the non-academic courses had limited conceptual knowledge and could not be used to progress scientific understanding. At best the knowledge was vocational and gave students a technical skill that may (or may not) be used in industry. At worst the knowledge was perfunctory and served the purpose of keeping students busy in the act of 'achieving'.

The case study data showed that the teachers of innovated courses were most concerned about instilling work ethic in students by using credits to direct them. As one teacher explained, building relationships with students is vital to redirecting their loyalty back to assessment success. Thus students were encouraged to 'buy in' to the credit collecting system rather than develop an identity as a science student.

The case study also showed that weakly classified subjects lacking specific subject boundaries are more likely to be taken by 'minority' ethnicities.   Both teachers in the non-academic courses identified the majority of their students as "Maori" or "Priority Learners" which supports other research (Ferral, 2005; Hipkins, 2013a) findings that ethnic divisions are still evident since the introduction of NCEA. This is despite the social justice agenda which underpinned the restructuring of the New Zealand curriculum (Phillips, 2010). Rather than addressing underlying socioeconomic issues affecting these learners, horizontal and vertical knowledge has been conflated in an effort to engineer 'success' for these learners.

In contrast, knowledge in the academic subjects in the case study was conceptual and specialised and allowed progression into deeper science concepts. However links between achievement standards were often not explicitly taught to students and therefore the hierarchical nature of the knowledge was undermined. Even though teachers thought the ability to link knowledge across standards is necessary to progress to higher levels in the subject, their teaching was affected by assessment practices which do not prescribe any links between standards. According to the typology the academic subjects became less strongly classified by modularisation of assessment. Lack of links between topics within traditional academic subjects had the same effect as weakening subject boundaries in non-academic courses. Students were encouraged to focus on achieving or achieving each standard with 'endorsement' rather than developing a loyalty to the subject. The result is that identities as chemistry or physics students were secondary to working the system of accreditation. This trend was also reported in Hipkins' research where students' learning identities were described not as subject specialists but as 'credit hunters' (Hipkins & Vaughan, 2012).

Thus the system focuses student attention on the short term extrinsic value of knowledge instead of its stable intrinsic value. The adoption of a completely new set of accreditation language such as 'achieved', 'endorsed with merit' or 'endorsed with excellence' is an example of 'dereferentialisation' - a phenomenon where generic terms can be "mobilised to legitimise whatever priorities markets or managements require" (Beck, 2002, p. 624). Although teachers have differentiated between the relative value of knowledge according to its "explanatory power" (Maton & Moore, 2010, p. 3) NZCER researchers have dismissed these teacher observations as tacitly held value judgements to be modified. Here lies the stark contrast between the postmodern Relativists who reject the hierarchy of truth, knowledge and authority (Beck & Young, 2005) and therefore contribute to its unequal distribution and the Realist position which accepts the principle of knowledge differentiation and specialisation. From that principle is derived the Bernsteinian commitment to knowledge as a basic student right 'enhancing' the individual's life with "confidence to act" (Bernstein, 2000, p. xx).

Bernstein does accept that knowledge by itself does not fully immerse the student into the practice of democratic participation within society. Schools can reinforce the democratic participation of socioeconomic groups if students have some control over *how* knowledge is learnt in other words if the course is weakly framed and students have some control over the content selection, sequencing and pacing. Thus streaming students by ability does not exclude 'low ability' or 'disengaged' students if those students are given the same conceptual knowledge as other groups but allowed some flexibility in its teaching (Hallinan & Kubitschek, 1999).

Nature of Science knowledge (New Zealand Curriculum, 2007) encourages this level of student participation because once students have been introduced to the rigorous methods of controlling variables and attaining reliable data, students can apply the scientific method to their own fields of interest. In contrast if scientific knowledge is assessed as competency in a small set of predefined outcomes, training exercises rather than authentic investigation skills are encouraged (Alison, 2005; Moeed & Hall, 2011). Drilling predetermined results into students validates the notion that scientific knowledge is just another kind of subjective cultural knowledge. In her critique of vocational training, Wheelehan (2007) explains that students need access not only to knowledge but also to the generative processes that produce knowledge. The lack of opportunity to discuss, reflect and create within science lessons, is identified as a major reason why students lose interest in science. Students can feel "frogmarched across the scientific landscape from one feature to another, with no time to stand and stare, or to absorb what it was they had just learned" (Bull, Gilbert, Barwick , Gilbert, & Baker, 2010, p. 29). Separated from its method of production scientific knowledge comes to resemble an imposing foreign culture whose relative value is open for debate.

> Students are encouraged to regard the processes of knowledge building in science as unproblematic, leading unambiguously and inevitably to "proven science". Scientists are regarded as experts whose views have authority conferred on them by the power of the scientific method and its universal applicability. The illusion is reinforced by a heavy reliance on didactic teaching styles and by an approach to investigative work in which students spend the bulk of their time on cookbook-type exercises designed to reach particular predetermined outcomes (Bencze & Hodson, 1999, p. 522)

Rather than using practical sessions to emphasise the 'right answer' or teach practical skills, science investigations that are more weakly framed could focus on the process of producing objective knowledge and analysing certainties. Practising the process of scientific enquiry enables students to transcend the particular context by providing them with critical thinking ability that can be used in other spheres of life.

> Teachers and pupils often conspire in perpetuating a false sense of security that manifests itself in the reliance on ‘right’ answers and a view of the expert as one who knows, rather than one who uses knowledge to refocus doubt. (Rudduck, 1986, p. 6 quoted in Bencze & Hodson, 1999, p.522)

The challenge in the science classroom is to balance the accurate portrayal of the body of truth compiled during centuries of scientific enquiry with the scientific trait of open mindedness (Harding & Hare, 2000). This is not the same as treating all knowledge as relative but means acting like scientists who form and revise ideas as relevant evidence emerges.

> … excessive teacher control leaves students less able to conduct scientific tests of their own design, less able to appreciate the complexity of relationships among science, technology, society, and the environment, and less able to act in the critical role essential for achieving responsible citizenship. (Bencze & Hodson, 1999, p. 523)

It is ironic that the very knowledge that would allow students to practise the “stable, explicit and rigorous methodology of production” of scientific knowledge (Moore & Muller, 2010) to realise its inherent objectivity (Siegel, 1994; Matthews, 2000; Stanley & Brickhouse, 2001) is the knowledge often omitted in school curricula. The physics course was the only course that included a science investigation standard that allowed students some choice of topic and time period to complete. Two of the teachers encouraged some development of Nature of Science thinking throughout the course but generally the consensus was that there was not enough time to move the focus away from assessment material. In such a curriculum students experience less control over the instructional pedagogy which in Bernstein’s terms qualifies as strong framing. Although strongly classified (academic) subjects are by nature strongly framed, science investigation portfolios would allow some flexibility in course framing.

Pedagogy in Level 2 science courses

The typology developed from Bernstein's concept of instructional pedagogy identified two different aspects of pedagogy, the subject expertise and pedagogical expertise of the teacher. While subject expertise identifies how well the teacher knows the language and concepts of the science, pedagogical expertise identifies how well the teacher can introduce those concepts to the student.

The typology contained the assumptions that the teachers from academic courses would act as subject and pedagogical experts and the course would be strongly framed, whereas the teachers from non-academic courses would be acting as subject and pedagogical facilitators and the course would be weakly framed. The case study data showed a more complex picture. While the case study data showed that subject expertise was not necessary for the non-academic courses, it revealed pedagogical expertise was necessary in both types of courses. The academic courses were strongly framed but the non-academic courses were moderately framed.

The case study identified clear differences between the subject expertise required of the teachers from academic and non-academic science courses. Scientific language was an essential component of the academic science courses but an optional extra in the non-academic courses. The teachers of non-academic subjects were not experts in the fields that they found themselves teaching. The students in these science courses may well have learnt more about sowing seeds or designing spread sheets from a family member than from the teacher.

However both sets of teachers were Level 2 experts because they were well versed in the NZQA assessment criteria of the course. For instance if a student learnt chemistry only from a professional chemist, or learnt propagation only in a nursery the student may not perform well against the specific NZQA criteria. One chemistry teacher in the case study identified her role as explicitly specifying the achieved, merit and excellence knowledge identified by NZQA within each Standard. Therefore despite the different kinds of knowledge available to students in the different science courses all of the courses required pedagogical expertise from the teacher. The concept of the teacher as a facilitator was not borne out by the research. In fact less academic students were more dependent on the teacher than the academic students to translate the learning objectives and assessment criteria into meaningful tasks, and scaffold the development of the tasks.

However the nature of the pedagogical expertise required by the teacher was different between academic and non-academic science courses. The teachers of the academic science courses all related stories about how they introduced difficult scientific concepts to unique groups of teenagers; boys, girls or mixed ability. Their focus was on finding a way for students to connect from their previous experience and incite their curiosity to understanding an intangible concept. In contrast the pedagogical expertise required by the teachers of non-academic science subjects pertained to their ability to organise the tasks and differentiate the pace of lessons to learners. Time within lessons was carefully planned to allocate time for whole class teaching, group work and practical activities. Computer research was carefully structured so as to direct not overwhelm the student.

The findings from the case study data show that all knowledge types require a pedagogical expert to direct student learning which supports the Social Realist idea that accessibility of knowledge is a pedagogical issue as well as a curricula issue. If a science course can be more weakly framed and the teacher and students have the opportunity to negotiate the sequencing, pacing and assessment styles there may be no need to replace scientific knowledge with the more ‘relevant’ knowledge which characterised the ‘innovated’ science subjects.

The skilful pedagogue can “understand a student’s worldview (and) anticipate which meanings in a science curriculum will appear plausible and which will not” (Aikenhead, 2008, p. 4), but valuing a student’s perspective is not the same as ‘constructing’ knowledge *from* a student’s worldview (Young, 2010b). It is the pedagogical role of the teacher to bridge the gap between students’ worldviews and scientific knowledge not the role of a curriculum designer to design a curriculum around students’ worldviews (Young, 2008; Rata, 2012; Maton & Moore, 2010). Student experiences are a starting point for a ‘way into’ knowledge rather than the basis of a science curriculum (Rata, 2012). And because disciplinary knowledge allows students to move from personal and present experiences into a conceptual analytical framework it is especially ‘powerful’ for students of marginalised groups (Young, 2010a).

In contrast approaches which conflate horizontal and vertical knowledge and create more ‘relevant’ and ‘inclusive’ curricula for certain ethnic and socioeconomic groups deny students access to both academic advancement and industry expertise while still requiring intensive pedagogical skill from the teacher. Regardless of how well students achieve within weakly classified subjects, the students have no opportunity to form subject identities and to be included within the associated power structures of that discipline. However instead of finding ways for students to gain disciplinary identities and enter disciplinary power structures the NZCER Report (Hipkins, 2013a) assumes those power structures can be dismantled if we argue their relativity and award credits to all knowledge types. The intrinsic value of scientific knowledge and the associated identity as a science student becomes secondary to the extrinsic accreditation identity.

However it is not just students that suffer this identity confusion. Sociologists have noted that teaching professionals have (internationally) had their own identities challenged as a result of 'market ideologies' finding their way into the education sector (Beck, 2002; Beck & Young, 2005). 'Market analysis' of poor educational outcomes assume that lack of student success is related to lack of specific direction from teachers toward success criteria. Thus a good teacher is considered not necessarily one with a claim to specialist knowledge but someone that can 'sell' the most assessment products to the most student customers. As academic school subjects become less recontextualised from academic disciplines teachers must morph their disciplinary identities from subject experts to pedagogical experts in order to teach only the 'relevant' knowledge recognised in the subject's performance criteria. Professional autonomy and the practice of professional judgement, integrity and subject loyalty is replaced by "free market competition" in student achievement (Beck & Young, 2005, p. 188). Consequently teacher commitment and accountability is no longer directed toward the teaching profession and the subject discipline but (as with students), toward the NCEA accreditation system. Students and teachers are measured by their 'trainability', their ability to constantly adapt to external directives.

Chapter 7: Conclusions

The findings from the empirical data illustrate the theoretical concepts of knowledge differentiation and its relationship to student identity. The academic Level 2 courses contained specialised language and hierarchical concepts that required teaching from a subject specialist. In Bernstein's terms the knowledge was vertically structured and the courses strongly classified. The teacher's pedagogical role included modelling the specialist language, creating interest in the topic of study, and highlighting the conceptual links between modules of work. The courses were strongly framed as even individual teachers had very little control over the sequencing, pacing or evaluation of the course. Acquisition of this knowledge allows students to progress to higher levels of the school subject and to tertiary studies in a science discipline. The student has their identity as a science student reinforced by their current and future potential access to scientific knowledge.

In contrast the knowledge in the non-academic Level 2 courses was composed of unrelated discrete units of work or modules of contextually specific foci. The knowledge was horizontally structured and could be moderately to weakly classified depending on whether the teacher compiled thematically similar modules of work into the course. There was no prescribed specialised language and the class could be taught by any teacher with the organisational skills to follow the performance criteria and the social skills to relate well to the students. The course was weakly framed from the teacher's perspective, the teacher could slow the pace and change the sequence but students had little control over the instruction process.

Although the non-academic science courses had been adapted to include lower achieving students (who were predominantly of Maori and Pacifica descent), the effect was to exclude them from access to scientific knowledge and progression within the department. Students from the non-academic courses could only attain identities as credit collectors because their 'innovated' subjects offered a different type of knowledge. The students could not form identities as science students because vertical knowledge from strongly classified subjects had been replaced with horizontal knowledge from weakly classified subjects.

This research concludes by suggesting that if science curricula are adapted for lower achieving students they can be adapted in a way that still allow students to progress (albeit at a slower pace) within the sciences. Rather than removing specialist scientific knowledge from curricula, and the associated opportunities and identities that come with that knowledge an alternative paradigm is to give students some control over the content, sequencing, pacing, and assessment of scientific knowledge. Giving students some control over their own learning can be practised with Nature of Science investigations that encourage students to work as scientists, tackling big theories with small scale practical methods. Although weakly framed courses would reduce the number of credits accrued within the science department, this social realist paradigm requires a commitment to the intrinsic value of scientific knowledge rather than to an external accreditation system. It assumes that giving students opportunities to think critically and feel engaged is the ultimate purpose of a liberal education and anticipates that these future citizens will participate in a scientifically literate democratic society.

Appendix A

The following questions are about the *concepts* taught in this course:

1. Can you briefly identify the essential concepts that are taught in one of the achievement standards for this course?
2. What pre-requisite concepts do you pre-test for when teaching this standard?
3. Which concepts are essential to grasp for a student advancing in this subject?
4. What opportunities do students have to test the concepts they are taught?
5. In your experience how relevant is the historical context (ie historical discoveries) to learners' understandings? Do you mention any figures like Mendel or Gallileo in your course?
6. Thinking about the whole years' work, how interrelated or independent are the various topics or achievement standards? Is there an effort or need to link the topics?
7. Is it necessary to teach this course in a specific sequence so the concepts progress naturally?
8. Do students identify or understand any relevance of the school subject to our local context and environment?
9. Do students identify or understand any links between their local context and broader international issues or concepts?
10. Can the skills (Nature of Science) learnt in this course be applied in other sciences?
11. What other information can you give me about the concepts taught in this course

The following questions are about the *role of the* teacher in the classroom:

1. Could you describe your role in the classroom?
2. Could you describe how dependent the students are on your specialist knowledge?
3. Do students work at their own individual pace or as a class?
4. How bound to course deadlines and lesson planning are you with this course?
5. How essential is acquisition of specialist language for students in this course?
6. What other information can you give me about the role of the teacher in this course?

The following questions are about the *pedagogy* employed to teach this course:

1. Are there any opportunities for independent research in this course?
2. If so; what parameters are students given to research? Can you provide examples?
3. Are all students given the same time and materials for their research?
4. When researching, does the student know how to test for validity of information?
5. When teaching, do you find yourself instructing the whole class or spending more time with individuals?
6. How is specialist language made accessible to learners (especially of limited ability)?
7. Can you describe the pedagogy you would like to employ as well as the pedagogy you often find yourself using in this particular class?

Bibliography

Aikenhead, G. S. (2008). Science Education: Boarder Crossing into the Subculture of Science. *Studies in Science Education Vol 27(1)*, 1-59.

Alison, J. (2005). *Teachers talk about NCEA.* Wellington: Post Primary Teachers' Association.

Banks, J. A., & McGee, C. A. (2010). *Multicultural Education: Issues and Perspectives.* John Wiley and Sons.

Barth, R. (2002). The culture builder. *Educational Leadership 59(8)*, 6-11.

Beck, J. (2002). The Sacred and the Profane in Recent Struggles to Promote Official Pedagogical Identities. *British Journal of Sociology of Education 23(4)*, 617-626.

Beck, J., & Young, M. F. (2005). The assault on the professions and the restructuring of the academic and professional identities: A Bernsteinian analysis. *British Journal of Sociology of Education 26(2)*, 183-197.

Bell, B., Jones, A., & Carr, M. (2008). The development of the recent national New Zealand Science Curriculum. *Journal of Science Education 26(1)*, 76-105.

Bencze, L., & Hodson, D. (1999). Changing Practice by Changing Practice: Toward More Authentic Science and Science Curriculum Development. *Journal of Research in Science Teaching Vol 36 (5)*, 521-539.

Bernstein, B. (2000). *Pedagogy, Symbolic Control and Identity: Theory, Research Critique.* Rowan and Littlefield.

Bishop, R. (2012). Achievements, orthodoxies and science in Kaupapa Maori schooling. *New Zealand Journal of Educational Studies 47(2)*, 51-62.

Bolstad, R. (2011). *Taking a Future Focus in Education - What does it mean?* Wellington: New Zealand Center for Educational Research.

Boud, D. (2000). Sustainable Assessment; Rethinking Assessment for the Learning Society. *Studies in continuing education Vol 22(2)*, 151-167.

Brandes, D., & Ginnis, P. (1996). *A Guide to Student Learning.* Cheltenham: Nelson Thornes.

Brown, B. A., Reveles, J. M., & Kelly, G. J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning. *Science Education 89(5)*, 770-802.

Bull, A., Gilbert, J., Barwick , H., Gilbert, R., & Baker, R. (2010). *Inspired by Science.* Wellington: New Zealand Council for Educational Research.

Driver, R., & Oldham, V. (2008). A Constructivist Approach to Curriculum Development in Science. *Studies in Science Education Vol 13 (2)*, 105-122.

Ferral, H. (2005). *Clustering students by their subject choices in the Learning Curves Project.* Wellington: NZCER.

Gilbert, J. K. (2004). Models and modelling: Routes to more authenic science education. *International Journal of Science and Mathematics Education 2(2)*, 115-130.

Hallinan, M. T., & Kubitschek, W. N. (1999). Curriculum differentiation and high school achievement. *Social Psychology of Education 3(1-2)*, 41-62.

Harding, P., & Hare, W. (2000). Portraying science accurately in classrooms: Emphasizing open-mindedness rather than relativism. *Journal of research in science teaching 37(3)*, 225-236.

Hipkins, R. (2007). *Course innovation in the senior secondary curriculum: A snapshot taken in July 2007.* Wellington: NZ Council for Education Research.

Hipkins, R. (2013a). *NCEA One decade on. Views and experiences from 2012 National Survey of Secondary Schools.* Wellington: Ministry of Education.

Hipkins, R. (2013b). *Reflecting on Purposes for Learning Science.* Wellington: Ministry of Education.

Hipkins, R., & Neill, A. (2003). *Shifting Balances; The impact of Level 1 NCEA on the teaching of Mathematics and Science.* Wellington: Ministry of Education.

Hipkins, R., & Vaughan, K. (2012). *Shaping our futures: Meeting secondary students' learning needs in a time of evolving qualifications: final report of the Learning Curves project.* Wellington: New Zealand Center for Education Research.

Hipkins, R., Vaughan, K., Beals, F., & Ferral, H. (2004). *Learning Curves; meeting student learning needs in an evolving qualifications regime.* Wellington: New Zealand Council for Education Research.

Hipkins, R., Vaughan, K., Beals, F., Ferral, H., & Gardiner, B. (2005). *Shaping our futures: Meeting seconcary students' learning needs in a time of evolving qualifications. (Final report of the Learning Curves project, 2005).* Wellington: Ministry of Education.

Hoadley, U., & Muller, J. (2009). Codes pedagogy and knowledge. In *The Routledge International Handbook of the Sociology of Education 69* (pp. 69-78). Routledge.

Jensen, S., McKinley, E., & Madjar, I. (2010). NCEA Subject Choices in Mid-low Decile Schools: "What Schools and Parents Need to Know About the University Pathway. *Research Information for Teachers (2)*, 37-43.

Kauffman, J. M., & Sasso, G. M. (2006). Toward ending cultural and cognitive relativism in special education. *Exceptionality (14(2)*, 65-90.

Macdonald, D. (2003). Curriculum change and the post-modern world: Is the school curriculum-reform movement an anachronism? *Jounal of Curriculum Studies 35(2)*, 139-149.

Maton, K., & Moore, R. (2010). *Social realism, knowledge and the sociology of education: Coalitions of the mind.* London: Continuum.

Matthews, M. (1993, August 26). Curriculum Reform Degrades Science. *The New Zealand Herald*.

Matthews, M. (2000). *Time for Science Education How Teaching the History of Pendulum Motion Can Contribute to Scientific Literacy.* New York: Springer Science and Business Media.

Meyer, L. H., McLure, J., Walkey, F., Weir, K. F., & McKenzie, L. (2009). Secondary student motivation orientations and standards-based achievement outcomes. *British Journal of Educational Psychology 79(2)*, 273-293.

Ministry of Education. (2014). *Ministry of Education*. Retrieved from http://www.minedu.govt.nz/Boards/TeachingAndLearning/NewZealandCurriculum.aspx

Ministry of Education. (2007). *The New Zealand Curriculum for English-medium teaching and learning in years 1-13.* Wellington: Learning Media.

Moeed, A., & Hall, C. (2011). Teaching, learning and assessment of science investigation in Year 11: Teachers response to NCEA. *New Zealand Science Review 68 (3)*, 95-102.

Moore, R., & Muller, J. (2010). Voice Discourse, Problem of Knowledge, Identity. In K. Maton, & R. Moore, *Social Realism, Knowledge and the Sociology of Education* (pp. 60-80). London and New York: Continuum International Publishing Group.

Ormond, B. M. (2013). Powerful knowledge through the discipline of History - its fragility and the potential for dislodgement. *The Second International Social Ralism Symposium, Homerton College,.* Cambridge University, UK.

Phillips, D. (2010). Curriculum and Assessment Policy in New Zealand: Ten years of reforms. *Educational Review*, 143-153.

Pilcher, E., & Philips, D. (2007). Changing Courses: a study of the responsiveness of schools to the National Qualifications Framework. *New Zealand Annual Review of Education 16*, 151-71.

Popper, K. (1978). Three Worlds. *The Tanner Lecture on Human Values* (pp. 141-167). Michigan: Ann Arbor.

Popper, K. (2005). *The logic of scientific discovery.* London and New York: Taylor & Francis.

Raffe, D. (1994). Modular strategies for overcoming academic/vocational divisions: issues arising from the Scottish experience. *Journal of Education Policy 9(2*, 141-154.

Rata, E. (2012). *The Politics of Knowledge in Education.* New York and London: Routledge.

Rata, E. (2014). Knowledge and Democracy; The Strife of the Dialectic. In B. Barret, *Knowledge and the future of the curriculum: International studies in social realism.* Houndmills: Palgrage MacMillan.

Robinson, V., & Lai, M. K. (2006). *Practicioner Research for Educators: A Guide to Improving Classrooms and Schools.* USA: Corwin Press.

Siegel, H. (1994). Multiculturalism; Universalism and Science Education, in search of common ground. *Science Education Vol 78(4)*, 387-398.

Stanley, W. B., & Brickhouse, N. W. (2001). Teaching Sciences: The multicultural question revisited. *Science Education Vol 85 (1)*, 35-49.

Stiggins, R. (2005). From formative assessment to assessment for learning: A path to success in standards-bsed schools. *The Phi Delta Kappan 87(4)*, 324-328.

Torrance, H. (2011). Using Assessment to Drive the Reform of Schooling: Time to Stop Pursuing the Chimera? *British Journal of Educational Studies Vol 59(4)*, 459-485.

Vaughan, K. (2003). Changing lanes: Young people making sense of pathways. *New Zealand Council for Educational Research Anual Conference: Educating for the 21st century* (pp. 1-12). Wellington: New Zealand Council for Education Research.

Wheelehan, L. (2007). How competency-based training locks the working class out of powerful knowledge: A modified Bernsteinian analysis. *British Journal of Sociology of Education 28(5)*, 637-651.

Young, M. (2008). From constructivism to realism in the sociology of the curriculum. *Review of research in education 32(1)*, 1-28.

Young, M. (2010a). Why Educators must differentiate knowledge from experience. *Journal of the Pacific Circle Consortium for Education 22(1)*, 9-20.

Young, M. (2010b). The Future of Education in a Knowledge Society; The Radical Case for a Subject Based Curriculum. *Journal of the Pacific Circle Consortium for Education Vol 22(1)*, 21-32