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**Integrated Curriculum, Mathematics and
Standards Based Assessment in Secondary Education:
Parts of the Solution**

**A thesis presented
in partial fulfilment of the
requirements for the degree of
Masters of Educational Studies (Mathematics)
at Massey University**

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Abstract

The concept of integrated curriculum (IC) has a long history in the education literature dating back to the 1920s. The approach is based on the belief that curriculum is most engaging and effective when driven by student interest and subject boundaries are transcended as required to support thematic and inquiry based learning. Integrated approaches had little impact on mainstream subject based curricula through most of the twentieth century but in the last 10 to 20 years interest has increased markedly.

A case study methodology was adopted for this research to explore: how IC is currently being implemented in New Zealand, how mathematics is related to integrated programmes; how standards based assessment (SBA), particularly NCEA, impacts on IC; and how current proposals for the evolution of NCEA and SBA for IC are regarded by IC practitioners. Three secondary schools with substantial IC programmes participated. Data was gathered primarily through semi-structured interviews with senior teachers: four from integrated studies disciplines (English and social sciences) and four from mathematics.

The three schools were found to be distributed widely along the interdisciplinary continuum from strongly subject based to more transdisciplinary curricula. Three major categories of integration themes were common to all three schools: *Social Justice and Local Issues*; *Sustainable Economics and Environment*; and *Biography, Self discovery and Change*. The three schools had quite distinct ways of managing the formal collegial collaboration required for the coordination and development of integration programmes. All three reported tensions related to this collaboration. It is suggested that the interdisciplinary continuum conceptualization of IC be expanded to include a social dimension.

Learning gains, increased student motivation and improved student behaviour were reported to be the main benefits of IC although the mathematics participants were more equivocal about motivational benefits than the integrated studies participants. The main challenges reported were concerned with integrated curriculum development, rigour, assessment, and timetable and programme coordination. Strategies suggested for overcoming perceived difficulties included professional development for teachers in all aspects of IC, and time and funding for the development of integrated curriculum and assessment resources.

Mathematics was found to be a particularly difficult discipline to integrate with others, especially the social sciences. The mathematics/integrated studies divide was characterised by contrasting orientations toward curriculum and assessment, differing perceptions of student

motivation and differences in collegial collaborative styles. The mathematics participants regarded small group and inquiry based learning and assessment as promising strategies for developing IC in mathematics. Level 1 NCEA mathematics unit standards and level 3 statistics standards were reported as being amenable to combinations with standards in other learning areas for assessing interdisciplinary courses.

The NCEA was seen by participants as a positive development for IC. However, negative impacts also noted included: credit seeking, curriculum fragmentation, and constraints placed on interdisciplinary combinations of standards by university entrance requirements. The proposed development for NCEA regarded as most promising for IC was new broad-based integrated standards linked to groups of existing content and skills specific standards.

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Chapter 1: Introduction

1.1 Integrated curriculum

Curriculum in mainstream western secondary schooling has traditionally been subject based in design and academic rationalist in conception. The purpose of the subject based curricula is to enhance students' intellectual abilities in those learning areas deemed most worthy of study. They emphasise examinations, rigour, testing, knowledge and skills (Print, 1993). The principal weakness of subject based, academic curricula is their lack of integration between subjects and the consequential demarcation between disciplines within educational institutions. There is also the risk with subject based curricula that assessment, particularly for qualifications in the senior school, can become such a priority for teaching that it overpowers the potential value of the learning situation (*ibid.*). Critics of the purely subject based approach to curriculum comment also that content is often not of immediate relevance to students and that this leads to student disengagement from learning (Brown, 2006).

Evidence for increasing student disengagement in New Zealand mainstream schooling can be found in steadily worsening student attendance and behaviour statistics (Harrison, 2004). The persistent low academic achievement of some ethnic and socioeconomic groups is also a concern (Walshaw & Anthony, *in press*). To what extent these statistics are related to failings of curriculum design is unclear. Accumulating evidence however indicates that integrated curriculum (IC) designs contribute positively not only to student engagement with learning, attitude toward schooling and motivation, but also to assessment results which can equal or exceed those of more traditional academically oriented schooling methods (Boaler, 2006; Drake, 2007; Ferrero, 2006; Gutstein, 2006; McKinnon, 1991).

Integrated curricula seek to re-organise teaching and learning around big themes and contexts of universal relevance and relate them to students' particular questions and interests. Integration themes and questions typically involve issues such as: environmental protection, making and managing money, crime and violence, social justice, future technology, and individual life pathways (Brown, 2006). Discipline oriented instruction is not excluded from IC. The integrated approach seeks to balance traditional with innovative approaches to teaching and learning by using a mix of disciplinary, intradisciplinary, interdisciplinary, and transdisciplinary instructional modes. In the intradisciplinary mode, the norms, knowledge, and skills of each subject dominate while real world themes and issues or generic competencies provide the examples and contexts for integration. In the interdisciplinary mode the themes are used to coordinate and relate the subject based material of the contributing subjects. In the

transdisciplinary mode the subjects are called on only as required to support the theme, issue or project around which courses are organised (Drake, 2007).

Print (1993) defines five basic conceptions of curriculum: *academic-rationalist*, *humanistic*, *cognitive-processes*, *social-reconstructionist*, and *technological*. Traditional subject based curriculum are most closely associated with the academic-rationalist conception. Within integrated programmes, the humanistic, social-reconstructionist and cognitive-processes conceptions of curriculum assume greater importance relative to the academic conception. The humanistic conception is particularly influential with its emphasis on balancing cognitive, affective and psycho-motor faculties in the development of integrated individual human beings. The technological conception has a developing role in both subject based and integrated curricula.

Integrated curriculum is an idea that has appeared repeatedly in the education literature since the 1920s and 1930s but has never gained mainstream acceptance. Early attempts to introduce integrated curricula to schools in the U.S. succeeded for a time but then retrenched to less ambitious versions of the ideal (Applebee, Adler, & Flihan, 2007). The ground breaking New Zealand study on IC in practice—the Freyberg project (McKinnon, 1991)—reported significant gains in student achievement and motivation; but also that resistance to integrated approaches persisted. McKinnon attributed the resistance to two factors. Firstly the reforms challenged the conventional role and purpose of schools and of teachers. Second, high-stakes assessment dominated curriculum and pedagogical freedom. The present study explores both of these factors and the relationship between them as they affect the status of IC within the current broad adaptive landscape of secondary education. While the National Certificate of Educational Achievement (NCEA) has extensively altered the nature of high-stakes assessment for secondary school qualifications in New Zealand since its introduction in 2002, the significance of assessment imperatives for curriculum development remains.

1.2 Mathematics and integrated curriculum

Although opportunities to make connections for students between mathematics and other curriculum areas and between mathematics and the world of everyday life appear to abound, in practice it seems, they are not easily realised. There are indications in the literature that learning areas such as mathematics, science, and technology do not readily find their way into interdisciplinary programmes which tend instead to be dominated by English and social sciences (Applebee et al., 2007). There seems to have been little enquiry into why this is so.

The integration of mathematics teaching with everyday real world problem solving and with other learning areas appears to have great potential to support both mathematical achievement and the broader thematic learning goals of integrated curricula. Investigating issues of social justice with mathematics and emphasising the building of relational equity and respect amongst students within the classroom emerge from the literature review as particularly effective integrative strategies for mathematics teachers. At the same time the literature indicates that many mathematics teachers are likely to find such changes of emphasis in their practice problematic (Archer, 2000). Mathematics' role as a societal 'gate-keeper', reinforced through high-stakes assessment for qualifications, appears to lie at the root of this problem.

This thesis argues that adoption of integrated approaches by mathematics educators, with a consequent reduced emphasis on the discipline's gate-keeping function, could be a lynch pin which enables integrated curriculum to progress from its present peripheral status to having a more central role in education. At the same time, advances in assessment methods and systems for certification would seem to offer mathematics teachers wishing to adopt a more integrated approach to their curriculum their best means of making progress. Such advances are likely to go beyond heavy reliance on traditional external examinations and toward more interactive methods that integrate the formative and summative purposes of assessment (Harlen, 2005; Wiliam & Black, 1996). Internally assessed standards—based on portfolios or oral presentation and directed toward fostering self, peer, and group assessment in the classroom—are all promising possibilities.

1.3 Assessment and integrated curriculum

Curriculum and assessment are inextricably linked. Although it may be ideal that curriculum is established first, through professional and political consultation, and then assessment devised to align with those curriculum objectives, in reality it is often assessment that leads educational reform.

As reformers dream about changing education for the better they almost always see a need to include assessment and testing in their plans and frequently see them as the main instruments of their reforms. This is because assessment and testing are both ways of expressing aims and means to promote or impose them (Black, 2001, p. 65).

In 2002 New Zealand began a staged introduction of a coherent, standards based secondary qualifications system, the National Certificate of Educational Achievement (NCEA). By 2005

the NCEA had entirely replaced the former collection of various norm referenced qualifications for students in years eleven to thirteen. Standards based assessment (SBA) qualification systems have been welcomed as a major advance over earlier norm referenced systems by educators (Gipps, 1994), particularly those practising integrated curriculum (Drake, 2007). Instead of students being judged against one another on the basis of a single end of year exam in each subject, they are now assessed through a number of independent standards some of which will be externally examined and some of which will be internally assessed during the school year by their own teachers. The NCEA has allowed low achieving students, who would almost certainly have failed in the past, to gain qualifications (Hipkins, Wylie, & Hodgen, 2007; Meyer, McClure, Walkey, McKenzie, & Weir, 2006). It has also offered educators far greater curriculum and pedagogical freedom. However, as Hipkins et al. (2007) emphasise, assessment policy should not be expected to carry the impetus for educational change alone.

Assessment takes place in complex contexts shaped by all participants' views of learning and its purposes, views about learners (including beliefs about likely learning success on the part of both teachers and the students themselves), views about knowledge and curriculum (including the relative value of practical and academic forms of knowing), and the overall translation of these into school structures (e.g. the timetable) and practices (e.g. guidance and support) (ibid. p. 25).

Despite the professional approval that has greeted the introduction of the NCEA, there is broad agreement in the literature that in its current form it also has a number of negative impacts on teaching and learning. These impacts are of direct relevance to integrated curriculum. Excessive credit seeking by students (distracting their attention from the overall coherence of their qualification), perceptions of curriculum fragmentation and of assessment driving curriculum, and hardening of the academic/vocational divide are all negative impacts of NCEA that require attention (Hipkins et al., 2007; Meyer et al., 2006). The introduction by the New Zealand Qualifications Authority in 2007 of certificate endorsements related to grade point averages has the potential to reduce the extent of credit seeking behaviour. More significant design changes have been proposed however which are more directly related to curriculum integration.

Three current possibilities for the evolution of SBA are considered in the present study which support the development of integrated curricula. First there is the possibility of clustering existing standards into related groups assessable together within single events that make sense within the context of particular IC courses, as is already occurring in a number of New Zealand secondary schools (Hipkins et al., 2007; Pilcher & Philips, 2006). Second there is the suggestion to create new discipline specific standards for the assessment of the New Zealand

curriculum's five key competencies¹ (Hipkins, Vaughan, Beals, Ferral, & Gardiner, 2005). Third there are proposals for the creation of new broad-based standards—possibly used in conjunction with several of the currently existing 'base' standards—to assess integrated courses utilising 'big assessment tasks' (Drake, 2007; Hall, 2005). On the basis of the study participants' reflections and the literature on SBA for integrated curriculum, the first and last of these possibilities in particular are further elaborated in chapter 5 and their implications for IC development in New Zealand are discussed.

The present study is timely in a number of ways. In recent years there has been a marked increase of interest in integrated learning (Huber & Hutchings, 2004; Ng, Stillman, & Stacey, 2007). Two new schools with a major commitment to integrative learning have opened in New Zealand since 2002 and the latest version of the New Zealand curriculum encourages teachers and schools to consider and explore integrated approaches to teaching and learning (Ministry of Education, 2007). The literature on integrated curriculum has been largely descriptive rather than conceptual and the field is considered to be under-theorized (Applebee et al., 2007). This thesis explores possible avenues for extending the conceptualization of IC based on findings from the case studies conducted and a wider review of the literature on curriculum and assessment, including recently published research on the relationship between the NCEA and student career pathways. This study is the first concerned with the practice of IC in New Zealand since the introduction of the NCEA. It is also probably the first to compare two or more schools practising IC in this country and the first to focus on the role of mathematics specifically in relation to integration across the curriculum.

1.4 The research objectives and questions

This study investigates how three New Zealand schools—leaders in the practice of integrated curricula and pedagogy—are interpreting and implementing integrative approaches to secondary schooling that systematically attempt to span all, or most, learning areas. The research is based on semi-structured interviews with eight senior teachers, four from the integrated studies and four from the mathematics departments of these schools.

In looking to future focused developments of integrated curriculum the study sought participants' priorities for the development of their integrated studies and mathematics curricula.

¹ Managing self ; Relating to others; Participating and contributing; Thinking; and Using language, symbols, and texts.

Participants' responses were also sought to proposals for creating standards to assess key competencies, the potential for the clustering of standards to support interdisciplinary courses and proposals for the creation of new integrated broad-based standards.

The following three fields of enquiry, and their interrelationship, guided the literature review and research for this thesis:

- the current practice and potential development of integrated curriculum in New Zealand,
- the current and potential role of mathematics within integrated curricula, and
- the current and potential constraints and affordances of NCEA for the development of integrated curriculum in New Zealand.

The research accordingly has focused on the following four questions.

1. What is integrated curriculum; how is it currently being interpreted and implemented in the participating New Zealand schools; and what are its educational benefits, costs and challenges?
2. What is the relationship of secondary mathematics education to integrated curriculum; how is that relationship currently being managed in the participating New Zealand schools; can the two be mutually reinforcing, and if so, how?
3. How does standards based assessment (particularly the NCEA) constrain or afford the educational objectives of integrated curriculum?
4. What curriculum and assessment development strategies appear to have the most promise for nurturing the progress of effective integrated learning?

1.5 Outline of thesis

This thesis is comprised of five chapters: introduction, literature review, methodology, the interview data, and discussion and conclusion. Chapter 2 reviews the literature in three sections each related to one of the major fields which the thesis spans: integrated curriculum, the relationship of mathematics to IC, and the relationship of Standards Based Assessment to IC. Chapter 3 discusses the case study methodology adopted for this research and the interview, data generating technique, applied. The first major section of chapter 3 describes the philosophical background, strengths and weaknesses, and associated ethical implications of case study research. The second describes the design of the interview schedule, provides related background details on the participating schools and teachers and details the stages of the interview data analysis.

Chapter 4 presents the interview data in a narrative form using frequent direct quotations to support the points made. The opening section, titled *Divergence*, compares and contrasts first the case study schools, then the two learning areas—integrated studies and mathematics—across all three schools. The central section, titled *Agreement*, presents the participants' views on the benefits and challenges of integrated curriculum, and the impacts of the NCEA on curriculum development in their schools. Tables are used to display the number of participants mentioning each of the key issues raised, in total and by school and learning area. The final section of this chapter, titled *Convergence*, is concerned with participants' plans and aspirations for future curriculum progress in their subject area and their views on proposals for the development of the NCEA as these proposals relate to integrated curriculum.

Chapter 5 completes the thesis with an extended discussion of the study's key findings and their implications for the evolution of integrated curriculum and learning in New Zealand secondary school education. The four research questions, introduced in section 1.4, are answered in the opening section of the chapter where the key findings are presented in 12 numbered paragraphs. Explicit links are drawn between each research question and the relevant key finding paragraphs. The conceptualization of integrated curriculum, introduced in chapter 2, is then reconsidered on the basis of the present research. An adaptive fitness landscape metaphor is used to characterise the various forms of integrated curricula and their relationship to traditional subject based curricula. A structural model for the coherent development of integrated curricula in the context of New Zealand secondary education is also proposed. Significant aspects of the relationship between mathematics education and integrated curricula in the case study schools are discussed in light of previous research. Some suggestions are offered for ways in which the development of integrative approaches in mathematics and the closer relationship of mathematics with other learning areas can be fostered.

Finally the participants' reflections on proposals for the evolution of NCEA are discussed in conjunction with suggestions in the literature regarding the development of standards based assessment for integrated curriculum. The concept of broad-based, integrated standards in particular is elaborated. Its implications are explored with respect to constraints such as the nature of existing NCEA standards, particularly in mathematics and student career pathways through secondary education.

Chapter 2: Literature Review

This chapter is presented in three sections. The first deals with the nature of integrated curriculum (IC), its historical development in the U.S. and in New Zealand, and its educational strengths and weaknesses. The second section investigates the relationship between mathematics and IC. It reviews the literature on mathematics teachers' beliefs and practices and their responses to curriculum reform. The so called societal 'gate-keeping' role of mathematics and the implications of this role for IC reform is also explored. The third section focuses on assessment, particularly the NCEA, how it impacts on curriculum and how the qualification might evolve if it is to better support the educational aims of IC.

2.1 Curriculum and Integration

2.1.1 *Integrated and Subject based curricula*

The term *integrated curriculum* (IC) in the literature most often refers to learning programmes organised around big ideas, themes, issues, or interests, which form interdisciplinary links between one or more of the traditional school subjects (Drake, 2007). A definition of curriculum integration however is particularly elusive, since integration incorporates more than simply combining of school subjects under study themes. Drake suggests that we understand it as "looking at things from more than one perspective" (p. 25). Huber & Hutchings (2004) connect IC with the fundamental ideals of a liberal education. "At the heart of liberal education lies the idea that learning should be greater than the sum of its parts" (p. 2). Starting from a more *intra* disciplinary point of view, Hipkins, Vaughan, Beals, Ferral, & Gardiner (2005) maintain that we need to provide students with both meta-knowledge—that is, the way knowledge is constructed within different discipline areas—and access to the really big ideas of our heritage from all disciplines. Furthermore they hold that this learning should be academic, practical and future-focused. Hipkins et al. (2005) point out that such a vision of education is far from the traditional subject based curriculum focused on existing knowledge, skills and values that dominates the well-established mass schooling practices of the western world. IC has been interpreted in the present study as encompassing both *inter* and *intra* disciplinary meanings of integration.

The aims of integrated curriculum and learning are consonant with constructivist and sociocultural learning theories which emphasise the development of metacognitive skills to foster independent learning (Anthony, 1997; Huber & Hutchings, 2004) and the idea that

education is a process of simultaneous enculturation and transformation (Wells & Claxton, 2002, p. 2). These theories do not themselves require deliberate interdisciplinary connections to be drawn. However, proponents of interdisciplinary curricula suggest that curriculum integration is particularly effective for the development of integrated individuals capable of both constructive intentional learning and also of greater social integration and political efficacy (Huber & Hutchings, 2004). These authors prefer to use the phrase *integrative learning*—a term that embraces integrated curriculum, pedagogy, and assessment. They believe a key to the development of life-long integrative learning is the fostering of *intentional learning*.

Intentional learners have a sense of purpose that serves as a kind of “through line” (as the playwrights call it), connecting the sometimes far-flung and fragmentary learning experiences they encounter. They approach learning with high levels of self-awareness, understanding their own processes and goals as learners, and making choices that promote connections and depth of understanding. They are, if you will, on the road to life-long learning (p.7).

Brown (2006) recommends that students create their own integrated curriculum based on their own questions. In his experience students can and do ask substantive questions that revolve around themes such as environmental issues, making and managing money, crime and violence, issues of power, future technology and their own pathway in life. Beane (1993; 1997) also advocates that IC be developed from the interests of students themselves and that these questions can be categorized as personal growth or social issues. From the themes and big ideas typically selected for integrated courses it is clear that IC is concerned both with the personal development of individuals and with the integration of human civilization as a whole: environmentally, economically, politically, and culturally.

Integrated curricula should not be regarded as the antithesis to subject-based, academic conceptions of education. Ferrero (2006) suggests we view integration as a dialectic between and synthesis of, *traditional* and *innovative* educational ideologies. His characterisation of the two ideologies is shown in Table 1. The most striking feature of this polarity is its relationship to the dimension of time. The *traditional* perspective is oriented toward the past. It uses antipathy and critique to determine what knowledge is worth retaining in the archives of culture. The *innovative* perspective by contrast is future oriented. It uses sympathy and enthusiasm for experimentation and exploration to create new understandings and realities.

Table 1 Education's ideological divide²

| TRADITIONAL | INNOVATIVE |
|----------------------------|---|
| Standardized tests | Authentic assessment |
| Basic skills | Higher-order thinking |
| Ability grouping | Heterogeneous grouping |
| Essays/research papers | Hands-on projects |
| Subject-matter disciplines | Interdisciplinary integration |
| Chronology/history | Thematic integration |
| Breadth | Depth |
| Academic mastery | Cultivation of individual and civic talents |
| Euro centrism | Multiculturalism |
| Canonical curriculum | Inclusive/critical curriculum |
| Top-down curriculum | Teacher autonomy/creativity |
| Required content | Student interest |

2.1.2 Curriculum design theory

Integrated curriculum is a specific form of what Print (1993) calls the eclectic curriculum conception. Most curricula are in fact eclectic being comprised of mixtures of five basic conceptions of curriculum in various proportions as shown in Table 2.

Table 2 The five basic curriculum conceptions³

| |
|-----------------------------|
| 1. Academic rationalist |
| 2. Cognitive processes |
| 3. Humanistic |
| 4. Social reconstructionist |
| 5. Technological |

Print (1993) also defines four basic curriculum designs with their related variants, which are commonly used to implement eclectic mixtures of conceptions. These are shown in Table 3. The distinction between those designs emphasising curriculum content and those emphasising instruction parallels Ferrero's (2006) traditional/innovative distinction.

² (Ferrero, 2006)

³ Print (1993)

Table 3 The four curriculum designs with their associated emphases⁴

| Design | Emphasis |
|-----------------|---|
| subject-centred | curriculum (content) instructional (pedagogical) |
| core designs | |
| learner-centred | |
| problem-centred | |

National curricula in western education are largely dominated by the academic rationalist conception and curriculum subject-centred designs. The recently published New Zealand Curriculum (Ministry of Education, 2007) follows this pattern but also has elements of the other four conceptions particularly the humanistic and social reconstructionist. Each conception has its particular strengths, weaknesses and characteristic expression of the four elements of curriculum design: *purpose, content, approach* and *evaluation* (Print, 1993).

Drake (2007) refines the characterisation of integrated curriculum by defining four degrees of integration: *fusion, multidisciplinary, interdisciplinary* and *transdisciplinary*. It should be noted that Drake uses the term *interdisciplinary* both in this restricted categorical sense, as just one of the degrees of integrated curriculum, and also to refer generally to any course or programme involving two or more of the traditional subjects. In this study I have adopted the latter usage, unless specifically stated otherwise.

At the fusion level, a subject or topic is fused to the already existing curriculum. For example, groups who represent teachers of history in the US have built a case for infusing history into reading programmes and instruction at large arguing that official emphasis on improving reading and math test scores has pushed history into a marginalized position (Drake, 2007). In New Zealand, the Ministry of Education's current *literacy across the curriculum* programme is another example of fusion. Fusion, in this context, can be thought of as equivalent to intradisciplinary integration.

At the multidisciplinary level disciplines remain distinct, but deliberate connections are made between or among them by teachers in their planning. Typically, the students study a similar theme in their different classrooms. (Drake, 2007) gives the example of using the American

⁴ Print (1993)

Civil War as a theme. The Civil War is studied in history classes and concurrently in English, the students are reading a novel set in that era. From the multidisciplinary perspective, teachers make little change to their instructional programme. Content and assessment remain firmly within a single subject. The students are generally expected to make the connections among subject areas themselves.

At the interdisciplinary level, more explicit connections are made for students between subject areas. Again, the curriculum revolves around a common theme, issue, or problem, but generic concepts or skills are emphasised across the subject areas rather than just within their usual disciplinary context. For example, a unit may be organized around a universal concept such as conflict or change, or may emphasise generic research skills where the skills of one learning area (such as information and communications technology, ICT) may be applied and developed while studying the content of another (such as Shakespeare in English).

At the transdisciplinary level the students select or are presented with a real-life context such as a local community issue. The students and teachers decide together on an appropriate approach to the issue or problem and the various disciplines are then drawn upon to contribute as and when required. Drake (2007) reports on one Canadian school where grade four to six students produced a video documentary about forests based on their own research in a local biosphere reserve. They investigated three world views of forests: the scientific, the indigenous perspective, and local ecological knowledge. The students created materials later used as a teacher resource for use in other classrooms as one outcome of their project.

In their study of 11 interdisciplinary teaching teams in different schools involving 30 teachers and 542 students in the U.S., Applebee, Adler and Flihan (2007) were concerned with examining the curricular structures used to integrate disciplines, the pedagogies through which they were implemented and the kinds of activities in which students engaged. They applied a conceptual framework which they called *the interdisciplinary continuum*. The five stages of this continuum are *predisciplinary*, *disciplinary*, *correlated*, *shared* and *reconstructed*. The more innovative the curriculum stage it seems, the fewer examples there are of it. Applebee et al. classified five of their 11 teaching teams as *correlated*, four as *shared* and two as *reconstructed*. These final three stages correspond closely with Drake' (2007) multidisciplinary, interdisciplinary and transdisciplinary degrees.

2.1.3 Integrated Curriculum and the Humanistic Triad

Emphasis on development of individual students as whole human being is typical of integrated curriculum designs (Drake, 2007; Matters, 2001; Spady, 2001). This holistic approach to curriculum is also characteristic of the Humanistic conception of curriculum which seeks to effect an integration of the cognitive, affective and psychomotor faculties of the human being (Print, 1993). These three faculties, which I will refer to as the *humanistic triad*, are a perennial theme in the education literature (Biddulph, Taylor, & Biddulph, 2000; Print, 1993; Steiner, 1996). In a variant of the humanistic triad terms, Tanner and Jones (2003) refer to the cognitive, affective and *conative* faculties. The terms *conative* and *psychomotor* both refer to capacities for action. The conative dimension however is concerned with questions such as: “Am I sufficiently confident of that understanding to put it to immediate use?” (Alsop & Watts, 1997, p. 639), while the term *psychomotor* refers to the actual motor skills and actions: conscious, unconscious and intuitive.

The humanistic triad (in its conative rather than psycho-motor form I suggest) is fundamental to Drake’s (2007) model of integrated curriculum and assessment design. There it is referred to as the KDB (Know, Do, Be) umbrella. The influence of the humanistic triad on recent curricular developments is apparent at several points in the most recent New Zealand curriculum (Ministry of Education, 2007): for example, in the arts curriculum and in the health and physical education curriculum where the Taha Maori concept of *hauora*—with its four components of well-being—is incorporated. Perhaps most significantly the triad is apparent within the five key competencies of the curriculum that are intended to be cultivated in all learning areas, namely: managing self; relating to others; participating and contributing; thinking; and using language, symbols, and texts.

The humanistic triad can be seen as a structural principle also at the collective level of human experience. A number of educational and social theorists have argued for the existence of a strong relationship between the individual psychological plane and the social level, or group plane of human experience (Ernest, 2007a). Steiner (1972) names the Social-Cultural, Rights, and Economic spheres as the components of a *three-fold social order* corresponding with the cognitive, affective and psycho-motor faculties respectively in the individual. Although only one of the following four examples of implemented integrated curriculum designs sourced from the literature employs an explicitly triadic structure, there are strong correspondences identifiable between elements of each design and Steiner’s three-fold social order.

1. Gutstein (2006) proposes a triadic integrated curriculum design based on his ten years experience teaching mathematics for social justice at Rivera, a K-8 neighbourhood school in Chicago. The three components of his curriculum design are *community knowledge*, *critical knowledge*, and *classical knowledge*.
2. At Hersey High and Northtown Academy also in Chicago, students attend integrated classes focused on controversy and interdisciplinary themes as well as traditional ability grouped classes focused on content and skills aligned with the ACT⁵ College Readiness Standards and standardized diagnostic assessments (Ferrero, 2006). All classes in the 9th grade relate to four main integration themes (one per quarter): *current social issues and the political spectrum*; *identity (race, class, gender)*; *belief, values, and morality*; and *current global issues*.
3. Matters (2001) Australian *New Basics* trans-disciplinary curriculum defines four clusters of “practices that are essential for survival in the worlds that students have to deal with” (p.2). The four clusters are titled *life pathways & social futures*, *multiliteracies and communications media*, *active citizenship*, and *environments & technologies*.
4. Spady (2001), proposes a curriculum design based on a hierarchy of ten *life performance* roles and eight *spheres of living*. He emphasises integration of the individual based on competencies and multiple intelligences.

Although IC design is currently an active field there appears to be little consensus around structural theory (Applebee et al., 2007). From his theoretical work in evolutionary biology Kaufmann (1995) develops the idea of organisms and human social entities evolving by adaptation on rugged fitness landscapes. Drawing on this framework, schools such as the three that participated in the current research and those referenced above can be thought of as pioneering entities modifying practice and improving fitness as they explore a largely unknown region of the adaptive landscape of education. As they explore and report back on progress, we can create maps of the terrain in the form of more grounded theoretical understandings of integrated curriculum. A humanistic triadic model at two levels—the individual and the social—would seem to be a strong contender for such a coherent theoretical structure.

⁵ American College Test

2.1.4 The Integrated curriculum debate

Background

Although integrated curriculum as an idea has been around since the 1920s in the U.S. (Applebee et al., 2007) and the 1930s in New Zealand (McKinnon, 1991), it has been consistently resisted by mainstream education. McKinnon advances two main reasons for this resistance. First, IC reforms not only challenge the role and purpose of schools but are also perceived as being critical of teachers themselves and their role definitions. This effect is discussed further below under the heading of *teacher perspectives*. The second reason he suggests is the dominance of high-stakes assessment over curriculum and pedagogical freedom. The separate subject hegemony in New Zealand is supported by exams and exams perpetuate the system (ibid).

The introduction of the standards based NCEA qualification in New Zealand in 2002—with its increased emphasis on internal assessment throughout the school year—has brought schools and teachers increased curricular and pedagogical flexibility. At the same time, end of year examinations remain for the assessment of external standards. There are now in fact external examinations at level 2 where there were none under the previous, entirely internally assessed Sixth Form Certificate. However, student achievement at all levels and in all subjects is no longer judged on the basis of a single end of year exam. A student's NCEA qualification can be based on a personalised selection of standards, both internals throughout the school year and externals in the end of year exam. Interdisciplinary combinations are amongst the programme innovations being trialled. Pilcher & Philips (2006) report that one third of the 183 schools which responded to their nation wide survey of secondary schools had, as a result of NCEA, introduced courses that assessed standards from different learning areas. Typical pairings included standards from different subjects within a learning area such as human biology and science as well as more interdisciplinary combinations such as computing and visual arts. A recent survey of 198 New Zealand secondary school principals reported that 25% of their schools had taken up opportunities to combine assessment of several internal standards into one event (Hipkins et al., 2007). Aspects of English for example could be assessed via writing produced in another subject or statistical knowledge in mathematics could be assessed in the context of the sciences and geography (ibid). The use of external standards within integrated courses however is likely to be problematic since the exams remain subject based and each standard is assessed independently of all others. While changes in high stakes assessment since the early 1990s have increased curriculum options for schools, IC development is still constrained by subject based examination imperatives.

Interest in integrated curriculum and learning continues to grow (Huber & Hutchings, 2004). Examples of new IC designs such as those discussed in section 2.1.3 are appearing more frequently and the influence of curriculum integration principles is also evident in the New Zealand Curriculum (Ministry of Education, 2007). Since 2000 two new schools with a major commitment to implementing and developing IC have opened. Both of these schools contributed to the research for this thesis.

The benefits and challenges of integrated curriculum

Designers of mainstream subject based curricula are under continual pressure to transfer content from what was once part of the hidden or external curricula, to the overt and enacted curricula. This knowledge was once either unconsciously transmitted as assumed values, attitudes, and beliefs, or was the domain of institutions such as family or church. Print (1993) warns that because schools and teachers are unwilling to surrender subject based content, the problem of the *finite curriculum*—that school programmes cannot be expanded without limit—may eventually force the need for a total re-conceptualization of national curricula.

Integrated curriculum proponents claim to address the problem of the finite curriculum directly by their readiness to reconsider both the explicit and hidden curricula in their totality and to reprioritise subject content, skills and values: thus putting disciplinary imperatives and social issues on a more equal footing. Unifying themes and big contexts are seen by IC designers as focusing educational attention on the challenges and opportunities of the immediate and long-term future that are most relevant to students (Brophy, 2001; McKinnon, Nolan, & McFadden, 1992; Spady, 2001). The modern world of information overload requires us more than ever, to integrate disparate facts in our search for real insights. Participation in the *knowledge society* that requires flexibility and mobility within one's career means that:

students are now advised that the knowledge they gain in their majors will not be useful for long unless coupled with skills and dispositions that enhance their ability to find and take advantage of new opportunities as they arise (Huber & Hutchings, 2004, p. 3).

As well as concerns of relevance and appropriate knowledge focus, mainstream schooling in New Zealand is increasingly experiencing problems with absenteeism and poor behaviour: clear indicators of student disengagement. From 1991 to 1998 suspensions per 1,000 students (in state and integrated schools) rose from 6.6 to 17.5. In 1999 the Ministry of Education introduced stand-downs as part of a new system of formal discipline for schools and in 1999/2000, the total rate of suspensions and stand-downs combined reached 30.2 per 1,000 students (Harrison, 2004). Practitioners of integrated curricula by contrast, report increased

student motivation, engagement with schooling, attendance, reduced behavioural problems, and increased inter-ethnic respect: all outcomes of intrinsic value that also contribute fundamentally to significant gains in learning for all groups of students (Boaler, 2006; Drake, 2007; Ferrero, 2006; Gutstein, 2006; Nolan & McKinnon, 2003).

Several studies provide evidence that students in IC programmes achieve academic success on par with and exceeding that of their peers in traditional programmes. From the Freyberg High school integrated curriculum project, McKinnon, et al. (1992) reported that the first cohort achieved the highest grades ever for this school in the national School Certificate English examination. Drake (2007) cites a number of studies dating from 1942 to 2006 which indicate that in interdisciplinary programmes, students do as well as or better than students in traditional programmes. Ferrero (2006) reports increased academic achievement results with the implementation of a hybrid IC at Hersey High and Northtown Academy in Chicago. He maintains that the benefits expected from innovative interdisciplinary curricula and the benefits of traditionalist academic rigour were realised within one integrated programme. Notably, he writes, “value-added growth was most dramatic for students most at risk, including low-income and special education students” (p. 10). Boaler (2006) and Gutstein (2006) also report academic success in intradisciplinary mathematics programmes, equal to and better than those achieved in comparable traditional courses. These results are discussed in more detail in section 2.2.2 under the heading *Successful mathematics integration*.

Not all of the literature is positive about integrated curriculum however. George (1996) makes a number of critical observations, some of which have been balanced by subsequent research but others of which remain as serious constraints to the effectiveness of integrated curricula. First, he challenges proponents of IC to give the concept clarity and also to provide evidence that it is in fact able to achieve its goals any better than the traditional subject based curriculum. Second, he observes that many integrated courses have in fact very little integration with the rest of the programme in which they are embedded.

Most examples of interdisciplinary, multidisciplinary, or integrated curriculum units that I have encountered have virtually no obvious connection to any prior learning or clear tie in with whatever may follow such a unit. [Integrated units] may attempt to take student interests into account, but rarely plan to knit together a close connection to other integrated units or to any other part of the curriculum (p 14).

Third, he points to the enormity of the change being proposed and the inertia of the institutions that would need to change. This is a particular issue for secondary schools where the majority of teachers have studied only one or maybe two subjects in depth.

To change this situation would require an epistemological revolution at the college and university level that would reverse centuries of practices related to the acquisition of knowledge, as well as a complete reorganisation of teacher education: these are unlikely events (ibid, p 16).

Applebee, Adler and Flihan's (2007) large scale study of mostly English and social studies integration across grades seven to eleven, reported that all eleven teaching teams echoed the full range of benefits and problems of IC previously reported in the literature. To the benefits listed already they added: reinvigoration of stale teaching and the power that comes from the sense of shared purpose. To the problems they added: the need for compatible personalities among team members, the propensity for interdisciplinary programmes to degenerate over time with one of the contributing subjects coming to dominate the curriculum at the expense of the others, difficulties in arranging sufficient planning time, and the lack of purpose made textbooks and other materials.

Applebee et al. (2007) conclude that interdisciplinary course work is neither a problem nor a solution in efforts to increase student achievement. They claim that IC involves a number of tradeoffs that need to be considered at the school site. These researchers did not however attempt to measure student achievement in relevant ways maintaining that they were more concerned with understanding what "relevant achievement" might mean to the schools and teachers involved.

2.2 Mathematics and Integration

In the research studies on IC it has been noted that mathematics is one of the most difficult discipline to bring into an integrated curriculum (Drake, 2007; George, 1996). Only one of the eleven interdisciplinary teams studied by Applebee et al. (2007) included mathematics and that was only at grade seven.

In this section the relationship between mathematics education and the aims of curriculum integration is first explored at the level of individual students and classes where particular attention is given to how these curriculum areas can offer each other mutual support. The focus then moves to teachers' points of view on traditional mathematics teaching, school reform and curriculum integration. Finally the evolution of the mathematics curriculum is discussed with respect to the discipline's strong relationship to assessment and its consequent 'gate-keeping' role within westernised society as a whole.

2.2.1 *At the individual class level*

Employment and real world contexts

Research that underlies both constructivist and situated cognition theories of learning has shown that students' acquisition of knowledge and skills is highly dependent on the social and physical context in which the learning takes place and is unlikely to transfer automatically to other unfamiliar contexts (Ernest, 2007a; Lave, 1988; Valero, 2007). In her work on adult literacy Lave finds that *just plain folks* employ mathematical reasoning in everyday situations such as supermarket shopping to a high degree of accuracy using their own mental strategies. They perform poorly on comparable problems posed in formal pencil and paper type test situations where they struggle to apply methods only half remembered from their school days.

Integrated curricula recognise the situational specificity of learning and cognition. Extending mathematics instruction to realistic everyday contexts and integrating it with, or even re-situating it in other learning areas—such as home economics, physical education, technology and science—is seen as crucial to the desired learning process and outcomes. The significance of situated arithmetic strategies lies also in their universality. In a New Zealand study of the mathematical needs of school leavers, Knight, Arnold, Carter, Kelly and Thornley (1994) found clear evidence that the single most important mathematical ability required by people both for everyday life and employment is the capacity to make sensible quantitative judgements in

problem-solving situations. These judgements are most likely to involve estimation and to be based on mental arithmetic.

Gutstein's (2006) programme at Rivera in Chicago combined the *Mathematics in Context* (MiC) curriculum—designed to develop students' functional mathematical literacy—with projects designed to cultivate students' critical awareness and personal engagement with social justice issues. Virtually all the mathematics in MiC is embedded in real-world situations, with no pages of de-contextualised number sentences evident in accompanying texts. The fact that the MiC stories are from everyday activities, sends the message not only that mathematics is about the world but also that it is a language form intimately related to written and spoken English.

Integrated curriculum teachers have discovered links between the thinking skills in mathematics and those in literacy (Drake, 2007). High school teachers for instance have found that they learned more about students' understandings and misconceptions by asking them to write in response to prompts—such as 'Why is $5/0$ undefined? How does knowing that $17^2 = 289$ help you calculate 16×18 quickly?'—than they would have by traditional methods (Miller, 1992). Clarke, Waywood, & Stephens (1993) report from a study of Australian secondary school students' mathematical journals that those students' writing demonstrated movement towards greater reflection on their personal understandings and mathematical activity over time. This integration of numeracy and literacy also appears to be encouraged by key competency number five in the NZ curriculum *Using language, symbols, and texts* (Ministry of Education, 2007).

Relational Equity and Social Justice

Mathematics education as a scientific field of study has been narrowly defined to focus on the relationships among teachers, learners and content to the exclusion of connections to the external social environment (Valero, 2007). Until twenty years ago, mathematics was considered a value free and culture free subject: this is no longer the case (Atweh, 2007; A. Bishop, FitzSimons, Seah, & Clarkson, 1999). The term *social justice* has been used very broadly to refer to all three spheres of the triadic social order (Ernest, 2007b; Gutstein, 2006). Issues related to environmentalism, critical citizenship, ethics, psychology and the spirit-cultural have all been included.

Classroom research studies have found that where teachers have integrated mathematics with education for social justice (in the *Rights-Political* sense) two distinct purposes are evident: first the fostering of relational equity amongst the students within a class (Ball, Goffney, & Bass, 2005; Boaler, 2006), and second the development of a general political critical awareness and

literacy (Gutstein, 2006; Noyes, 2007; Valero, 2007). Either of these purposes can also be pursued in conventional classrooms, but in integrated learning social justice achieves a status equal to and sometimes greater than the acquisition of mathematical knowledge. To the extent that this balance of priorities is maintained in a classroom it could be said that its curriculum is effectively integrated.

Mathematics is a subject through which people seem to divide themselves into two groups: those with a “natural interest” and those who are “mathematically handicapped” (Gellert, Jablonka, & Keitel, 2001). This subjective distinction mirrors a societal reality referred to by some authors as the *gate-keeping* or *critical filtering* function of mathematics’ (Davis, 1993; Ernest, 2007b; Gutstein, 2006; Noyes, 2007; Valero, 2007; Volmink, 1994). This socioeconomic role of mathematics education is discussed further in section 2.2.3. Although mathematical learning difficulty is an issue that has traditionally received much attention in education research, the integration of pupils aiming to become mathematicians and those labeled “not gifted” remains a seemingly unsolvable dilemma (Gellert et al., 2001). To what degree mathematical facility is an inherited characteristic is uncertain: that social factors play a part in forming students’ self attributions however is undeniable. McBride (1994) for instance maintains that individualism is the hidden ideology of much of modern school mathematics. She holds that the emphasis on individual choice and on mathematics as underpinning rational judgement permeates school mathematics texts and fails to recognise that human beings are social beings whose identities are constructed and defined by their relationships with other persons (ibid). This particularly true of the adolescent years (Santrock, 2003). Thus, inclusion within integrated mathematics classrooms where relational equity is a high priority, arguably has great potential to help students avoid self destructive, exaggerated (positive and negative) self attributions of ability.

At Railside urban High school in San Francisco the mathematics students experienced a curriculum designed to develop relational equity within the classroom. The emphasis was on, understanding one another’s differing viewpoints and developing positive collaboration (Boaler, 2006). At Railside the teachers “taught their students to respect one another. As a result, the ethnic cliques so evident in many schools did not form. Indeed, lessons were calm and peaceful, students were productive, and few behavioral problems surfaced” (ibid, p 75). Mathematics had an important role to play in developing these students feeling for *relational equity*, just as relational equity had an important role to play in developing the students’ mathematical knowledge.

For the purpose of developing critical citizenship, mathematics offers tools to examine and analyze the deep economic, political, and social inequalities in our society. Ideal questions for statistical investigation are for example, 'who voted in the last election and why? How does our system of school funding shape the quality of education that different children receive?' (Ball et al., 2005, p. 4). A strong grasp of mathematical ideas can greatly help students understand the details underlying many political issues and the intricacies of possible resolutions. For example, to appreciate how standardized tests results relate to student socioeconomic characteristics, students needed to understand correlation and causality: and the difference between them (Gutstein, 2006).

Cultural taonga⁶ and personal values

Included among the many reasons that have been given for teaching mathematics are that we teach it for its own sake, because it is beautiful; because it reveals the divine (Davis, 1993). That is, mathematics is a cultural treasure, a taonga. At this level the discipline has many connections with other learning areas in the curriculum.

Mathematics represents an ancient and remarkable set of cultural achievements and engagements. As such, the historical development of mathematical ideas and methods offers a medium for studying history and culture and their intersections in domains of human activity as diverse as architecture, art, music, science, and religion (Ball et al., 2005, p. 4).

Cultural context provides a specific form of situated learning that can support mathematical learning. The more rooted in context, cultural background and personal knowledge an event is, the more readily it is understood, learned and remembered (Leder & Forgasz, 1992). The fostering of mutual ethnic, religious and philosophical understanding in turn supports students in building their own identities in relationship to the unique identities of others (Ball et al., 2005).

Mathematics also has its own contribution to make to the educational challenge of balancing self esteem with humility.

In mathematics lessons, students have the chance to meet something so large they cannot easily comprehend it, to be struck by something of such beauty and elegance they cannot fail

⁶ *Taonga* is a Taha Māori language term with many associated meanings in English. A representative but not exhaustive list of translations includes: treasure, asset, heritage, wares, utensil, inventory, possession and masterpiece. (Learning Media Ltd, n.d.)

to appreciate it, to appreciate something of such power that they are humbled by it (Morris, 1995, p. 36).

In this regard we can mention topics such as Pythagoras' theorem (which leads to irrational numbers), the Fibonacci sequence and the golden ratio, the concept of infinity and Cantor's infinities, non-Euclidean geometries, chaos, complexity, imaginary numbers, transfinite numbers, and so on. These topics lend themselves to artistic geometric illustrations and historical connections to the development of human consciousness. Through immersion in such concepts and their manifestations in nature, students may be brought to an appreciation of the spiritual in mathematics (Winter, 2001). Winter stresses that giving meaning to the word *spiritual* is a personal journey. She links spirituality with "our propensity to regard the world with wonder and to follow this with wondering" (p 209). Ultimately it is this appreciation of the ultimate mysteries and of the wholeness of existence and human experience that motivates integration. Pursuing the aesthetic, cultural and identity nurturing spiritual connections of mathematics can be given greater emphasis in an integrated curriculum.

2.2.2 Mathematics teacher beliefs and diverse perspectives on reform of practice

Teacher beliefs

Based on interviews with 10 secondary school mathematics teachers in Australia, Archer (2000) suggests that teachers' beliefs about the nature of their discipline and their role will be challenged by current reforms towards authentic or "rich" tasks. Authentic tasks mirror problems encountered in the world outside school: they move across traditional discipline or syllabus areas and have intellectual depth (ibid). While the 17 primary teachers in her study tended to see mathematics as tied to students' everyday lives and linked with other aspects of the curriculum, secondary teachers tended to see mathematics as self contained and viewed their role as guiding students through its orderly, logical structure. Secondary mathematics teachers also agreed that manipulating physical objects—as supported by authentic tasks within an integrated curriculum—would help students to understand mathematical concepts, but argued that it was difficult to use this strategy in high schools.

As already noted, group work that includes whole class discourse and small group assessment, has been proven effective in developing relational equity together with mathematical understanding in integrated classrooms (Boaler, 2006). The mathematics teachers in Archer's

(2000) study did not use much group work. They said they “found group work too disruptive” (ibid, p 19).

In the mainstream secondary schools she studied, Archer (2000) found that belief in the motivational value of success was most obvious in teachers’ endorsement of streaming classes by ability or previous achievement in mathematics (ibid, p.11). Pilcher & Philips (2006) note that the increase in the number of alternative courses available to students following the introduction of the NCEA in New Zealand secondary schools, has also been accompanied by widespread ability level streaming. The practice of streaming students by ability (or tracking as it is called in the US) has been criticised as damaging and as particularly inappropriate within the context of integrative education for social justice (Boaler, 2006; Gutstein, 2006). Ability grouped classes are however used extensively and effectively in the integrated programmes at Hersey High and Northtown Academy in Chicago. The school believes that the common core curriculum mitigates the stigma associated with remediation in tracked classes and ensures that all students grapple with the same content and issues (Ferrero, 2006). The issue of ability based streaming within IC settings is clearly undecided and would benefit from on-going research.

Mathematics teachers’ perceptions of their role and student motivation have been found in a number of research studies to differ markedly from that of their students. The notion of mathematics as a set of procedures to arrive at a right answer is deeply ingrained in most mathematics teachers (Archer, 2000). Archer comments that no secondary mathematics teacher in her study made mention of motivation coming from connections with life outside school. In his 1992 study of six middle-school mathematics teachers and their classes, James Middleton (1992) found that most of the teachers had little notion of the motivational beliefs of their students and that “the ways in which they attempted to build motivating exercises seemed to be more dependent upon the teachers’ personal conceptions of intrinsic motivation than their beliefs about their students” (p. 1). Rawlins (2007) reports a similar disjunction between teachers’ and students’ perceptions about the relative value of different forms of feedback. His study investigated student perceptions of the formative learning potential of NCEA assessment in three New Zealand year twelve mathematics classes at Euclid College, a medium to large provincial urban secondary school. The teacher participants in this research perceived oral feedback as having the most positive benefits for learning. The students however preferred opportunities to discuss scaffolded written feedback from teachers with their peers and displayed the capacity to develop corrective strategies and deepen learning through that peer to peer interaction. Even where teachers have been committed to finding locally relevant social justice projects for IC to motivate students, problems of divergent perceptions of motivation have occurred. For example, in Porto Alegre teachers for years investigated thematic

complexes by talking with adults in the favelas (poor, informal settlements). Slowly, they also began to investigate students' themes and discovered that they were not necessarily the same as the adults' themes (Gutstein, 2006).

Consideration of values is of the essence in integrated curricula but open discussion of personal values appears to be a sensitive area for mathematics teachers even in confidential research settings (A. Bishop et al., 1999; Ernest, 2007a, 2007b). It seems that many mainstream mathematics teachers are likely to be far from an IC perspective in the way they currently view their discipline and its educational purposes.

Changing Schools and Teachers' practice

Teachers' personal investment in and commitment to the system which educated them as students—on which their teacher training is also based—in itself can offer one of the greatest challenges to curricula reform (Archer, 2000; Gutierrez, 1996; Nolan & McKinnon, 2003; Wilson & Cooney, 2002). Even teachers who are enthusiastic about IC reform find the shift in approach a major professional challenge (Gutstein, 2006). Those schools that have attempted the move to IC affirm that such change takes several years of persistent effort from school leaders and even then may not be readily accepted by some teachers. In his study of Hersey High, Ferrero (2006) notes that even after five years:

... some in the surrounding district and inside the school deny the merits of the approach, despite the overwhelming performance data testifying to the school's success, palpable improvements in school climate, and consistent testimonials from parents and students (p. 14).

Gitlin and Margonis (1995) have attributed the failure of integrative reforms to teachers' rational response to the unreasonable additional workload demands of having to create and implement new curriculum while continuing to deliver instruction assessed against traditional expectations. Walshaw and Anthony (in press) observe that failure of policy implementation within mathematics education is frequently presented, if not as negatively as sabotage, then at least as due to the misinterpretation of implementing agents.

Reporting on mathematics departmental change in the U.S., Ziebarth (2003) is less positive. He finds that apathy with respect to colleagues' attitudes about reform and continued professional development remains a prominent issue for some teachers involved in the Core Plus Mathematics Project (CPMP). In larger mathematics departments it is more difficult to establish consensus and colleagues close to retirement are reluctant to learn "anything new" (p. 15). Walshaw and Anthony (in press) suggest that attempts to understand how change

processes in education fail or succeed require greater attention to how individual teachers conceive of the changes being recommended by policy initiatives. In addition to the effects of professional communities on individual teachers it is important to comprehend how a teacher understands policy messages and “their self-in-community” within proposed policy initiatives (p. 3).

Integrated curricula require the generation of new resources, programmes and professional development processes. The cost in terms of time, energy and money are significant. One study of the integrated mathematics programme at Railside high school in San Francisco found that the teachers spent approximately 650 minutes each week planning, individually and collectively but their paid work week provides for only 450 minutes of preparation time (Boaler, 2006). The MiC mathematics curriculum—used in the Rivera IC—took seven years and roughly \$8 million to become fully operational and published, with a team of about 50 researchers, curriculum developers, consultants, and teachers (Gutstein, 2006).

Perhaps the most ambitious reform of the New Zealand mathematics curriculum ever has been that associated with the Numeracy Development Project (NDP). The success of this reform has been attributed to affordances such as quality resourcing and the provision of teacher release time, as well as personal factors such as teachers' level of content knowledge (Walshaw & Anthony, in press). Other factors noted by these authors as important in facilitating change in teachers' practice were: school-wide systemic change that aligns with reform, principals who respect the professional expertise and change intentions of the school's mathematics teaching community, and lead mathematics teachers who are key players in interpreting the reforms for their staff.

Collaboration in designing curriculum and teaching methods, and a shared commitment to fundamental principles amongst mathematics teaching staff and school managers were also cited as important factors in the successful implementation of the integrated curricula in U.S. and Australian schools (Boaler, 2006; Bobis, 2004; Ferrero, 2006; Gutstein, 2006).

Successful mathematics integration

The literature on current mainstream education suggests that the changes required to introduce integrative learning and curriculum would be both extensive and difficult to realise. However, notable examples of successful integration of mathematics with social justice issues that extend beyond the traditional mathematics curriculum can be found.

The mathematics students at Railside urban high school in San Francisco were compared with their peers at two suburban high schools in the same city by way of tests conducted at the beginning and end of their freshman year and at the end of their sophomore and junior years (Boaler, 2006). Incoming freshmen at Railside scored significantly lower on the test than did incoming students at the other two schools but had caught up with their peers by the end of their first year. By the end of their sophomore year, they were outperforming the students from the two suburban schools. Surveys and interviews showed the Railside students were consistently more positive about mathematics from their sophomore year on (ibid). The Railside teachers also rewarded various approaches to problem solving in their grading schemes. "The students at Railside achieved high grades not only because they got correct answers but also because they asked good questions, rephrased problems, explained ideas, worked logically, justified their methods, or brought a different perspective to a problem" (p78). Boaler attributed these results to the teachers' integration of relational equity and respect building with teaching for mathematical understanding, as goals of equal priority.

Group work and group assessment were integral features of the Railside lessons. Teachers continually reminded students that they needed to work together and make sure all members of the group understood the work. Group testing involved all students working together to complete the test but all students being awarded the same grade based on just one of their papers. Acceptance of the group work restrictions was not immediate, particularly by those higher achieving students who initially just wanted to get on with their own learning. By the end of the second year, however, these students had changed their minds (Boaler, 2006).

At Rivera, Gutstein (2006) reports that, at the very least, no data suggest that the MiC programme harms students' performance on traditional measures. In the 2003-2004 school year, the mathematics test scores of Philadelphia eighth graders, all of whom studied MiC, rose by 11.1% (p. 119). With respect to his own students who used MiC integrated with social justice projects, Gutstein reports results from the class that he taught in their seventh and eighth grade years of 1998-99. As expected of students in the honours track, this class did well on conventional measures of success. All 26 passed the eighth-grade Iowa Test of Basic Skills (ITBS) exam that determines whether they pass the grade, and all also passed his own class tests in both years. The time spent on social justice issues is seen by the author as a benefit to the students over and above their academic learning which was not compromised in the process.

Gutstein (2006) used the MiC curriculum for about 75 to 80% of the classroom time in combination with real-world projects in social justice. He reports that it was the MiC curriculum that contributed most to the development of students' mathematical power

(functional literacy). It was the real-world social justice projects however which most engaged students' attention and influenced their beliefs about the value of mathematics in the long term.. The projects were designed to develop students' ability to 'read and write the world with mathematics'—that is, to develop their critical literacy—and to have them take personal stands on social issues relevant to them. For example, he used SAT⁷ and ACT⁸ college entrance scores and demographic data to provide material for students to investigate the politics of high-stakes gate-keeping assessment regimes and read to his students from academic writings on the racist history of standardized testing and its relationship to capitalism and labour stratification. The dual purposes of developing both functional and critical literacy within an integrated mathematics course were not however entirely compatible. Gutstein concluded that:

One can apply already known ideas, concepts, and procedures to analyze injustice and meaningfully read and write the world—but not also create solution methods and reinvent significant mathematics at the same time. That occurred when I reduced the mathematical challenges on the real-world projects (p. 108).

Although mathematics is an effective tool for learning 'to read and write the world' for social justice, Gutstein (2006) found that there is a point at which critical mathematical knowledge is no longer enough and teacher and students must move on to critical knowledge in general. This leads him to the view that the long term goal for mathematics curriculum integration must be based on collegial collaboration across disciplines.

2.2.3 Society and the Gatekeeper

Where the previous section discussed the relationship between integrated curriculum and mathematics teachers' beliefs about their subject, this section considers the role of mathematics, assessment and IC in relation to society as a whole. It focuses particularly on assessment for qualifications and the 'critical filtering' of individuals administered by this assessment (Davis, 1993; Ernest, 2007b; Gutstein, 2006; Noyes, 2007; Valero, 2007). Volmink (1994) notes that mathematics, more than any other subject

has been cast in the role of an "objective" judge, in order to decide who in society "can" and who "cannot". It therefore serves as the gatekeeper to participation in the decision making processes in society (p. 51).

⁷ Scholastic Aptitude Test

⁸ American College Test

It is the gate-keeper role of mathematics and its relationship to maintaining status quo economic, social and cultural patterns of power and discrimination which perhaps most illuminates the roots of the discipline's isolation in an IC setting. The social justice themes and values of integrated curriculum directly call into question the traditional emphasis on the role of gate-keeping in mathematics education.

Economic imperatives

Mathematics in the senior secondary school has long been dominated by the abstract content and skills required for tertiary level academic study aimed at a narrow range of professions. Knight et al. (1994) report that school leaving qualifications of that time emphasised algebraic, trigonometric, formal geometry and calculus skills which would "be used by relatively few students" (p 4). This emphasis appears to have changed little in the 15 years since that study. According to Noyes (2007), on formal calculus oriented mathematics is motivated by the demand for science, technology, engineering and mathematics (STEM) tertiary level graduates, which are believed essential to the maintenance of western society's economic prosperity.

Bourdieu and Passeron (1977) suggest the relationship between education and economy can be better understood by regarding knowledge as *cultural capital* and treating it as we would economic capital—that is, as a saleable and exploitable commodity. This *commodification* of knowledge has led to educational success being defined in terms of numerical targets which measure the production of knowledge and of human capital (Ernest, 2007a). From the 'cultural capital' point of view, student poor achievement/failure can be regarded not as an aberration but as a natural consequence of our capitalist, transnational, corporate economic system. This economy functions most efficiently when there is a (measured) unemployment rate of about four to six percent because it is concerned primarily with profit maximisation and only secondarily with the distribution of resources and employment (Apple, 1979). Similarly education—and particularly mathematics education since it is so closely aligned with the production of cultural capital—requires failure to generate the competition necessary for motivation by assessment (ibid). Thus academic success goes disproportionately to those who have been granted access to cultural and economic capital as a consequence of their birth circumstances.

According to Apple (1986), curricula which emphasise higher mathematics for the attainment of prosperity through advanced career opportunities are apparently also promulgating a myth. The labour market does not actually have positions for all those highly educated workers. What it does need, however, in an era of transnational capital movement, are specific types of workers

(Lipman, 2004). The fastest growing categories of employment in the U.S.—as reported by its Bureau of Labor Department—are those with the lowest earnings requiring the lowest levels of work related training (Gutstein, 2006). To the extent that schools with integrated curricula seek to oppose these pervasive, global patterns, they swim against powerful economic and social currents. This is particularly true for integration of senior mathematics with a social justice element. Not only do they threaten the supply of STEM graduates but they actively seek to question the myths of *consumer inadequacy* and *progress* (Ernest, 2007a), upon which capitalism depends.

Social Political imperatives

Encouraging critical literacy education in public schooling—as advocated for integrated mathematics curricula emphasising social justice—encounters resistance not only because it appears to threaten the economy’s supply of STEM graduates but also because it challenges cultural discrimination related to racist and militaristic attitudes in society. Modern warfare not only requires a secure supply of mathematically based technical expertise but also of young, able bodied, willing soldiers. Working-class youth of colour, particularly Latinos, are for instance over represented in the U.S. military and are concentrated in more the dangerous front line combatant positions (Gutstein, 2006). Senior Pentagon officials have identified Latinos as by far the most promising ethnic group for recruitment, because their numbers are growing rapidly in the U.S. and they include a plentiful supply of low-income men of military age with few other job or educational prospects (ibid). The importance of the gate-keeping function of mathematics for the military is further underlined by the history of high-stakes assessment systems. In fact the U.S. army, during the First World War, sponsored the early development of IQ testing. IQ testing (still used by the military in 2001) is based on psychological theories of intelligence as a unidimensional, fixed trait and is underpinned by the mathematics of psychometrics (Black, 2001).

Cultural imperatives

Mathematics relationship to the gate-keeper function of high-stakes assessment also works negatively because culturally it has been protected from inspection. Western white mathematics is not only imposed as the privileged form of thinking of human beings it is also seen as being apolitical and this makes it difficult for researchers, teacher educators, teachers, and pre-service teachers to conceptualize teaching and learning mathematics for social justice (Gutstein, 2006). Furthermore, mathematics is integral to the Newtonian-realist world view, etched deep into the

public consciousness as an underpinning 'root metaphor' even though the modern science of relativity and quantum theory shows it to be scientifically untenable (Ernest, 2007a).

Mathematics education outcomes are dramatically different for certain ethnic groups. In the United States Latinos/Latinas and African Americans score well below Whites in mathematics on every major assessment, at any grade level (Gutstein, 2006). A similar contrast is apparent between Maori and Pasifika, and Pakeha (European ancestry) New Zealanders (R. Bishop & Glynn, 1999; Meyer et al., 2006; Ministry of Education, 2003). In their *Best evidence synthesis* of effective mathematics pedagogy, Anthony and Walshaw (2007) maintain that identifying and explaining effective mathematics practice "that meets the needs of *all* students is more urgent now than at any previous time" (p 9). Postmodernist epistemologies with their view of knowledge as socially and culturally embedded are beginning to challenge and transform the Newtonian world view of western consciousness (Ernest, 2007a). Integrated curricula seek to recognise this integration of knowledge and learning with culture.

Valero (2007) describes *distributed positioning* as a third form of power (beyond economic and social class) inspired by Foucault's analysis of the microphysics of power in modern societies. In this view, power is a relational capacity of social actors to position themselves in different situations, not as a consequence of open struggle and resistance, but through their participation in social practices and in the construction of discourses (p 10). Similarly Gutstein (2006) stresses the importance of starting teaching for social justice in mathematics from issues and generative themes that live in the communities in which teachers and researchers are working. This *distributed positioning* construct has been used in New Zealand to analyse the fluctuating dynamics of power within a group which included a white expert consultant and members of a socially disadvantaged Maori community, working together on the development of a mathematics curriculum (Meany, 2004).

In so far as integrated curriculum aims to realign society's values with considerations of social justice and equity, it must also contribute to, and await, a corresponding shift in the values and practices of the interdependent relationship between mathematics education and high-stakes assessment for qualifications. State mandated tests tend to reduce instruction to the literal comprehension of isolated facts and skills (Black, 2000; Wiliam, Lee, Harrison, & Black, 2004). High stakes tests are inevitably designed to be as 'objective' as possible, since there is a premium on reliable marking in the interests of fairness. This has the effect of reducing what is assessed to what can be readily and reliably marked. Generally this excludes many worthwhile outcomes of education such as problem-solving and critical thinking (Harlen, 2005).

Attempting to circumvent the negative consequences of high-stakes assessment by ignoring the socially sanctioned standards of satisfactory performance and the rigour that they express, is unlikely to be a strategy much valued by curriculum reformers (Black, 2001). The issue is not so much one of assessment or even gate-keeping per se: it goes deeper, to individuals' and societies' core values. It means asking and answering questions about: what standards we are testing for, what the intended consequences of assessment are, and what the relationship between mathematics and educational assessment *ought* to be.

2.3 Assessment and Integrated Curriculum

While high stakes assessment for qualifications is a central concern throughout secondary education it is particularly important for developers of integrated curriculum. Drake (2007) for instance states “I believe now that the door to mainstream acceptance of interdisciplinary approaches is through assessment” (p. xxi). While some developers critique existing assessment regimes as educationally restrictive (Gutstein, 2006; McKinnon, 1991), all take great care to show that their IC either improve students’ standard assessment grades or at the very least, do not undermine them.

Part one of this section addresses the relationship between curriculum, pedagogy and current high stakes standards based assessment (SBA) systems focusing on experience with the NCEA in New Zealand. Part two investigates current progress toward, and proposals for forms of SBA that support the educational objectives of integrated curriculum.

2.3.1 The curriculum-assessment relationship

Historical Background

Prior to the introduction of NCEA in 2002, secondary qualifications in New Zealand were based on norm-referenced assessments (Alison, 2005). Norm-referencing has its origins in the psychometric testing paradigm in which an individual’s performance was ranked in relation to other individuals rather than with respect to the task itself. Criterion referenced assessment proposed by Glaser (1963), specifically rejected the use of norm-referenced comparisons in education and introduced instead, assessment of student performances against (ideally) objectively defined criteria. Although criterion referencing ultimately proved unworkable for complex, educationally valued tasks (Gipps, 1994), Wood (1986) maintains that every development in educational assessment since Glaser’s seminal paper is based on the criterion-referenced model.

Standards based assessment (SBA) emerged around the late 1980s as an evolution of criterion referencing which retained the rejection of normative ranking but represented a move towards greater trust in assessor judgements (Gipps, 1994). The approach is anti-analytic and results in more holistic assessments designed to reflect the actual tasks in which educators want students to engage and the skills they want students to develop. Standards are specified through a combination of verbal descriptors and exemplars (Sadler, 1987). Reliability in SBA depends on the effective moderation of assessor judgements. Group moderation processes offer

opportunities for beneficial effects on teaching practice that go far beyond the immediate purpose of assuring assessment validity and reliability (Gipps, 1994). The consensus forming involved is in itself mutual professional development for teachers and the collegial relationships established can be extended to meeting at other times for other purposes, such as curriculum development.

SBA brought its own set of challenges such as: perceptions that assessment requirements dominate curriculum aims, high time demands for both students and assessors, resourcing difficulties and expenses, provision of wide-ranging assessment situations, and the establishment of reliable moderation systems (Gipps, 1994; Rawlins et al., 2005). Despite these challenges Rawlins et al. (2005) from their review of the literature conclude that “the impact of SBA on pedagogy is moderately positive.” (p. 110). In particular they noted that studies reporting teachers’ concerns—that both their curriculum and teaching were being driven by assessment—were balanced by other studies that found such effects were not extreme.

The professional and public response to New Zealand’s version of SBA, the NCEA, has been similarly mixed during its first five years of operation (Hipkins et al., 2007; Richardson, 2006a, 2006b; Stirling, 2006). There are concerns with aspects of the qualification’s design connected to some of its negative impacts (Alison, 2005; Hipkins et al., 2007; Meyer et al., 2006; Pilcher & Philips, 2006). It is these design issues as they relate to integrated curricula that are a key focus of the present study.

NCEA strengths and weaknesses

The NCEA has had two significant, positive impacts on New Zealand secondary education. The first is that low achieving students now succeed in gaining qualifications whereas in the past they would almost certainly have failed (Hipkins et al., 2007; Meyer et al., 2006). Second, NCEA’s modularity gives teachers the possibility of adapting the qualification to suit the diverse needs and strengths of particular individuals and groups of students (Hipkins & Vaughan, 2002). Although proposals for the further evolution of the qualification build on these strengths, they arise primarily from considerations of how to address its weaknesses. The remainder of this section therefore focuses on four issues most relevant to IC: credit seeking, flexibility versus fragmentation, the academic/vocational divide, and the influence of university entrance requirements on school course structures.

Modular and continuous assessment can generate high levels of motivation, participation, and engagement and foster better learning, but it can also produce a passive focus on passing

modules without an integrated overview of the qualification (Hipkins et al., 2005; Lee & Lee, 2000; Pilcher & Philips, 2006). Hipkins et al. (2007) note that many students, from across the ability spectrum, have become “happy collectors of credits” (p. 9).

The issue of credit seeking is complicated by the fact that there are three types of standards—internal and external achievement standards and internal unit standards—only two of which (the achievement standards) have grade values attached. In July 2007, the New Zealand Qualifications Authority (NZQA) announced that from 2007 and retrospectively, NCEA levels 1 to 3 certificates would be eligible for endorsement with merit or excellence grades (NZQA, 2007). What difference this policy change will make to credit seeking remains to be seen. It may serve to raise the value of grade quality over credit quantity for academic students who base their qualifications largely on achievement standards. It is also quite likely to have the effect of widening what Hipkins et al. (2007) refer to as ‘the academic/vocational divide’ since vocational students base their qualifications more on internally assessed achievement and unit standards. It will therefore be difficult for students with large numbers of unit standards to gain a qualification endorsed with merit or excellence even if those unit standards represent an achievement of comparable value to a higher grade in some equivalent achievement standard. Pilcher and Philips (2006) note that most schools responding to their national survey regarded unit standards as making a valuable contribution to their programmes but that students were able to earn more credits in unit standards in less time than in achievement standards. The view that unit standards were academically inferior to achievement standards was also expressed by some participants, particularly in boys’ and private schools. Hipkins et al. (2007) report that the students involved in their *learning curves* research regarded credits from achievement standards as more valuable and unit standards as “easy to get”. Some of the teachers interviewed however saw certain unit standards as harder to gain than their achievement standard equivalents. Alison (2005) reports a similar range of views on the differences between standards and recommended that credit values of standards be reviewed and changes made based on workload.

The modularity of SBA is both an advantage and a disadvantage for designers of integrated curriculum. On one hand it seems to present an opportunity for curriculum design to assert itself over assessment imperatives. On the other, modularity comes at the cost of sacrificing the assessment of higher order analytic, critical and synthetic thinking of any greater scope than can be captured by the excellence level of single standards. There is arguably therefore, a continual pressure for teachers to ignore connections among standards and focus instead on the fragments of curriculum that they represent.

On the issue of NCEA's fragmentation of curriculum there has been some debate. A number of studies have reported teachers' concerns that courses are being broken down into too many assessment components making the integration of knowledge and skills across standards difficult (Alison, 2005; Crooks, 2002; Pilcher & Philips, 2006). Alison, in her study for instance, comments that while modularisation of assessment provides very specific learning objectives for students and lends itself to flexible course development, some teachers felt that "students were not retaining knowledge or transferring it from one part of the course to another" (p. 11). Meyer et al. (2006), report that teachers experiencing curriculum fragmentation had many insightful suggestions regarding how the assessments and qualification aspects might be adapted or refined to address concerns. These authors do not however enlarge on what those suggestions were. Hipkins et al. (2005) note that while some teachers have lamented the 'compartmentalisation' of learning in their discipline area, others have taken up the opportunity to redesign courses—either of different duration, for example, as semester or two-year packages, or with different combinations of content—both within and, less commonly, across discipline areas.

Students like teachers, see the options NCEA affords them as positive although some students, teachers, and parents have concerns about whether all students are mature enough to make these potentially critical career decisions (Meyer et al., 2006). Despite the perception of choice in NCEA, the actual options available to students according to Hipkins et al. (2007), remain limited to traditional perceptions of appropriate pathways through school and the associated academic/vocational divide. Pilcher & Philips (2006) also comment on the long term limiting effect for students of courses being associated with ability streams assessed by particular types of standards within disciplines.

Employing Bernstein's 1971 classification of educational knowledge, Hipkins et al. (2007) suggest that three main types of courses may be discerned in New Zealand senior secondary schools:

1. Traditional-discipline (TD) options, mainly assessed by achievement standards, reflecting traditional ways of thinking about subject structure and content.
2. Locally redesigned (LR) options assessed with a mix of achievement and unit standards, sometimes drawn from different year levels, and occasionally also from different subject areas.
3. Contextually-focused (CF) options typically having their origins in redesigned 'applied' or 'vocational' courses, linking school learning to everyday or future work contexts. These courses were mainly internally assessed by unit standards and usually offered a reduced number of credits. (ibid, p 13)

A tension exists between structured pathways that lead to specific career destinations, and opportunities for students to explore the curriculum and keep course options open. Pilcher and Philips (2006) report that teachers in their study acknowledged this conflict as being a huge challenge for all students to meet, in constructing their individual programmes and see it as an issue needing further research.

The influence of student learning pathways on secondary education is such that the development of integrated curricula in the senior school may require consideration of separate interdisciplinary courses tailored to the specific requirements and character of existing pathway contexts. For designers of IC the tension is between meeting existing individual and social economic needs for particular skills and knowledge, and educating individuals capable of a broader more integrated vision and intentional, practical approach to future social and economic challenges.

The LR courses of Hipkins et al. (2007) for instance, seem to be those most immediately amenable to NCEA assessed integrated curriculum designs because they involve a broad range of subject areas and relatively high number of unit standards (which are entirely internally assessed). However, these researchers found LR courses were also the least common and the students in these courses had the least positive feelings about their learning environment.

The CF pathway with its focus on contextual-vocational subject combinations and high involvement in unit standards could also be well suited to the development of integrated courses. Students in this pathway however, tended to be the least purposeful when exercising the choices NCEA affords. Some had no command of their credit totals at all (Hipkins et al., 2007).

At a later stage of their *learning curves* project, Hipkins et al. (2005) further refined the analysis of student pathways by applying cluster analysis to student subject choice data from six secondary schools. Eight distinct clusters were identified at year 11, five at year 12 and four at year 13. Ferral (2005), who was responsible for the analysis comments:

That clear patterns of subject choice merely exist is interesting, and further, that the identified clusters bear strong relationships to all the demographic variables available is also a matter of great interest, and points to possibilities for further research into the nature of the associations between the subjects students choose to take at school and their demographic profiles (p. 29).

Hipkins et al. (2007) report that one of these clusters, populated by 9 percent of the year 11 student sample (n=70, N=749), was characterised by a combination of CF English, ESOL, CF mathematics, CF science, agriculture/horticulture, health and life skills, practical technology subjects, computer studies, and transition subjects. The lowest decile⁹ school in their study was over represented in this cluster, as were Maori and Pasifika students, “many of whom sit in New Zealand’s ‘long tail’ of low achieving students” (p. 14). While there are students taking contextually-focused courses, happily and purposefully engaged following clear career goals such as modern apprenticeships, faculty leaders, particularly in the arts and technology learning areas, believe some CF pathway students are being shunted into courses they do not opt for simply to fill gaps in their timetables.

While CF and LR pathway students can be disadvantaged by lack of access to higher status achievement standard qualifications the reverse appears also to be true. Academic students wanting to gain more practical technical skills are prevented from taking these courses because of their involvement in the traditional discipline stream (Hipkins et al., 2007). Students following the TD pathway show the highest levels of engagement with school and are more likely to be strategic with their assessment choices (ibid). They are also likely to be the most difficult to design integrated curriculum for—given the traditional subject based orientation of their courses and their resulting higher participation in externally examined achievement standards.

The ‘approved subjects list’ for university entrance¹⁰—which maintains a traditional emphasis on academic subjects (Hipkins et al., 2007)—also has implications for the design of interdisciplinary courses for students in the TD pathway. Designers of integrated programmes are likely to want the total 42 required level 3 credits for university entrance to be drawn from a

⁹ The New Zealand Ministry of Education uses a decile rating system for school funding purposes. Each decile contains approximately 10% of schools. Schools in decile 1 have the highest proportion of students from low socio-economic backgrounds. Schools in decile 10 have the lowest proportions of students from low socio-economic backgrounds.

¹⁰ To qualify for entrance to a university in New Zealand a student must obtain a minimum of 42 credits at level 3 or higher on the National Qualifications Framework, including a minimum of 14 credits at level 3 or higher in each of two subjects from an approved subject list, with a further 14 credits at level 3 or higher taken from no more than two additional domains on the National Qualifications Framework or approved subjects. They must also meet minimum numeracy and literacy standards. For numeracy they require a minimum of 14 credits at level 1 or higher in Mathematics or Pangarau on the National Qualifications Framework and of literacy they require a minimum of 8 credits at level 2 or higher in English or Te Reo Māori; 4 credits must be in Reading and 4 credits must be in Writing. The literacy credits will be selected from a schedule of approved achievement standards and unit standards. (source: <http://www.nzqa.govt.nz/ncea/ue/> retrieved 28 December 2007.)

wider range of learning areas than is currently permitted. In effect, the universities' policy is in direct conflict with both research based evidence of the value of integrated curricula, and the government's policy of promoting integrated approaches in the New Zealand curriculum (Ministry of Education, 2007).

2.3.2 Integrated assessment

In this section, proposals for changes to NCEA that would support the assessment of integrated curriculum are considered, beginning with current theoretical work on SBA for IC in North America as reported by Drake (2007); three proposals specific to NCEA then follow. First, there are proposals to create new broad-based integrated standards (Hall, 2005; Hipkins et al., 2007). Second, there are proposals to create new standards for assessing generic competencies across learning areas (Hipkins et al., 2005). Lastly there is the possibility of extending the clustering of existing standards for the assessment of particular interdisciplinary courses as is already occurring to some degree in many schools (Hipkins et al., 2007; Pilcher & Philips, 2006).

Big Assessment Tasks and the KDB umbrella

According to Drake (2007) the key to successful integration within an SBA framework is a relevant and challenging big assessment task (BAT). A BAT is then assessed by a combination of what she refers to as *broad-based* and *concrete* standards. Two or more *broad-based* standards from different disciplines are selected to represent the desired scope of the BAT. Each broad-based standard is related to a group of two or more content specific, subordinate *concrete* standards which ground the task in particular knowledge and skills. The BAT can be thought of as equivalent to a culminating learning experience upon which assessment attention is focused for summative as well as formative purposes. The activity is planned into the unit of learning from the outset along with appropriate methods for documenting evidence of the desired learning. The big assessment task is very similar to the concept of *Rich Tasks* in the Queensland QSE 2010 *New Basics* approach to transdisciplinary integration. In this process "teams of teachers map backwards from the rich tasks, identifying what students have to produce for assessment, and the features that typify high-quality performance" (Matters, 2001, p. 11). It is the rich tasks that require teaching to be transdisciplinary.

In Drake's (2007) network of inter-related integrated curriculum design elements it is *big understandings* (for example, "Living things adapt to their environment") related to *big questions* (e.g., "How do living things adapt to their environment?") that give rise to a BAT.

Drake recommends a comprehensive document scan and cluster process as a precursor to finding appropriate standards to assess in tandem with the elements of the BAT itself. *Concrete* standards are grouped under one (or more) of the *broad-based* standards. Drake also recommends drawing one to one connections between each big understanding and a particular disciplinary broad-based standard from which then follow the concrete standards to be used for assessment. An example of a concrete standard could be “Identify populations of organisms within an ecosystem and factors that contribute to their survival” (p. 115) which might be related to a broad-based standard such as “Describe ways in which humans can change habitats and the effects of these changes on the plants and animals within the habitat” (p. 97).

Big assessment tasks serve curriculum integration at the level of the individual student and the humanistic triad through Drake’s (2007) concept of the *Knowing, Doing and Being*, KDB umbrella (ibid). The standards themselves are analysed (starting with the broad-based type) as part of the scan and cluster process for their relationship to the KDB umbrella, using parts of speech in the standards title. Nouns (and accompanying adjectives) which reveal the ‘*Know*’ are underlined and the verbs which reveal the ‘*Do*’ are italicised as in the following example: Students *identify* the positive and negative effects of technology. Here, the ‘*Be*’ is implicit. Students must make a value judgement on what is negative or positive so they can utilise technology in a way that benefits society (Drake, 2007).

The formative-summative continuum

Big and rich assessment tasks are recent expressions of the work of assessment developers (over at least the last four decades) influenced by constructivist and socio-cultural theories of learning. These theories suggest that learning and its evaluation can be improved simultaneously by building a closer relationship between assessment *for* learning (formative assessment or FA) and assessment *of* learning (summative assessment or SA) (Harlen, 2005; Wiliam & Black, 1996). That these theories have also influenced the design of NCEA can be seen in the extent to which teachers are now involved directly in the assessment of unit standards and the internally assessed achievement standards. While the assessment of external achievement standards is still confined to traditional summative examination settings, internal standards are amenable to the full range of both FA and SA methods.

The capacity for NCEA to support integrated curriculum development through the coordinated use of internal standards for both formative and summative purposes appears strong. On the basis of his study of three year 12 mathematics classes at Euclid high school, Rawlins (2007) concludes that while the NCEA has strong potential to serve both the formative and summative

purposes of assessment, the formative potential is yet to be fully realised. The student participants in his study displayed underdeveloped knowledge of assessment criteria which was effectively reducing their capacity for independent use of self- assessment strategies.

Integrated standards for NCEA

The concept of an integrated standard involves assessing and crediting the synthesis of curriculum content, processes and skills from two or more existing, content specific *base* standards. The term *base* in this context is equivalent to Drake's (2007) use of the term *concrete*. I have introduced the term *base* at this point to specify the context of NCEA, rather than SBA in general. Credits are awarded for the integrated standard as well as the base standards themselves. Drake's (2007) broad-based standards are effectively *intradisciplinary* integrated standards similar to the concept of *integrated standards* suggested for the NCEA by Hall (2005).

Whether NCEA has such broad-based standards in sufficient numbers is currently unclear but could be investigated. The phrase *broad-based* has been used elsewhere in the literature on NCEA to refer to collections of domains within learning areas as in "broad-based science standards" referring to level 1 standards that include sections on biology, chemistry and physics (not necessarily integrated) (Ministry of Education and New Zealand Qualifications Authority, 2006).

Very few of the exiting NCEA mathematics standards at levels 1 to 3 could be described as broad-based in the sense of being useable as integrated standards within the context of an interdisciplinary BAT. Statistics standards—such as the unit standard 7565: *Carry out and report on a given statistical investigation*—would seem to be the best contenders. This does not however rule out mathematics standards as possible base standards for BATs. Broad-based research standards exist in most other subjects. They are however often left out by teachers and their students may see research as merely a process of information retrieval and repackaging (Hipkins et al., 2005).

Prescriptive, outcomes-focused models of education such as NCEA are not conceived in a way that easily accommodates and recognises student initiative, creativity and originality of thought. Hipkins et al. argue that for this to change, both the curriculum and the assessment standards would have to change: a possibility that will need to be confronted as the qualification evolves. Hall's (2005) proposal for a new type of standards-based assessment that focuses on the integration of learning across each subject course as a whole, not on the separate components,

has received qualified support. While they think the idea has merit, Hipkins et al. (2005) also note the possibility for tension between integrated standards and NCEA's inherent flexibility should the former become over specified in terms of the content being integrated.

The concept of an integrated, broad-based standard is well exemplified by the recently developed *Education for Sustainability Draft L2 Achievement Standards* (Education for Sustainability, 2007). The six standards (see appendix D) have been published in draft form on the World Wide Web. They have been approved for general use in 2008 and level 3 standards will be available in 2009 (Ministry of Education, 2008).

Key competencies and generic standards

In another approach to interdisciplinary assessment Hipkins et al.(2005) have suggested that the five cross curricular key competencies of the current New Zealand curriculum (Ministry of Education, 2007) could be assessed by NCEA standards. These authors acknowledge that the competencies would need to be taught in different disciplines in context specific ways but, maintain that this could be achieved without loss of NCEA's flexibility to meet individual students' needs. They acknowledge also that developing assessment methods for competencies such as *managing self* and group collaboration (*participating and contributing*) would be challenging. The fact that multiple contexts must also be incorporated means key competency standards would be expensive to assess relative to ordinary standards. Such standards could however, have important learning benefits for students. Generic skills taught in one discipline do not generally transfer readily to other disciplines and contexts (Lave, 1988; Wolf, Kelson, & Silver, 1990). Wolf et al. however go on to show that problem solving ability in areas outside a learner's familiar occupational area can be improved when generic skills are purposefully taught in two or more contexts simultaneously.

Clustering Standards

Adapting SBA for an integrated curriculum requires a thorough knowledge of both the standards and a comprehensive and coherent curriculum structure to which the standards may be related (Drake, 2007). Intra- or inter-disciplinary grouping of existing standards can be undertaken either independently of, or coordinated with, the development of related broad-based and integrated standards.

Although New Zealand secondary schools are already experimenting with interdisciplinary assessment events that utilise combinations of NCEA standards (Hipkins et al., 2007; Pilcher &

Philips, 2006), experience with cross-disciplinary combinations of NCEA standards is as yet limited. It is unclear just how 'modular' (in the sense of being 'seamlessly re-combinable') the standards actually are between disciplines. It is also conceivable that broad-based integrated standards might require different clusters of concrete standards in different student career pathway contexts. This question would appear to be one for further research. Hipkins et al. (2005) note that:

Many NCEA standards, especially those we have called 'traditional-discipline' achievement standards, continue to address the type of knowledge that was also assessed by the previous system. Clearly, for this to change, both the curriculum and the assessment standards would have to change (p. 136).

Chapter 3: Methodology

3.1 Introduction

The central objective of this study was to gain a deeper understanding of integrated curriculum (IC) in practice in New Zealand and its relationship to mathematics education and standards based assessment. Three features of the research context and questions commend a case study methodology as being the most appropriate. First, the processes and structures under investigation are embedded within a highly complex social, cultural and physical environment. Second, the observers with the best vantage point for reporting on the nature, benefits, and challenges associated with developing IC in contemporary New Zealand secondary schools are the senior teachers in schools where it has been or is being established. They are embedded in the daily school reality of IC in action. Third, as noted by (Applebee et al., 2007), IC as a field of investigation is under theorized. Extending the conceptualization of IC and assessment was an aim of this research project and a purpose to which explorative case study methodology is ideally suited.

This chapter is organised in two main sections. The first deals with the theoretical underpinnings of case study methodology. The second describes how the methodology has been applied through the gathering of interview data and its analysis.

3.2 Theoretical background

3.2.1 *The nature of reality*

Two possible philosophical orientations to the nature of reality in research are the 'positivist' and 'interpretive' paradigms (Bassey, 1999). In the positivist paradigm reality is considered to be objective and out there waiting to be discovered. Reality is unique and entirely independent of any observer. Discovering the absolute truth is a matter of simply accessing the phenomena. In the interpretivist paradigm reality is considered to be subjectively conditioned and a matter of social construction. Multiple realities may exist for a given situation: each related to an observer's point of view and the special consensus to which they belong.

The present research is guided by a synthesis of the positivist and interpretive paradigms which might be called an 'asymptotic' perspective on reality. This perspective maintains that there is an objective reality in which we exist and an absolute truth to which we are subject but because we are integrally part of that reality and truth there is no way for us as observers to find an

objective platform from which to comment on or control reality in any absolutely authoritative or final way. Rather, as researchers, we approach the truth of each new situation asymptotically through sustained observation which strives for detachment; reflective, critical and imaginative thought; and the social process of consensus formation.

An implication of the interpretivist paradigm is that the researcher must make explicit their own beliefs and background relevant to the field of investigation in order to maximise the validity of interpretations of the data they present (Rawlins, 2007). Since it includes the interpretivist paradigm, an asymptotic perspective also accepts this implication. Accordingly the details of the researcher's experience in secondary education are outlined in section 3.2.3.

3.2.2 Case study methodology

Case study methodology is characterised by the belief that human systems exhibit integrity and wholeness: they are not simply a loose assemblage of essentially independent traits that can be examined without reference to the multiple relationships among them (Sturman, 1999). These relationships tend to not have clear and definite boundaries. Schools for instance cannot really be understood in isolation from their external environments of parent communities and national educational contexts, nor do individual teachers or the subject departments to which they belong, operate independently of one another. Case study is the preferred methodology in situations where it is very difficult to separate the processes and structures of interest from their surrounding influences (Yin, 2003).

Yin (2003) describes three sub-categories of case study: descriptive, explanatory, and exploratory. The present study can best be described as exploratory. The cases have been chosen because they are thought to be typical of a wider class of cases—that is, schools applying some form of large scale, systematic, interdisciplinary curriculum integration and assessment—which are the central interest. Although they are also of interest as unique entities in their own right the individual cases are subordinated to the questions and larger issues with which the research begins and ends. Often also, case study methodology is employed where the current theoretical background is felt to be inadequate and the researcher is seeking to elaborate the conceptual understanding of the central issues (Yin, 2003). In this study the unidimensional concept of the *interdisciplinary continuum* was adopted as a starting point for the comparison of the three participating schools, with the intention of expanding on this construct should the data gathered suggest a more appropriate model. This exploratory perspective is consistent with the concept of 'research before theory' articulated by Nachmias and Nachmias (1992).

3.2.3 Validity and reliability

External validity

Lack of external validity is often seen as the main weakness of case study methodology (Ary, Jacobs, Razavieh, & Sorensen, 2006). The model for externally valid research yielding strong generalisations is that provided by the physical sciences where large samples, small numbers of variables and replicable, controlled conditions are the rule. In the social sciences, particularly where case study methodology is applied, the complexity of the phenomena studied means that generalisation becomes a matter of persuasive argument from the evidence presented, on the part of the researcher, and judgements about that evidence and those arguments, on the part of the reader. Whereas in statistical social research probabilities can be attached to conclusions, in case study analysis, conclusions must be expressed in even more tentative terms: without quantitatively described margins of likely error.

In the present research the sample of eight participants is far too low to provide an acceptable level of statistical validity although majority points of view are still of interest and have been reported. However, the sample is probably highly representative of the study's target population—that is, New Zealand teachers with substantial experience of systematic, interdisciplinary curriculum integration and assessment—because this population is likely to be small. While there are reports of more secondary teachers using two or more NCEA standards from different learning areas within new courses to assess possibly integrated contexts (Hipkins et al., 2007; Pilcher & Philips, 2006), these still appear to be largely isolated rather than widely coordinated events within schools. The three schools participating in this research, while aware of one another, knew of only one other secondary school in New Zealand that might have been attempting curriculum wide integration.

Internal validity

Historically, validity has been defined as the extent to which an instrument measured what it claimed to measure. More recent views of validity focus not on the instrument itself but rather on the interpretation and meaning of the data gathered (Ary et al., 2006). From the point of view of the asymptotic and interpretivist views of reality, multiple realities do exist. Each school is a particular case and each interview participant is providing the researcher with access to a complete and extensive reality which is their own understanding of a particular case. Internal validity is a particular strength of case study methodology seen from this point of view (Merriam, 1998). Case studies have the potential to reveal previously unsuspected relationships

(Ary et al., 2006). Whereas statistical analysis of large complex data sets has the power to confirm suspected or even to illuminate unexpected patterns in quantitative data, it will not of itself provide creative original insights to issues or offer directed suggestion in the way that case study participants often can. For this reason case studies are often used as a hypothesis generating strategy for more rigorous subsequent testing (ibid.).

The validity of the interpretations given by the researcher to narrative interview data depends on the shared cultural understanding and knowledge base between the participants and the researcher. Not all statements can be taken at face value and must be evaluated in terms of the broader discussion (Rawlins, 2007). The researcher's background in the present study was advantageous to the valid interpretation of the interview data. As the researcher, I was a secondary school teacher of mathematics for 16 years. The greater part of this time was spent in a small (450 student) K-12 composite school where there was only one class at each year level and each teacher in the high school was effectively head of their department. Collegial collaboration was largely interdisciplinary although curriculum content remained predominantly subject based. Throughout the years preceding the introduction of NCEA in 2002 I maintained a keen interest in the evolution of standards based assessment and took advantage of all professional development opportunities. My teaching experience also includes a half year teaching mathematics with NCEA assessment in a large state secondary school and relief teaching across all learning areas. This background has prepared me well for the present research through shared understandings with the participants.

Semi-structured interviews were the principal data gathering instrument in the present study. Interviews have the advantage of generating large volumes of in depth data quickly and allow immediate follow-up and clarification of participants' responses. The possibility for participants to withhold or even falsify information can be a serious threat to validity associated with this research method (Ary et al., 2006). More valid responses however can also be anticipated where participants are both interested and informed about the interview topic. In the present study, participants' biases might be anticipated regarding the benefits, challenges and negatives of integrated curriculum, given their levels of professional and personal commitment to it. The participants were in fact very forthright about the challenges and barriers associated with IC development and were cautious and measured about its perceived and potential advantages. Not all participants in fact favoured integrated approaches and in some cases offered contrasting perceptions and interpretations of events and phenomena. Extensive direct quotations from the interview recordings have been used in chapter 4 to allow readers to evaluate for themselves both the validity and reliability of the researcher's interpretations of the data.

Reliability

Reliability based on the replicability of research is problematic in the social sciences. The ever changing nature of phenomena such as interview participants' judgements means failure to replicate findings even with the same participants does not necessarily invalidate interpretations of the original data considered as time, locality and socially situated unique events. Yin (2003) maintains that the critical issue is not the isolation of one singular and final truth, but the plausibility of the interpretation given to the data presented compared to other possible interpretations. There is also an onus on the readers of case study research to assess the generalisability of the results reported and interpretations given to the particular situations they are interested in and have detailed knowledge of (Ary et al., 2006).

In the present study reliability was enhanced through the interrelated nature of many of the interview questions throughout the interview schedule. Effectively, a degree of redundancy was thus built into each interview enabling subsequent cross referencing and consistency checks of each participant's responses. The interview schedule for the integrated studies participants is shown in appendix B while that for the mathematics participants appears as appendix C.

Triangulation

Eisner (1998) defines *structural corroboration*—also known as *triangulation* (Ary et al., 2006)—as a “means through which multiple types of data are related to each other to support or contradict the interpretation and evaluation of a state of affairs” (p. 110). The types of data and methods chosen to achieve triangulation ideally should have compensatory strengths and weaknesses (Gillham, 2000). Case study methodology has traditionally employed qualitative techniques such as interviews, observation and document analysis (Merriam, 1998). It does not preclude the use of quantitative data and can be powerfully corroborated by externally generated statistical data since the two sources have sharply contrasting strengths and weaknesses in respect of internal and external validity (Ary et al., 2006).

This research project has used both document analysis and external databases to provide a degree of triangulation on the details of school structure, student demographics, and student achievement in NCEA provided by participants in the interviews. Details of timetable structures and school policies that would have been difficult and tedious to clarify in conversation were provided by the schools as documentary evidence. Data were also provided by both the New Zealand Ministry of Education (MoE) and the New Zealand Qualifications

Authority (NZQA). This has enabled the presentation of school details such as total roll, ethnicity proportions, gender ratios, NCEA participation and NCEA achievement by type and mode of assessment, and their comparison with national average values (see section 3.3.2).

Participant feedback was used for the triangulation of the researcher's interpretations of participants' statements as recommended by Ary et al. (2006). Once all interviews were completed a verbatim transcript of each was prepared using numbered paragraphs for convenient referencing. The researcher's paraphrased summaries of participants' extended responses to each question of the schedule, including questions that arose in the course of the interview, were also prepared and inserted at appropriate points in the transcript. These composite transcript documents, along with points for clarification, were then returned to the participants for comment before any detailed analysis was undertaken. All but one participant offered feedback. Only one correction to the substance of part of one summary was required.

For the triangulation of participants' perceptions on the central issues related to integrated curriculum in their school and the relationship of IC to mathematics and assessment, reliance was placed on contrasting and comparing the statements of the eight participants. The value of these contrasts and comparisons were enhanced by having three schools from diverse community contexts and teachers from each of two clearly distinct learning areas in each school participating in the study. Multiple perspectives on the phenomena under investigation were generated—ranging from divergent yet complementary, to close consensus, to apparent contradiction—which has provided a rich multifaceted picture of leading contemporary IC practice in New Zealand.

3.2.4 Ethics

In any research studies involving people, ethical concerns must be identified and addressed. These concerns include participant selection, informed consent of participants, maintenance of confidentiality and anonymity, data collection, and dissemination of results. This research has followed the Massey University Human Ethics Committee (MUHEC) guidelines. A successful application was made to MUHEC for approval to conduct the research.

Three schools known to promote integrated programmes were selected for the study. Contact was established initially by phone and then by email directly with the appropriate senior staff members in each school. Following an expression of interest from these teachers, letters were sent to the respective Boards of Trustees of the schools seeking and gaining permission to visit

the school, conduct the interviews and to visit classes. An information sheet was sent to participants with a copy of the schedule of interview questions. The Boards of Trustees letter, which also included the information sheet, is shown as appendix A. Although I observed classes and spoke with students and teachers (other than the participants) while in each school, these classroom observations and conversations did not contribute to the data gathered for analysis.

A high level of confidentiality in this research project was readily achieved as data gathering was restricted to one-to-one interviews in private settings. All recordings and data have been kept stored on a single computer secured by recognised firewall software. Data on student achievement obtained from NZQA have been similarly stored and reported only in a highly aggregated form. Anonymity particularly for the participating schools has been harder to guarantee since there are so few schools known to be practising large scale systematic curriculum integration in New Zealand. Measures to maximise anonymity have included the use of pseudonyms for schools and participants and the avoidance of specific personal profile data for participants. The potential risks to anonymity were deemed to be outweighed by the value of the participants' contributions to the research knowledge base on integrated curriculum.

3.3 Data and analysis

3.3.1 The Interviews

The data generation method selected for this study was single subject, semi-structured interviews conducted by the researcher, in the participants' work spaces, over three weeks in March 2007. The interview schedule was arranged in three sections. Section one addressed the first two research questions while sections 2 and 3 dealt with questions 3 and 4.

1. **Current Situation:** How are the integrated and mathematics curricula currently practiced within the school, how are they related to one another and what are the benefits, costs and challenges of interdisciplinary integration?
2. **Relationship of programme to assessment and NCEA:** What forms of assessment are currently used in the integrated studies and mathematics programmes and how do the assessment requirements of NCEA affect their educational aims?
3. **Future of the Integrated Curriculum, Dreams and Realities:** How do factors external to the school affect the development of the IC? What resources are needed and

how might NCEA be developed to further support the educational aims of curriculum integration which includes mathematics?

Two versions of the schedule were use, one for the integrated studies participants and the other, following the same basic outline but appropriately adapted, for the mathematics participants (see appendices B and C).

3.3.2 The Schools

The three participating schools—Fibonacci High, Cantor College and Gödel Grammar—are all co-educational, state secondary schools located in main urban areas. (All participating schools and teachers are identified by pseudonyms). Recently established, Cantor has been described by the ERO as a school of *special character* and Gödel is defined by the MoE as a *designated character* school. Fibonacci, in contrast is a long-established school which has a history of integrated curriculum.

Fibonacci High had a roll of around 1200 students in 2006. Both Cantor College and Gödel Grammar had smaller numbers at the time of the interviews— ~800 and ~400 respectively— with continued student growth expected in future years. At the time of the interviews the oldest cohort at Cantor College had just started year twelve.

The female to male gender ratio at Fibonacci is female biased at 58:42. Cantor is more even at 53:47 while Gödel shows a male bias at 41:59. The three schools have strikingly different distributions of student population across ethnicities as shown in Table 4. These proportions are based on numbers of senior students participating in NCEA in 2006¹¹. In terms of socio-economic status of the communities they serve, none of the three schools are extremely high or low. Fibonacci is decile 7, Cantor decile 4 and Gödel decile 6.

¹¹ Data supplied by NZQA

Table 4 Ethnic proportions for the three participating schools based on numbers of NCEA candidates in 2006

| | Fibonacci | Cantor | Gödel | New Zealand |
|-----------------|------------------|---------------|--------------|--------------------|
| European | 65% | 37% | 85% | 62% |
| Maori | 25% | 27% | 13% | 16% |
| Pasifika | 2% | 21% | 1% | 8% |
| Asian | 6% | 11% | 0.5% | 12% |
| Other | 2% | 4% | 0.5% | 2% |

The participation of each school and its students in NCEA¹² in 2006 is shown in Table 5. Whilst these statistics are presented to provide a context for the interview participants' remarks about NCEA in the following sections of this report, they should be interpreted with care since they can be influenced by individual schools administration of NCEA¹³.

Table 5 School roll numbers and NCEA participation rates for 2006 levels 1 to 3 combined

| | Fibonacci | Cantor | Gödel | New Zealand |
|---|------------------|---------------|--------------|--------------------|
| School Roll (July) ¹⁴ | 1,230 | 740 | 280 | 309,938 |
| NCEA Candidates | 618 | 246 | 189 | 150,186 |
| NCEA Stds Achieved ¹⁵ | 13,370 | 5,924 | 1897 | 3,537,430 |
| NCEA Participation rate ¹⁶ | 50% | 33% | 67% | 48% |
| No. Achieved per Candidate all year levels | 22 | 24 | 10 | 24 |

Fibonacci High has participation rates in NCEA close to the national average. Cantor College has a low proportion of its students participating, which is expected since in 2006 they had as

¹² All NCEA figures are based on data supplied by NZQA.

¹³ In Table 5 the reporting of student participation in internal assessments and the timing of student enrolments for externals for instance, are decisions left to the discretion of individual schools.

¹⁴ The July school roll figures have been supplied by the NZ Ministry of Education.

¹⁵ Results include all achieved unit standards and achievement standards, grades A, M & E.

¹⁶ NCEA Candidates as a percentage of the school roll.

yet no year 12 or 13 candidates. Gödel Grammar has a high number of its students participating in NCEA standards but a low number of standards per candidate. These statistics are consistent with the school's approach to assessment and qualifications as will become apparent from the comments of the Gödel participants reported in chapter 4. The number of standards achieved per student follows the same pattern as the participation rates.

Table 6 shows each school's achievement of level 1 NCEA standards by type and mode. Level 1 only is shown for comparability between Cantor and the other two schools, but the same general pattern holds for each school across all three levels. The main contrast observable in this table is between Cantor—where unit standards are the most frequent type of standard achieved and external achievement standards are the least frequent—and the other two schools, where the reverse situation holds.

Table 6 Proportion of level 1 NCEA standards achieved by type and mode for the participating schools

| Type | Mode | Fibonacci | Cantor | Gödel |
|-------------|----------|-----------|--------|-------|
| Achievement | External | 42% | 33% | 45% |
| Achievement | Internal | 25% | 29% | 20% |
| Unit | Internal | 33% | 38% | 35% |
| Grand Total | | 100% | 100% | 100% |

Cantor's pattern is most like the assessment pathways characterised by Hipkins et al. (2007) as locally redesigned and contextually focused and is consistent with the association between the latter pathway and lower decile schools with higher proportions of Maori and Pasifika students. Fibonacci and Gödel have type and mode profiles more suggestive of Hipkins et al's traditional disciplines pathway.

3.3.3 The participants

The eight interview participants' names have been subscripted throughout the text to aid identification of their school and learning area affiliations. The first letter in each subscript denotes the school and the second the learning area (either integrated studies (I) or mathematics (M)). The participants were Sarah_{FI} and John_{FM} (Fibonacci High), Jane_{CI} and Greg_{CM} (Cantor College) and David_{GI}, Liz_{GM}, Anne_{GI} and Brett_{GM} (Gödel Grammar).

Only two interviews were requested from each school, with senior teachers (usually heads of department): one in integrated studies and the other in mathematics. The greater availability of

the teachers at Gödel resulted in four interviews from this school: three senior staff members, two from IS, one from mathematics, and Brett_{GM}, a newly appointed mathematics teacher. Brett_{GM} has been included for the value of his recent experience with integrated curriculum in relation to mathematics at both Gödel and his previous school.

Although the term *Integrated Curriculum* is used throughout this thesis to mean the links to be made within and across *all* learning areas, in current practice *integrated studies* teachers, at least in the schools visited for this study and reported in the literature, have teaching backgrounds mainly in the Social Sciences, Humanities, Health and PE. The mathematics teachers tend to have largely mathematics and science backgrounds. The two exceptions to this general pattern—Anne_{GI} and Liz_{GM}—were both teachers at Gödel Grammar. Apart from her social science background, Anne_{GI} also has experience in teaching accounting, and mathematics while Liz_{GM}, the lead mathematics learning adviser is also a trained PE teacher. The second notable feature of the interview participant profiles is the trend of decreasing years of teaching experience from Fibonacci (average 30) to Cantor (average about 17) to Gödel (average 14).

3.3.4 Analysis

The analysis of the interview data followed a qualitative methodology adapted from the work of Vaughn, Shay Schumm, and Sinagub (1996) with focus groups.

Step 1 Transcription

Following the recording of all interviews the process of transcription was undertaken using the purpose developed software *Transana*¹⁷. Two levels of transcription for each interview were made in tandem, a summary version and a verbatim version. Summaries of participants' extended replies to the interview schedule questions and the conversations that followed were made for each question by allowing the recording to play back without pause while typing in note form the substance of the participant responses. Verbatim transcripts were then typed and time codes added to the text to mark possibly useful start and end points for quotable extracts. When the transcripts were complete they were exported as rtf files to Microsoft (MS) Word, reformatted as tables with paragraphs numbered for easy reference and sent to the participants for their comment and with questions of clarification where necessary. The transcripts were updated as the participants' corrections were received.

¹⁷ Available at <http://www.transana.org/>

Step 2 identifying the big ideas

The activity of identifying the *big ideas* as recommended by Vaughn et al. (1996) was ongoing throughout the data analysis process from transcription to their eventual re-examination and refinement. The big ideas were at first closely related to the interview schedule questions and based on impressions of majority or shared points of view amongst participants. Later, impressions of convergence and divergence amongst sub-groupings of the participants, relating more to the original research questions and transcending the individual interview questions, also began to emerge as big ideas. The big ideas were recorded and modified in a separate text file and eventually became the basis of the key findings section 5.2 in chapter 5.

Step 3 Unitizing the data as clips

The processes of defining data units (called *clips* in Transana) and then assigning these clips to categories (called *collections*) were carried out concurrently. The interview episodes were worked through systematically and clips defined using time codes, were given explanatory titles before assigning to the predefined collection folders within the Transana database. Clips varied in length from single sentences to extended paragraphs.

Step 4 categorizing the clips into collections

The process of working with collections was one of iterative synthesis working upward from the interview schedule questions toward a final outline form that supported the big ideas. The first iteration involved defining one collection for each of the 25 interview schedule questions¹⁸. Although mutually exclusive collections are the ideal it was often not possible to assign clips uniquely to one or another of the collections. Digressions in the interview conversations and extended answers with relevance to two or more of the schedule questions, at times required multiple copies of clips to be assigned to multiple collections. Once all clips were assigned in Transana they were exported and aggregated into a single MS Word file. The clip titles were made into level six or level seven headings for easier manipulation of clips within a hierarchical headings structure using the outline view in MS Word.

The second iteration of collection aggregation made use of the 3 section structure of the interview schedule but also began to move the question collections into larger groups within these sections guided by the need to find a narrative sequence for the final written report of the interview data. At iteration 3 the original schedule section structure was replaced by what

¹⁸ Each schedule actually had only 19 questions but differences between the integrated studies and mathematics versions generated another six distinct questions.

became the final three section structure suggested by the big ideas as they were developing: that is, *divergence*, *agreement* and *convergence*.

Step 5 Re-examining and refining the big ideas

Step 5 began with the writing of an extensive narrative connecting all the clips (some as frequencies under response categories in tabular form). Subsequent reductive edits of this narrative text was guided by dialectic between the big ideas and the actual clip data. The number and wording of the big ideas was modified while at the same time the number of clips, superfluous phrases within clips and the sections to which clips were assigned (particularly to avoid multiple assignments) were also modified to arrive at a close and economical alignment between the big ideas, now the key findings, and their evidential support in the form of quotes from the interview participants.

Chapter 4: The Interview Data

In this chapter the interview data has been organised under three major headings. The first, *Divergence*, compares and contrasts the participants' responses to the interview questions on the basis of their affiliation to the three schools and the two learning areas. The second, *Agreement*, emphasises participants' majority and frequently expressed points of view concerning the benefits, negatives and challenges of integrated curriculum (IC) and assessment. The third, *Convergence*, focuses on the goals and aspirations of the participants for their schools and learning areas. In many key aspects of curriculum, assessment and pedagogy these expressed goals showed movement towards the current educational practices and strengths of the other schools or other learning area. The central focus of the narrative is integrated learning, particularly integrated curriculum and assessment.

4.1 Divergence

4.1.1 School Contrasts

The three schools occupy quite distinct positions in the current adaptive landscape of New Zealand education. This landscape is defined by the main elements that determine school culture: curriculum structure and content, collegial and community relations, pedagogical styles, student motivation and behaviour, and assessment priorities. The elements of subject based, interdisciplinary, and transdisciplinary independent student directed learning, were identifiable within the curricula of all three schools. The degree of emphasis given to, and the manner in which each element was realised, varied widely however.

Fibonacci High

At Fibonacci the timetable followed a six day cycle of five 60 minute periods per day. Integrated studies—as the integrated curriculum at Fibonacci was called—was limited to years nine and ten and was essentially a combination of the English and social studies learning areas combined with specific contributions from the health, physical education (PE) and technology areas. The year nine integrated programme was organised around the theme of *Communities* and the year 10 programme around the theme of *Change*. There were four, one term units in each year.

Both Sarah_{FI} and John_{FM} felt that their teaching programmes worked well and that improvement was a matter of on-going steady incremental changes.

Sarah_{FI}: We kept with those themes [Communities and Change], because they work quite well with the requirements of the Social Studies curriculum, and we, can use that Social Studies curriculum content to teach the skills for English.

John_{FM}: The reality is at the moment that I've got a framework that is meeting the needs of almost every kid in the school. ... I think for the next few years we are simply going to continue this refinement.

As far as developing new and innovative integrated programmes based on student interests, Sarah_{FI} felt constrained by the school's formal assessment requirements.

Sarah_{FI}: That's where integrated studies came from initially. Letting the kids decide what they wanted to learn. But because of the constraints of having to assess to curriculum levels, it's very hard to reinvent the wheel every year. ... So we try and build it in a way that there's enough flexibility within it, for the kids to explore something they're actually interested in.

Assessment was built around integrated common assessment tasks. Student direction of their own learning was expressed through elements of the project topic they selected for assessment. For instance, in their integrated year ten English and History *Time Capsule* project they chose which famous New Zealander they wanted to study and which decade of New Zealand history they would focus on.

Professional interactions concerning curriculum at Fibonacci were strongly departmental. Sarah_{FI} reports that the arts, other languages and science all had supportive on-going connections with the integrated studies programme. Mathematics however, appeared to be relatively removed from integrated studies.

Sarah_{FI}: Don't really have anything to do with maths. I mean, there's no animosity or anything, but there's not a lot of common ground. Really the common ground is graphing, and that's about it really. And we do liaison: we have done in the past although to be honest, we haven't done much in the last couple of years.

Sarah_{FI} also pointed to positive effects of the integrated studies programme on teacher effectiveness and motivation across learning areas and on student behaviour.

Sarah_{FI}: It also builds on the strengths of the staff. ... And so by integrating the programme, we also get that integrated expertise, of the staff. ... And when we go on field trips we get staff asking to come with us from other departments, and seeing the students out side the classroom, you know, they shine. They're so well

behaved usually, and they just love it, and they're great and there's no problem.
So, we do get a lot of support to do what we do from, other subjects.

Whilst recognising some potential areas of overlap, Sarah_{FI} attributed the need of the mathematics and science staff to maintain the integrity of their subjects as a possible impediment to integration.

Sarah_{FI}: When curriculum integration first came in at Fibonacci, in the junior school when they trialled it with two extension classes, maths and science were also integrated into the programme, and that didn't last beyond the first year because the science and the maths teachers felt that it didn't meet their needs, adequately, to teach the basic skills that they needed to teach.

John_{FM} confirmed Sarah_{FI}'s recall of the early cross curriculum trial but had a different interpretation of why mathematics and science withdrew.

John_{FM}: In the very beginnings of 'integrated', there were attempts to, integrate, more sections of the curriculum document, so they were dealt with by integrated studies, and once it got beyond one or two classes, it was found to be so time consuming, that it collapsed. The inertia of getting so many people involved in so many things, sharing information became impossible.

His perception of the existing situation was more like tolerance however than peaceful coexistence.

John_{FM}: One of the ways that we do support our integrated studies programme is that we tolerate, the fact that we have weeks and in some instances, fortnights, of totally disrupted classes, so they can do their field study work. And we also support the health programme in that the kids come out of maths to go to health. ... So, we as a department feel we have given an awful lot. And it's time that we've given.

Both the integrated studies and mathematics departments invested a lot of collegial time and care in assuring that assessments were fair valid and consistent. Sarah_{FI} took pride in the fact that integrated studies made no concessions to academic rigour. NCEA type grading and feedback was emphasised in the mathematics department assessments right from the beginning of year nine. For John_{FM}, integration and synthesis of mathematical content was associated with the excellence grade of assessment.

John_{FM}: With our academic kids in the Junior School, we are preparing them from day one for, 'N A M E': Not Achieved, Achieved, Merit and Excellence. In our non academic junior programme, we are preparing them from day 1 for unit standards. And we run a programme where the assessment for them is marking like unit

standards, basically on an achieved/not achieved basis. Because it's so much more skill based, and we're not interested in dealing with the excellence type question which requires them to draw lots of things together, and synthesise.

Cantor College

Cantor College was conceived of as a project to “change the face of state secondary schooling in New Zealand”¹⁹ in accord with the recommendations of current educational theory research and best practice. The school timetable was structured around three 100 minute lesson units (each of two 50 minutes spells) per day. The longer teaching period strategy was part of Cantor’s approach to *authentic* or *integrated* learning and the associated teaching approaches that were seen as not easily fitting into a conventional 50 or 60 minute period.

The commitment to integrated curriculum (IC) was most obvious in the *foundation programme* of year 9 that integrated all learning areas including mathematics. Year 9 was seen as a transition from the primary school style of learning to the specialist discipline based learning of the senior secondary school. The year nine integrated programme was delivered by subject specialists who collaboratively planned each term programme around a unifying concept such as *Order and Chaos* or *Food*. Each concept was accompanied by a focusing question. For the *Food* concept the question was: *Why have I plenty of food on my plate but others go hungry?*

Years ten and eleven together formed the *graduation programme*. All students were expected to gain a minimum of 105 NCEA level 1 credits in their two years before graduating to the post-compulsory schooling of years 12 and 13. The graduation programme included a number of blended interdisciplinary courses such as *Nature in Balance* (a Science/Social Science combination).

Years 12 and 13 together were called the *qualification programme*. The students selected a programme designed to lead, on leaving school to either employment or tertiary vocational qualifications or tertiary academic qualifications. Students in the qualification programme could spend up to 20 percent of their time in independent study working in a large ICT rich learning space staffed by trained research assistants.

The school’s central educational aspiration was that students would develop into independent learners. Strategies fostering independent learning included posters in every learning space

¹⁹ Quoted from documentation supplied by the school

displaying the ten desired independent learning qualities, student learning logs of own goals and self evaluation across all subjects, and high status independent learner classes where students pursued self directed projects.

Although the years ten to thirteen curriculum remained largely subject based, the students participated with the year nines in the termly three day learning episodes. The students opted by interest to join one of a number of available, cross-curricular, mixed-age learning groups that focused for three days continuously on a particular project.

Jane_{CI}: It might be enterprise, it might be, global awareness. And teachers deliver 3 day programmes. The kids stay with the same teacher for all three days... It's normally always tied into what we call authentic real world learning.

A key element of the pastoral structure of the school was the whanau or house system reflecting the strongly multi-cultural nature of the school population. Both teachers and students remained with one whanau for the duration of their time at Cantor.

Curriculum development was highly structured and based on an ongoing commitment to formal planning meetings which involved all staff. Formalising the meeting structure helped sustain the creative effort required to build new curriculum but was not without its costs in terms of teacher fatigue and making sure all were involved and all priorities were satisfactorily met.

Jane_{CI}: Getting staff to talk, that's a challenge. The challenge is I suppose in ensuring we plan cross curricula meeting time. ... We used to have a HoLAs²⁰ meet during school time, but, as it got bigger and more courses were running it hasn't been able to be done. So they have their meeting after school now ... So, that's a bugbear, but, we still do it. ... And that's, hard for when we want to do sports.

Jane_{CI} and Greg_{CM} both conceded that the amount of work involved in developing integrated learning had been problematic particularly when satisfying interdisciplinary links had proven hard to find. However, both commented that the potential benefits outweighed the investment of time and energy.

Jane_{CI}: We're finding it really hard here. Time and resources to do integrated programmes, but, we'll keep battling it. We'll make sure we're doing it, because I think that's where learning is going.

The school's relationship with its parent community was challenging in two ways. First the community is ethnically and socioeconomically diverse. Second, the parents as a group did not

²⁰ Heads Of Learning Areas

have as strong a connection with the reformist educational vision of the school as the teachers might have liked.

Jane_{CI}: We've got decile ten feeders, or decile one and two feeders. That's how we come out to be a four. But we've actually got the two extremes. We've run integrated programme evenings. You don't get much parental buy-in sometimes. Or show-up, that doesn't mean you haven't had buy-in. ... Parents are very good at primary school but, their time commitments are less at, high schools

Cantor, like Fibonacci was very aware of the importance of NCEA for their senior students' successful transition to the workplace or further study. Both Jane_{CI} and Greg_{CM} spoke about what they regarded as a general misperception concerning the relative values of Unit and Achievement Standards. This issue was not mentioned at either Fibonacci or Gödel. Their concern with this issue was consistent with the relatively higher participation of students at Cantor in internally assessed unit and achievement standards rather than external achievement standards, as noted in Table 6 of section 3.3.2.

Jane_{CI} and Greg_{CM} also perceived there to be a lack of understanding of the school's educational philosophy and its relationship to NCEA from government agencies, universities and employers which had inhibited the development of integrated curriculum. A supporter of NCEA, Jane_{CI} saw patience and public education as the best ways of addressing these challenges.

Gödel Grammar

Responsiveness to student interests, individual choice, and intrinsic motivation were the principal educational values that drove all aspects of school life at Gödel. The interviews revealed that student attendance was excellent and discipline problems extremely rare. However, integrated curriculum design and implementation at Gödel was not without its own particular set of challenges. The senior teacher participants noted that difficulties of programme coordination and continuity for individual students and tensions surrounding the low priority given to the NCEA qualification were issues that remained unresolved.

The Gödel programme worked on units of five weeks or two blocks per term in contrast to the 10 week whole term units of work that characterised the programmes at Fibonacci and Cantor. The school timetable had a different shape each day of the week. David_{GI} explained that the varying length lessons (of 60, 90 and 120 minutes) were designed to meet requirements for time frames appropriate to the various courses available. Students were taking four or five courses at any one time. Some idea of the programme diversity can be gained from an inspection of the

courses on offer. In term 1 2007 for instance, the schedule included the following mathematics courses: *Cooking with maths*, *Maths in the Mall*, *Numeracy Credits*, *Math Unit Standards level 1*, *Algebraic Families*, *Big Brother Survivor (Budgeting)*, *Africa*, *Algebra (NCEA level 1)*, *Algebra (NCEA level 2)*, *Numeracy (basic Math without calculator)*, *Money*, and *Networks (NCEA level 2)*.

The curriculum was comprised of three approximately equal components, subject based *curriculum lessons*, *holistic* interdisciplinary lessons and student driven *learner directed experience* (LDE). LDEs were based on individual student interest and involve NCEA assessments where possible. No classes were segregated by age and appropriate prior learning was the only guideline for acceptance for students to any course in the programme.

Achieving an overall coherence in individual student programmes was managed principally through the IEP (Individual Educational Programme). Students met once a term with their home base learning adviser and their parents to negotiate, plan and monitor their IEP. However, advising students on their individual long term programmes in the absence of adequate systems for coordinating what they've covered with future programme options was reported by Anne_{GI} as an ongoing challenge:

Anne_{GI}: We've got to make sure we have good conversations with our students, those that are in our home base, because, we're supposed to be advising them as to, what's a good programme to take, in order to reach that goal, what things do you need to bring together, to weave together. We haven't mapped that out well enough for ourselves to know.

Years nine and ten were referred to as *foundation* classes. Classes above year ten were referred to as *advanced 1, 2 or 3* depending on the NCEA level involved. As at both other schools the holistic programme was restricted mainly to the foundation level although older students at Gödel can join these classes.

In mathematics the foundation courses were holistically or traditionally oriented on a biennial rotation.

Liz_{GM}: We have a basically, two year cycle. This year I do much more of what I call holistic maths ... And then the following year we would teach in a much more traditional mathematics programme. We find if we're teaching strongly holistically, that students often don't get the coverage which they need to go and do level 1, and level 2 maths.

The advanced classes were mostly oriented toward NCEA standards with a strong element of choice for students as to which standards they attempted.

Teachers reported that the high investment of learning adviser (teacher) time in being available to students had had an important down side for the school in that it severely limited the time available for organised collegial collaboration and consensus forming.

David_{GI}: Its not enough, we need to get more but, ... Trying to resolve differences of thinking around some of the things we do, because you employ staff who have got vision and opinions, and understanding of student directed learning, but of course everyone's views are slightly different so getting, a degree of consistency so that the essence of what we are doing as a school is sustained and maintained, that's always a challenge.

Both David_{GI} and Anne_{GI} were concerned that the school's poor performance in the NCEA league table created a public perception of poor academic rigour.

Anne_{GI}: There's a lot of people who are looking at this school and saying, well is this school going to, be successful ... And of course we don't, ... And parents who are inclined to feel anxious about that will feel anxious about it. Whereas we say, gaining credits is not the important thing. ... We're sending out from here young people who are adept at learning, want to learn forever, and are excited by it and, it's been successful.

David_{GI} and Anne_{GI} maintained that the school's poor league rankings for NCEA results are due to student choices, not poor academic standards and that any student who wants NCEA can certainly achieve it at Gödel.

David_{GI}: If you're a real academic, and you want to go to university and want to get 120 [credits], you're welcome. And here you could do more science than you might in a conventional school. ... Potentially there's more on offer.

Gödel required and received a high degree of support for its principles from its parent community. When asked about parents' commitment to their childrens' IEP meetings his reply was:

David_{GI}: Absolutely. I mean ..., there's no way that you can attend this school without being involved as a parent. ... So ... that's, really important.

Although it is the least ethnically diverse of the three participating schools, the students come from a range of socio-economic backgrounds. The high level of parent involvement in the education is the Gödel school community's most salient feature.

David_{GI}: We'd have a very broad cross section, very capable kids who've come from high decile schools, but have been frustrated by not having much choice around their work. ... Parents who are just, passionate about their kids learning and want a more hands-on role and involvement in the school, and, their kids [to] have more say.

When the school first opened parents and students were consulted in matters such as setting up the school charter and deciding what aspects of the New Zealand curriculum would and would not be emphasised. David_{GI} saw the parent community as being very supportive of the school's policy of de-emphasising NCEA credit accumulation. Other learning advisers however expressed disappointment at the extent to which this attitude undermined their efforts to promote holistic education and intrinsic learning motivation. Liz_{GM} and Anne_{GI} regarded parent expectations in respect of gaining an NCEA qualification as the external factor most limiting the integrated curriculum development.

Liz_{GM}: Parent, expectations are really, quite a big one. They see that their neighbour's son at Boys High, is getting all these credits. That's not always our objective. ... And I think we have changed here, quite a lot because of parent expectations about how we should offer NCEA. I think when you start you think you'll do it much more integrated than we have.

At Gödel not only did students influence course content and programme direction but they were also expected and encouraged to negotiate their assessment requirements. David_{GI} saw this approach as having two distinct motivational benefits for teachers and students.

David_{GI}: Students have got buy-in, to the topic because they'll be listened to and the nature of the learning experience is that they've had a hand in, developing it. The expertise of the staff member is also valued because they are a teacher and very skilled and that's been shared with the kids as well.

David_{GI} also saw improved student behaviour as a major benefit of Gödel's integrated approach to learning.

David_{GI}: I suppose safety is a big thing, many of our parents perceive this as being, a very safe environment for their kids. ... When you go to our classes there's no behaviour problems, because kids choose to be there. I spend no time on discipline issues at all.

Anne_{GI}'s evaluation of motivation at Gödel was positive but she was a little more circumspect than her colleague. She commented on the wide range of motivation levels shown by students.

Anne_{GI}: Well motivation is pretty high here, actually, for a number of the students. ...
Some of our students that come in here are yep! Great, this is wonderful. They're totally engaged. There are others that would go sit on the couch all day if they could. So how do you get them motivated? ... Because we still, struggle with that.

Attendance at Gödel appeared, like discipline to not be a problem apart from the demands it placed on teachers' time. Students clearly felt very at home within the school environment.

Interviewer: So it's all about students while the kids are there?

Anne_{GI}: yeah

Interviewer: and staff have to ...

Anne_{GI}: We fit, we fit in. Before school or after school. ... And sometimes that can be quite difficult because a lot of our students will stay until 4, 4:30.

Interviewer: So their programme actually goes from, year 9 to year 13

David_{GI}: year 14. We've 9 year 14s. ... Getting them out at the top end is not easy.

Despite difficulties with assessment and qualifications the teachers were generally positive about the potential of the NCEA as a system for supporting integrated curriculum. Two of the staff were or had been involved in the evolution of the NCEA system nationally. Anne_{GI} was at the time contributing to the development of standards for Education for Sustainability²¹ and Brett_{GM} at his previous school had been involved in the development of standards for the CAS²² pilot project.

4.1.2 The integrated curriculum and mathematics divide

The potential for disassociation between the integrated studies and mathematics learning areas has already been illustrated by the departmental divide at Fibonacci High. This divide, although much less marked at Cantor and Gödel, was apparent across all three schools. The two learning areas differed in their orientations toward curriculum and assessment, in their approaches to

²¹ See appendix D

²² (Computer Algebraic Systems) pilot project. This project has been run by the NZ Ministry of Education since the beginning of 2005 (Neill & Maguire, 2006). CAS level 1 NCEA standards were offered for the first time in 2007.

collegial collaboration, and in their perceptions of how curriculum integration affected student motivation.

Curriculum and assessment

The integrated studies and mathematics teachers differed markedly in how they saw the relationship between curriculum and assessment. In response to the question: *to what extent are the key competencies*²³ (Ministry of Education, 2006)²⁴ *already assessed within the context of the integrated study programme?*²⁵, all the integrated studies participants—Sarah_{FI}, Jane_{CI}, David_{GI} and Anne_{GI}—proffered judgement on the Curriculum document as a whole. They saw it as having positive implications for the future of integrated curriculum and their own efforts to embed the key competencies across the curriculum.

Sarah_{FI}: The biggest plus for curriculum integration is what they've done with the new curriculum document. Because it's telling us, it's giving us a message that we should be looking at it.

Jane_{CI}: The way the new curriculum document is worded, and worked. ... I love the fact that all the achievement objectives are at the back, with the learning outcomes and all this new stuff is up the front.

David_{GI}: I think that the new curriculum is stunning, you know. We felt that it was a definite move in the right direction. ... We really like the fact that, it's got a values basis as well, which it didn't have. Up front!

Anne_{GI}: We looked at the draft curriculum and some of the key competency stuff fits, meshes really nicely with..., what we try to do here, as a school.

Contrast then the mathematics participants' responses: John_{FM}'s initial judgement of the new curriculum document and associated key competencies for instance was uncomplimentary.

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- 23 1. Managing self
2. Relating to others
3. Participating and contributing
4. Thinking
5. Using language, symbols, and texts.

²⁴ Only the draft New Zealand curriculum document had been published at the time of the interviews.

²⁵ The full text of the interview schedules for the integrated studies and mathematics HoDs appear in appendices B & C respectively.

Preferring to steer away from the curriculum as a whole, he maintained that the NCEA and the NZQA set the real agenda for the mathematics department curriculum.

John_{FM}: Well I'm glad you can identify what's in that document. ... The 'relating to others', twaddle they do in integrated studies. Well, I'm being rude about that I suppose. ... The reality is that no matter what they put in that document, we will ignore it: well no, ... we will follow that document, at our peril. Because the real document, is what NZQA print, ... That's the real document. ... And kids are performance driven.

The other mathematics teachers were interested in fostering the key competencies by way of assessment, in their classes (although they had not gotten very far with this objective), but none gave any opinion regarding the NZ Curriculum itself. Greg_{CM}, Liz_{GM} and Brett_{GM} simply answered the question about assessment.

Greg_{CM}: I know with the thinking and using language skills, we assess those things in our written assessments, but, the first three, ... I think we're talking about group work, that's something we haven't worked on, yet.

Liz_{GM}: In terms of, one of the holistic programmes, we hope to have at least one of the key competencies within each of the maths classes, that you ought to be targeting ... Say for example, for the cooking one ... It would be 'participating and contributing', because we put them in groups.

Brett_{GM}: I think they're kinda really important skills that you need to acquire, as part of your education, ... and these are things that you need to function in whatever you do.

For the integrated studies teachers, curriculum led assessment while for the mathematics teachers the reverse seemed to be true.

Themes and contexts for integration

The problem of finding non trivial, unforced links to other learning areas was mentioned by all four mathematics teachers and one integrated studies teacher (Jane_{CI}). Table 10 in section 4.2.3 lists six categories into which the themes and contexts for integrated curriculum mentioned by participants can be segregated. The mathematics teachers contributed only seven of the complete list of 31 thematic items. The mathematics teachers offered various explanations for this difficulty including, the need to teach abstract concepts, lack of IC resources, lack of time to do the necessary research and the adolescent character of student interests.

- Greg_{CM}: In terms of students, there was always that challenge of the, abstract. And, still trying to make sense of the, relationship, and the links, the relevance,, ... And then our challenge as, teachers is to try and, get that across.
- Liz_{GM}: I'm on a learning [curve], I'm slowly learning ... but, it's easy, to do it, the more traditional way. It is hard getting those contexts correct and making sure the same coverage ...there's not masses of information out there about holistic studies, as yet.
- Brett_{GM}: I'm not sure. I think part of it's a time thing we just don't have enough time to really sit down and figure out, how to do it
- John_{FM}: What interests examiners and what interests the classroom teacher, often doesn't interest kids.. So that dragging kids into thinking about the real world, in a mathematics classroom is something we are all doing all the time. And that's our biggest challenge.

Content demarcation

Participants regarded students', parents', and teachers' attitudes about what was the correct way of 'doing' secondary schooling, as still strongly supportive of subject based content demarcations. While Anne_{GI} considered that she did have sufficient background to teach statistics in her Geography lessons, she encountered difficulties related to student attitudes about the appropriate place of mathematics (something Jane_{CI} also noted).

- Anne_{GI}: Our kids say, "that's maths. What are we doing it in geography for?" ... I mean that whole statistical analysis ...

Although both the integrated studies and mathematics participants identified the topic of graphing as a possible bridge between their disciplines it appeared to be somewhat of a disputed territory, at least at Fibonacci and Cantor. Sarah_{FI} saw graphing as the only likely link between mathematics and her own integrated studies lessons but didn't feel competent to teach it herself and thought the mathematics teachers would also rather the mathematics teaching remained with them. Jane_{CI} went further in challenging the right of mathematics to consider graphing as its exclusive territory.

- Jane_{CI}: Maths is the hardest one to integrate because maths teachers are [laughs] ... I think, why can't graphing be owned by Social Studies? ... Why is it a maths domain? ... It's a skill that's across everything.

When questioned further, she clarified that this was not an issue of departmental animosity within the school but rather one of community perceptions and expectations.

Jane_{CT}: It's just more that the time and the resourcing and the, perception. What the hell are you doing a maths standard for? ... Why is my kid doing a, ... you know?

Interviewer: And that, perception's with teachers as well as parents, and students?

Jane_{CT}: Yep, very much so, yeah, yeah.

While the social science teachers at Cantor and Gödel seemed to have no trouble imagining the integration of mathematics in their discipline, the reverse did not appear to apply. Greg_{CM} found the social sciences to be the hardest learning area with which to make links

Greg_{CM}: With mathematics you know, there's obvious links between science and subjects that are science related. ... So it's always easy, sort of, to create links there. But it's with the social sciences and things like that, that sometimes we sort of struggle.

John_{FM}'s attitude seemed to confirm Sarah_{FI}'s perception of how much transfer of generic skills was possible between mathematics and integrated studies at Fibonacci.

John_{FM}: In many instances mathematicians look at the graphs that some people draw, and go, ... scream!

He argued that time wise integrating statistics data collection or geometry into integrated studies field trips was unfeasible and the potential applications too trivial for the requirements of the mathematics curriculum.

John_{FM}: In terms of what we expect kids to be able to do in statistics, much of what they would gather would be trite, well and truly. ... So you wouldn't be gathering complex enough data, to actually deal with the kinds of preparatory things you need to do, for level 1.

Interviewer: And, outside of statistics, like, more deterministic mathematics. I'm thinking about trigonometry, survey the distance across a river or something.

John_{FM}: Yeah you could, but if you were going to do that kind of thing, you're going to take up a whole afternoon of their programme. ... And, that becomes very difficult.

Anne_{GI} saw the potential for collaboration between the geography and mathematics teachers at Gödel differently but later commented that in fact the necessary timetable coordination in the senior school was not easy to achieve. She also noted that geography and mathematics NCEA standards were difficult to combine within a single course. In the following extract she is talking about her level 3 students.

Anne_{GI}: When they come out to do beach studies, and they have to understand trigonometry, they've never come across trigonometry before, So, how do we learn our trigonometry now? so, where [can] they actually go and talk to another LA or see, ohh, there's an option on trigonometry coming up in the next five week module. ... Well if I do that, I'll be able to understand what I've got to do.

Collegial collaboration

The integrated studies and mathematics teachers reported approaches to collegial collaboration differed markedly across all three schools. The former appeared to put a higher value on face-to-face meetings with colleagues for professional development and their meetings were also more likely to include a purely social element. The latter tended to put greater emphasis on opportunities for independent reflection, planning and experimentation. The reported focus of their meetings was likely to be more functional than social.

Finding more time for and facilitating collegial collaboration was considered a high priority by the integrated studies teachers, Jane_{CI}, David_{GI} and Anne_{GI} as already noted. Sarah_{FI} also stressed their need for collaborative professional development time.

Sarah_{FI}: Time for professional development, ... we like to meet with our colleagues, because what we do is different to other schools so we need to meet regularly to make sure we're all doing it, all singing the same song, teaching to the same student learning outcomes.

Both Sarah_{FI} and Anne_{GI} also talked positively of collaboration experiences with other schools.

The mathematics participants' attitudes around collaboration time were either that there was too much or that it would for them come second to or after preparation time.

Greg_{CM}: It's been good, but it's a lot of hard work and ..., I think, one thing that I guess if I were, quite honest, you know, is that, every now and then we ..., we groan because 'oh no, not another session on integrated learning'. ... 'Cos it is very hard work.

Brett_{GM}: I guess for me that, the big negative, it comes up a lot in teaching, is time, to really do something properly it takes a lot of time, time planning and, and when it's integrated you need to meet, other teachers.

Liz_{GM} had no concerns about too much time given over to meeting colleagues—total meeting time was in any case low at Gödel—but it was apparent that the meeting time for the mathematic learning advisers at Gödel was relatively short and on a 'needs basis'.

Liz_{GM}: Not frequently, probably once a term. We can, choose to be part of the holistic programme. I don't teach within that group at the moment, but we can ... they always ask us for ideas, so it's always they come up and say, here are our ideas for next term, how could you get something within that?

In terms of the future she was focusing on collaboration outside the school and with agencies such as the Department of Statistics rather than with other mathematics teachers.

John_{FM} was also happy with the collegial meeting regime he had in place at Fibonacci. The time involved was less than that reported by Greg_{CM} at Cantor but more than for the learning advisers at Gödel. His vision of the future for collaboration was not more face-to-face meeting but less: by making better use of the internet. When asked under what resource conditions a move toward integrated curriculum might be conceivable for the mathematics department at Fibonacci, he, like Greg_{CM} and Brett_{GM} stressed the importance of time within his working week for independent planning and reflection.

John_{FM}: I think if we really were going to get down to the lands of, .. an hour in the classroom and an hour out of the classroom [for teachers], then that kind of thing is going to be possible. But it's fantasy land, ... Becauseyou'd have to double your teaching force ... At the moment the contract is, five hours in the classroom, and one hour out.

Interviewer: And can I get you to make a judgement about, the desirability of that, educationally?

John_{FM}: No, ... Well, ... Because it's such a pipe dream, it's somewhere where my fantasies have never gone. ... I think the more time a teacher has to dream and plan and be creative, the potential to improve education, grows.

John_{FM} also commented that the character and priorities of the mathematics teaching staff would be crucial in any attempt to integrate mathematics teaching.

John_{FM}: I think if I had a, ... a different group of people, then it might, be possible to change the direction.

Interviewer: So, can I just clarify. You might be saying here that, yes there could be advantages, it would depend very largely on the personnel and their preferences and the way they attacked it?

John_{FM}: Yes. And it's their very inner being, ... you know?, their very inner being.

Interviewer: What they believe about Mathematics?

John_{FM}: Yes

Brett_{GM} was quite reflective about what he saw as the antisocial nature of mathematics as a school subject. He suggested that the problem might be addressed by including mathematics teachers in Junior school *class learning teams*. This concept appeared similar to the whanau based teaching teams that were operating at Cantor College.

Brett_{GM}: A lot of maths teachers that I've known are really caught up in just doing their maths, and a lot are cut off [from] a lot of other subjects, it seems to be a subject that's, ... more divisive perhaps than, any other.

Interviewer: and what do you think will facilitate the breakdown, of that divide?

Brett_{GM}: the school I was at had been funded for a lot of research into teaching and learning and one thing we set up there were called class learning teams, where the four core teachers of a class, or year nine class would meet regularly and discuss the class and do our planning and stuff together

Student motivation

Increased student motivation and improved behaviour was an important benefit of integrated curriculum noted by the integrated studies teachers. The mathematics teachers were less certain about the motivational benefits of integration. Whether this caution was due to the inappropriateness of integration for mathematics, or to mathematics teachers' lack of experience with integration, or simply to inaccurate perceptions of student motivation, is unclear.

All participants tended to connect motivation primarily with more engaging activities for student and greater opportunities for students to exercise choice. Sarah_{FI} also saw the positive motivating potential of having more than one subject to call on in teaching.

Sarah_{FI}: I've taught in other high schools Social Studies and English, and it's often quite hard to get every student in the class engaged, whereas with integrated where you've got the English and the Social Studies and the ICT component, there's always something that we can hook them in with.

Jane_{CI} noted that conclusive evidence for motivational gains at Cantor had yet to be assessed against long-term learning outcomes and was in fact a focus of ongoing research in the school.

Jane_{CI}: We actually think that they're a lot more motivated, particularly [in] some of the three day programmes, we give a lot more learner choice, so, if you give kids learning choice, motivation always goes up.

Both Sarah_{FI} and Jane_{CI} commented that official and research interest in IC and integrative learning has been motivated at least partly by evidence of increasing student disengagement and discipline problems in mainstream subject based education and the potential for IC to reverse this trend. In the following extract Sarah_{FI} is responding to the question of resource needs for future IC development.

Sarah_{FI}: Resources for teachers to use especially stuff around teaching and learning. We're in the ministry contract at the moment so there is a bit of money out there, for this. How can you change your teaching and learning strategies, to engage students more and stop stand-downs? and exclusions. So basically the ministry speak is, "we want you to stop stand downs and exclusions" and we said "well we want some money for developing teaching and learning," and so we kind of managed to get together on that. And so this is our second year of the contract.

The mathematics teachers by contrast were ambivalent about student motivation benefits related to integration. John_{FM} initially responded that there were no benefits but later conceded that there could be learning gains to integration within the mathematics programme at years 12 and 13. He saw NCEA credits as the most important motivating factor in the mathematics programme. The other mathematics teachers, with some experience of integration, also saw credits as important to students but offered some qualified support for the motivational effect of integration.

Greg_{CE}: Yes and No. Sometimes the link, I think, for students, can be a little bit obscure. When we have completed our, project at the end of the term, I think kids might still be asking, "so what was that all about?"

And sometimes you try to create a link that's not really there. ... I think, that we're just starting to learn, if there is no obvious link, you don't create one....It's got to happen naturally.

Liz_{GM}: It can be [motivational]. Sometimes they just like to learn. And, some students like to learn that way. But other students don't feel like it's actually maths ... there's a real dichotomy, there are some students who just want to sit there, actually learn maths, whereas others, much, more prefer to know why its useful.

Liz_{GM} spoke of these two categories of students again in terms of their affective relationship to mathematics, when asked how she would like to see the mathematics curriculum develop in the school.

Liz_{GM}: I've got that real toss up between; ... there are students who like the real pure maths they love the activity, ... And those, who hate maths, [laughs] ... they need to learn why maths is fun and everyone can do it. I'd like to see it much more associated with life, and life skills. And how we use it in the real world.

Brett_{GM}: I guess I've found in terms of motivation, students are more motivated when the maths programme itself, is better.

Brett_{GM} provided an example of a successful course in probability he had done with a year nine group at Gödel. While the unit was not interdisciplinary he described a holistic approach to the topic involving activities outside the classroom relevant to the students' immediate world, and game playing activities that increased the students' conceptual appreciation of the mathematics involved in understanding probabilities.

4.1.3 Summary of section 4.1

In the first section of chapter 4 evidence has been presented from the teacher interviews of contrasts and divergence among the three schools and between two learning areas in terms of school structures, policies and teaching practices related to integrated curriculum and learning.

Among the three schools a progression from traditional to innovative approaches in curriculum, instructional formats, and assessment was evident in moving from Fibonacci High to Cantor College and then to Gödel Grammar. The integrated curricula extended to more learning areas and higher levels, the mix of instructional formats became progressively less subject based and more interdisciplinary, and assessment expectations on students became less prescribed and more negotiated. The three schools showed marked differences in the nature of the collegial collaborative structures they used to support IC coordination and development. All reported some degree of ongoing difficulty in facilitating these interactions.

Between the integrated studies and mathematics participants divergence was apparent with respect to the two learning areas' points of view on five key aspects of teaching and learning in the integrated setting: curriculum and assessment orientations, use of integration themes and contexts, content links and demarcation difficulties between learning areas, collegial collaboration styles, and views of student motivation. While the integrated studies participants

use curriculum documentation as a key point of reference for teaching practice the mathematics participants were more oriented toward assessment requirements, particularly for NCEA. The integrated studies teachers saw links between geography and mathematics but also reported various obstacles to integrating mathematics into their own courses such as: teacher, student, and parent expectations; teacher territoriality; timetable coordination problems; and for one participant, lack of mathematical expertise. The mathematics teachers also found connections to the humanities and social sciences difficult to establish. The integrated studies teachers reported increased motivation benefits from IC and attributed them to having a wider range of content available to appeal to diverse student interests, the greater choice for students in selecting content, and the intrinsically motivating nature of the integration themes themselves. The mathematics participants saw obscure integration themes and student dispositional types as motivational obstacles to curriculum integration. They tended to regard success in gaining NCEA credits and good mathematics teaching as more influential motivators.

4.2 Agreement

Section 4.1 focused on contrasts, that is, those responses of the participants to the interview questions which distinguished the three schools and two learning areas from one another. In this section the focus turns toward commonalities, the points on which there was general agreement among participants.

4.2.1 *The benefits, negatives and challenges of integrated curriculum*

Benefits

The benefits of integrated curriculum reported by participants fall into three broad groups, *learning gains*, *improved student motivation and behaviour* and *teacher motivation and effectiveness*. *Learning gains* was the benefit about which there was the most general agreement. Motivation and behaviour were discussed in section 4.1.2 as examples of divergence between the integrated studies and mathematics participants' points of view. Only John_{FM} responded initially that there were no benefits to be gained from integration. Later in his interview he qualified this position suggesting that with the right mathematics teaching staff and sufficient planning time educational benefits might be achievable, however this time allowance was in his opinion an impossible demand to make on school resources.

For Sarah_{FI}, learning gains from curriculum integration came through the greater time she was able to have with her students and efficiencies arising from overlaps in content and skills between the English and social science learning areas. (This benefit makes an interesting counterpoint to John_{FM}'s negative experience of reduced time with mathematics students in the same school as a result of the integrated studies programme).

Sarah_{FI}: We can have more hours ... because we cover some three or four curriculum areas, we're given time, with those kids. ... But the reality is, there's quite a lot of overlap, in terms of skills, we can basically cover more ground, or cover things in more depth [and], ... you get to know the students better. So you get, to know their abilities more quickly, and also you get more time for that formative work.

Likewise, David_{GI} used examples of integrated courses based on local neighbourhood issues and student run businesses to illustrate the synergistic effect on learning and the multiple inter-related learning opportunities arising from holistic integrated contexts.

David_{GI}: Our kids got so motivated by the proposal to put roads back in around here. They put submissions to the council, they worked with a couple of architects who were

friends of their families, and the presentation that our kids did to the council was unbelievable. It was such high level, quality thinking.

David_{GI}: We've got 15 thousand set aside every year to fund student businesses, and it's real business. It's not play, it's not pretend. And the board have invested money. They report back on their financial position. Pay back some, ... not as much as we'd like ... [smiles] but there's some great learning happening.

The main benefit of integrated curriculum reported by the mathematics participants was the opportunity to demonstrate the applications and usefulness of mathematics to students in everyday contexts and to make links to other areas of their schooling.

Liz_{GM}: I think that students can learn where maths is involved in day to day life and that's been the main aim of many of my courses certainly is just to be able to use maths where it gets needed day to day.

Greg_{CM}: Mathematics is, I don't know if essential is the right word, but mathematics is in a lot of areas. It's not just on it's own. Hopefully students get to see that mathematics is a tool, that's used by other subject areas.

Negatives

Participants' responses to the questions of the *negatives* and *challenges* associated with integrated curriculum have been grouped under a common set of six broad categories. Table 7 shows the *negative* items by category in descending order according to the number of participants that mentioned each. The corresponding list for the *challenge* items is shown in Table 8. Participants tended to list issues as negatives if they perceived them to be both serious constraints on integrated curriculum development and problems that they could do little to solve. Challenges however tended to be difficulties that participants saw as being resolved over time.

Issues of timetable and programme coordination at the top of the negatives list were mentioned by just three of the eight participants but these three came from both learning areas and all three schools. Issues of timetable and programme coordination were also ranked second in the list of challenges being mentioned there by six of the eight participants. Lack of funding was a negative for two of the integrated studies participants while issues of collegial collaboration and workload were negatives for two of the mathematics participants.

Table 7: Negative issue categories for integrated curriculum: Number of participants mentioning issue by learning area and school

| Category | Total | IS teachers | Math teachers | Fibo- nacci | Cantor | Gödel ²⁶ |
|---|-------|----------------|------------------|----------------|--------|---------------------|
| Timetable and programme Coordination | 3 | 2 | 1 | 1 | 1 | 1 |
| Funding | 2 | 2 | | 1 | 1 | |
| Collaboration and Workload | 2 | | 2 | | 1 | 1 |
| Staff commitment and training | 2 | 1 | 1 | | 1 | 1 |
| Curriculum, rigour and assessment | 2 | 2 | | 1 | | 1 |
| Student motivation and involvement | 1 | | 1 | | | 1 |
| Overall | | 4 | 4 | 2 | 2 | 4 |

Challenges

Within each of the six main categories of challenges it was possible to identify subcategories. The complete list of categories and their sub-categories are shown in Table 8 in descending order again by *No. participants* mentioning the challenge.

Curriculum, rigour and assessment was the number one ranked *challenge* but the fifth ranked *negative* suggesting that these issues were generally seen by participants as both high priority and solvable. Timetable and programme coordination, by contrast was the second ranked *challenge* and the highest ranked *negative* suggesting that these issue were perceived as very important but relatively less tractable

²⁶ When comparing the number of participants shown for the schools it should be noted that there were 4 participants at Gödel and only 2 at each of the other schools.

Table 8 Challenges for integrated curriculum: Number of participants mentioning challenges in each category and sub category by learning area and school

| Category | Total | Learning Area | | School | | |
|---|----------|---------------|---------------|-----------|----------|---------------------|
| | | IS Teachers | Math Teachers | Fibonacci | Cantor | Gödel ²⁷ |
| Curriculum, rigour and assessment | 8 | 4 | 4 | 2 | 2 | 4 |
| Appropriate Contexts & Themes | 5 | 1 | 4 | 1 | 2 | 2 |
| Rigour, Coverage & Assessment | 4 | 2 | 2 | 2 | | 2 |
| Subject Demarcation disputes | 3 | 2 | 1 | 2 | 1 | |
| Public perceptions and resistance to change | 3 | 2 | 1 | | 1 | 2 |
| Timetable and programme Coordination | 6 | 4 | 2 | 1 | 1 | 4 |
| TT coordination challenges | 3 | 2 | 1 | 1 | | 2 |
| Student course continuity | 3 | 2 | 1 | | | 3 |
| NCEA coordination | 3 | 3 | | 1 | 1 | 1 |
| Meeting Scheduling | 1 | 1 | | | 1 | |
| Student motivation and involvement | 5 | 2 | 3 | 1 | 1 | 3 |
| Ensuring Student input to Contexts & Themes | 2 | 2 | | | | 2 |
| Teaching & Learning | 2 | | 2 | | 1 | 1 |
| Student Mentoring | 1 | | 1 | 1 | | |
| Collaboration and Workload | 6 | 3 | 3 | 1 | 2 | 3 |
| Teachers openness to change | 3 | | 3 | 1 | 1 | 1 |
| Enabling collaboration & Workloads | 3 | 3 | | | 1 | 2 |
| Staff commitment and training | 5 | 3 | 2 | 1 | 1 | 3 |
| Staff commitment and training | 5 | 3 | 2 | 1 | 1 | 3 |
| Funding | 3 | 3 | | 1 | 1 | 1 |
| Funding | 3 | 3 | | 1 | 1 | 1 |
| Overall | 8 | 4 | 4 | 2 | 2 | 4 |

Most of the issues raised under challenges have been discussed in section 4.1, because they tend to characterise either differences between the learning areas or differences among the schools. While *curriculum, rigour and assessment* was the most frequently mentioned category of challenges across the three schools and two learning areas, its subcategories showed patterns that were less uniformly distributed. *Appropriate Contexts & Themes* was the one subcategory of issues raised by both learning areas in all three schools. *Rigour, Coverage & Assessment* was a concern at Fibonacci and Gödel. For Sarah_{FI} the challenge of meeting satisfactory standards of rigour in integrated studies has been well addressed in her department. John_{FM} however attributed lost time for coverage of basics in mathematics to timetable demands from the integrated studies programme. At Cantor, Jane_{CI} and Greg_{CM} felt that lack of rigour and coverage were not a problems for their integrated curriculum and Greg_{CM} tied this to the school's identification of *must-knows* from the New Zealand curriculum.

²⁷ When comparing the number of participants shown for the schools it should be noted that there were 4 participants at Gödel and only 2 at each of the other schools.

Greg_{CM}: We have our *must knows*. So, the things that are, crucial in our subject area, a particular thing is geometry and measurement. So that's always first. And then, we have a look and see how we might integrate.

Interviewer: How much of the syllabus turned out to be *must knows* and how much was, optional?

Greg_{CM}: about say 70 percent or something like that.

At year twelve the department has reduced coverage demands of the mathematics curriculum by splitting the standard year twelve programme into two courses—one statistics and the other calculus oriented—as is already the established practice for the year thirteen mathematics in New Zealand schools.

Gödel Grammar made a similar selective inventory of the curriculum in writing their school scheme. David_{GI} noted that the crowded nature of the curriculum requires schools to prioritise objectives for their students and to resist coverage pressures from assessment for qualifications.

David_{GI}: The curriculum is so crowded that, you can't do everything. ... We don't necessarily have to teach every single aspect of the curriculum to the point of mastery. There will be some aspects of the curriculum that if you've been exposed to it, within a class, not necessarily assessed against it but, you've actually had some experience in that aspect of the curriculum. That may actually be OK

Coverage of the academic mathematics curriculum in conjunction with a holistic programme from year eleven onward was a problem that Fibonacci and Cantor had not addressed and which Liz_{GM} at Gödel had found extremely difficult to solve, particularly with regard to algebra. Again here the difficulty of making meaningful links to other learning areas was mentioned.

Liz_{GM}: The main challenge has been getting the coverage needed for students to go on to do exams in maths if that's what they choose. Algebra I've found almost impossible to tie into an integrated study or holistic course.

Like Cantor, Gödel has also increased the number of course options in mathematics for senior students

Liz_{GM}: We have, ... I call it more user friendly, level 2 maths courses. We're looking at using unit standards. They're more hands-on. So that we have navigation or networks, geometry, so where you can actually manipulate something, and we kind of aimed it at people that really don't like algebra because the level 2 achievement standard course has got a lot of algebra in it.

4.2.2 Impacts of NCEA on integrated curriculum and learning

The participants' comments about NCEA, grouped into 14 categories, have been summarised in Table 9. The most frequently mentioned issues reflect findings reported in the literature. The most common positive categories were *Flexibility* and *Learning gains* although the latter was mentioned by only two participants. The most common negative categories were *Credit Counting*, and *Fragmentation* mentioned by 7 and 4 participants respectively. The pattern of both positive and negative comments across the specific categories is strongly characteristic of learning areas and of schools. This pattern has been discussed already in the *Divergence* section above.

Table 9 Positive and negative impacts of NCEA on curriculum: Number of interview participants in each category by learning area and school

| Category | Total | Learning Area | | School | | |
|---|----------|---------------|---------------|-----------|----------|---------------------|
| | | IS Teachers | Math Teachers | Fibonacci | Cantor | Gödel ²⁸ |
| Positives | 6 | 4 | 2 | 2 | 2 | 2 |
| Flexibility | 4 | 3 | 1 | | 2 | 2 |
| Achievement gains | 2 | 1 | 1 | 1 | | 1 |
| Minimal negative impacts | 2 | 2 | | 1 | | 1 |
| Internal assessment as formative strategy | 2 | | 2 | 1 | 1 | |
| Meeting UE requirements and IC goals | 2 | 2 | | | | 2 |
| Moderation | 1 | 1 | | 1 | | |
| Credit counting | 1 | | 1 | 1 | | |
| Negatives | 8 | 4 | 4 | 2 | 2 | 4 |
| Credit Counting | 7 | 4 | 3 | 1 | 2 | 4 |
| Fragmentation | 4 | 2 | 2 | 2 | 1 | 1 |
| Demarcation disputes | 3 | 3 | | 1 | 1 | 1 |
| Low status of US and Internal AS | 2 | 1 | 1 | | 2 | |
| League tables and IC goals trade-off | 2 | | 2 | | 1 | 1 |
| Coverage problems | 2 | | 2 | | 1 | 1 |
| Moderation | 1 | | 1 | 1 | | |
| Institutional inflexibility | 1 | 1 | | | 1 | |

Positive Impacts

Four of the participants from Cantor and Gödel reported that flexibility for curriculum and programme design was the most important positive aspect of NCEA for integrated curriculum. Jane_{CI} and Greg_{CM}'s comments were typical.

²⁸ When comparing the number of participants shown for the schools it should be noted that there were 4 participants at Gödel and only 2 at each of the other schools.

Jane_{CI}: The NCEA has really positives, in the sense that because it breaks down the learning into smaller chunks. You can just concentrate, on a certain skill or a certain standard. ... So that means, you can take some achievement standards from there, and from there and you can make a course up.

Greg_{CM}: We can go out into all these different areas. ... So I think there is a, there is a real potential for integration with the NCEA. Over the last few years, I've realised, you can do heaps of things with it now.

For John_{FM} one of the most positive features of the NCEA has been that it rewards achievement and important workplace skills for students that would have failed under the previous qualifications system.

John_{FM}: The huge impact, has been, that you are able to make kids think that they can, achieve. ... There is something we can[use to] assess every kid at level 1, appropriate to their needs and ability.

David_{GI} also felt that this ability to meet individual student's needs was the NCEA's most important positive impact on curriculum and learning.

David_{GI}: Well we think it's stunning. Because it enables us to do qualifications in a way that is appropriate to individual students.

Negative Impacts

The most often mentioned negative impact of NCEA was the tendency for students to focus on the number of credits they had accumulated rather than the intrinsic value to them and their overall qualification of achieving specific standards: despite the schools' emphasis on integrative learning and intrinsic motivation. John_{FM} saw credit consciousness as having a positive impact on student motivation and decision making abilities. Sarah_{FI} also remarked on this discriminating capacity amongst the most senior students.

Sarah_{FI}: They all play the numbers game now. By year 13 they know just exactly what they need, to get into where they need to go.

Jane_{CI}: Credit accumulation is a major problem. It's across all schools.

Anne_{GI}: The biggest things for NCEA here, I think, is that, we've got students now credit hunting like they do at every other school. Rather than looking at the, the intrinsic worth of the subject that they might have chosen or the courses.

It should be noted here that the interviews were conducted in March 2007 before the government's announcement that from 2007 (and retrospectively) NCEA levels 1 to 3

certificates would be eligible for endorsement with Merit or Excellence (New Zealand Qualifications Authority, 2007) which can be expected to affect the importance of credit counting in future years.

The curriculum fragmentation effect of NCEA was the second ranked negative. It was mentioned by four of the participants, Sarah_{FI}, Jane_{CI}, John_{FM} and Brett_{GM}. Despite acknowledging the flexibility benefits offered by NCEA, participants also commented on the downside of its unitising of the curriculum.

Sarah_{FI}: I think NCEA is about discrete little bits. That it breaks everything down into, discrete little pockets that don't mean anything in an overall sort of way.

John_{FM} also registered his dissatisfaction with the over sub-division of the senior mathematics curriculum.

John_{FM}: The frustration I do have is that I think we lost a lot, particularly in statistics and calculus, when we broke the course up into so many units. So, particularly I think for calculus. ... We would be better served, if there were just, two standards, each with 12 and a half or 13 credits.

Brett_{GM} and John_{FM} both mentioned the key role of coordinate geometry in the network of mutually reinforcing mathematical concepts in senior mathematics.

Integrated studies participants in all three schools mentioned the fact that certain NCEA standards were considered by teachers to be the exclusive domain of particular subject areas, as an obstacle to the development of interdisciplinary courses, even in the humanities and social sciences areas where integrated curriculum is best established. Such demarcation disputes could never have arisen under previous more discipline based qualification systems but the flexible standards basis of NCEA has created the possibility for these tensions. Both Jane_{CI} and Greg_{CM} commented on what they considered to be the general misperception that unit standards were always easier to achieve than content equivalent, achievement standards.

4.2.3 Addressing the Challenges

Throughout the interviews each mention of a challenge was accompanied by explanations from participants as to how it was being addressed. These responses tended to be quite individualised and most have been mentioned elsewhere. From the interviews as a whole, two sets of strategies consistently emerged as important for curriculum integration: first *themes and contexts* and second *formative assessment*. Both learning areas emphasised the importance of

the former although from quite different starting points. The mathematics participants were most enthusiastic about the potential of the latter.

Integration Themes

The hallmark of integrated curriculum is appropriate themes and contexts around which the integration of subject areas is organised. Participants were asked if certain themes tended to emerge more often than others when researching student interests for the creation of new integrated courses. The answer was a general 'yes'. Jane_{CI} puts this view clearly when asked how she would balance student interests and her own professional judgement in the design of any new integrated course.

Jane_{CI}: [students] have definitely got their interests and their needs, but somewhere there's got to be someone, guiding it, along.

Interviewer: So you'd start off with your own inspiration and judge that against their interests?

Jane_{CI}: Yeah, and also, what do we think they need out in the world, because we are better judges of that than the kids. They might disagree with that, although when you go and ask kids, they all come up with the same type of concerns that they're worried about, whether they're at this school, a school down the road or a school in Invercargill.

The themes mentioned fall into six broad categories as listed in Table 10. The categories are sorted in descending order by the number of participants suggesting items in each category and number of distinct items mentioned. The numbers of items listed are indicative only since the themes mentioned by participants showed wide variance of scope both in terms of their number of sub-themes and the total hours of lesson time devoted to them.

As already noted, the contributions to Table 10 were dominated by the integrated studies learning area. The mathematics teachers (Greg_{GM}, Liz_{GM} and Brett_{GM}) offered just seven items in three categories out of the total of 31 items from all participants. Amongst the schools, Gödel provided the highest number and richest variety of items (even allowing for the greater number of participants from this school) followed by Cantor. However this was also a reflection of the shorter duration of courses in the Gödel programme. The integrated studies themes at Fibonacci referred to courses that ran all year and had separate components in each term. Three categories of themes were common to all three schools: that is, *Social Justice/Local Issues/Communities*, *Sustainable Economics and Environment*, and *Biography/Self discovery/Change*.

Table 10 The major theme groups for integrated curriculum: Number of items mentioned by learning area and schools

| Theme Category | No. participants | No. distinct items | No. Distinct Items | | | | |
|---|------------------|--------------------|--------------------|---------------|------------|--------|---------------------|
| | | | IS teachers | Math teachers | Fibo-nacci | Cantor | Gödel ²⁹ |
| Communities/Social Justice/Local Issues | 6 | 8 | 4 | 4 | 1 | 2 | 5 |
| Sustainable Economics and Environment | 4 | 6 | 6 | | 1 | 1 | 4 |
| Health and Home | 3 | 4 | 2 | 2 | | 1 | 3 |
| Entrepreneurship & Enterprise | 3 | 7 | 7 | | | 1 | 6 |
| Biography/Self discovery/Change | 3 | 3 | 3 | | 1 | 1 | 1 |
| Computer Games, Graphics and e-commerce | 3 | 3 | 2 | 1 | | | 3 |
| Totals | | 31 | 24 | 7 | 3 | 6 | 22 |

Communities/Social Justice/Local Issues

Sarah_{FI}, Jane_{CI}, David_{GI}, Greg_{CM}, Liz_{GM} and Brett_{GM} offered contexts or themes belonging to the *Communities/Social Justice/Local Issues* category. When Sarah_{FI} was talking about the year nine *Communities* theme for integrated studies at Fibonacci, it was clear that she considered issues of environment and sustainability to be included.

Sarah_{FI}: Part of what we try to do in year 9 in integrated is, get the students to feel like they're part of the Fibonacci Community. ... and then we go .. into the human impact on natural communities, which is basically environmental issues.

Examples at Gödel which fell into the *Communities/Social Justice/Local Issues* category were both from the *Maths in the Mall* and *Africa*,

Sustainable Economics and Environment

Four teachers, Sarah_{FI}, Jane_{CI}, David_{GI} and Anne_{GI} referred directly to the importance of the Sustainable economics and environment category of themes. David_{GI} noted that *environment* was one of the themes arising from the school's earliest consultations with students to elicit their concerns and issues.

²⁹ When comparing the number of participants shown for the schools it should be noted that there were 4 participants at Gödel and only 2 at each of the other schools.

David_{GI}: One of the things when we started talking about a strategic plan and we had a group focus with the students One of the things that came through was that our kids wanted our school to specialise in environmental issues.

Anne_{GI} noted that the Education for Sustainability level 2 achievement standards³⁰ have a scope which covers all three of the common major integration theme groups identified in the opening paragraph of this section.

Jane_{CI} mentioned themes belonging to both the *Sustainable Economics and Environment* (Nature in Balance) and the *Biography/Self discovery/Change* categories in the following extract.

Jane_{CI}: We do a whole term on a theme. So this term was "the Journey", the journey of self discovery ... at year ten, they go into their courses ... and that's where we try and then continue some of that integration like "Nature in balance".

Health and Home

Four participants, Jane_{CI}, David_{GI} and Liz_{GM} suggested contexts that fit with the *Health and Home* theme category. Both Jane_{CI} and Liz_{GM} emphasised the connection between cooking and budgeting and Liz_{GM} used it as a context for at least two of her mathematics courses as already mentioned. David_{GI} connected the more outdoor activities of house painting with subjects across the curriculum including mathematics and Greg_{CM} suggested that sports would provide an ideal context for the integration of NCEA standards across health, PE, mathematics and English in the senior school.

Greg_{CM}: We can develop a course, to do with, sports. You can integrate within that, some maths standards, it might be, ... statistical analysis or something like that, and English might be able to incorporate something in there, Report writing, or whatever.

Entrepreneurship and Enterprise

The theme of *Entrepreneurship* and Enterprise was being developed in the integrated programmes at Cantor and Gödel. At Gödel it constituted a major real life application of integrated learning in the school. David_{GI}'s comments on this theme were quoted earlier in section 4.2.1 under the heading of *Benefits*.

³⁰ See appendix D

Biography/Self discovery/Change

Three teachers talked about integrated course themes in the *Biography/Self discovery/Change* category, Sarah_{FI}, Jane_{CI} and Anne_{GI}. Fibonacci's year 10 integrated studies course on change was built on the history subject area context but was closely related to the notion of personal change which she described as particularly relevant to the year 10 age group.

Sarah_{FI}: They're starting to change and so we look at change in New Zealand, change in technology because they're really into technology, and how that's impacting on society. ... And, they're changing, the whole, adolescent thing going on, particularly in that year. They're going from being children to being adults,

Jane_{CI}'s reference to the journey of self discovery was mentioned above. At Gödel, students have also expressed their interest in the disciplined study of self discovery, philosophy and spirituality.

Anne_{GI}: One of the things that a lot of our students have talked about is that they'd like to have a philosophy and psychology and things here. They're interested in, human nature, and the spiritual side of things. They don't all want to come here and have glory hallelujah and everything, but they want to explore the spirituality.

Computer Games, Graphics and E-commerce

Apart from student businesses Gödel has also developed its own video-animation and 3D graphics course called *Down-Town Digital* which it markets to other schools in the form of specialist resources. David_{GI}, Anne_{GI}, and Brett_{GM} mentioned courses based on contexts in this theme category.

David_{GI}: We call it *downtown digital* ... a specialised unit on which we're getting film video, 3D animation and 3D game making. They're the three biggest growth industries in the world. ... We actually employed somebody who was a specialist in languages from the university, a film-video maker, who'd worked with Peter Jackson and a 3D animator.

Formative assessment strategies in mathematics

While integration themes and contexts are the direct route to developing integrated learning, assessment must also become integrated. Development of integrated assessment offers an

alternative approach to leading curriculum reform in the direction of integration. Integrated assessment methods may in fact be the more important strategy for expanding integrated curriculum in mathematics than in integrated studies given the strong relationship that mathematics learning area has with assessment. As discussed in in chapter 2, integrated assessment is most likely to depend more on innovative, formative, internal, extended time frame, process-product and multi modal assessment methods than upon traditional summative, external, time limited, product oriented, written exam formats.

For all four mathematics participants the most successful learning gains for students they reported were related to improvements they had introduced in their formative assessment practices. John_{FM} and Greg_{CM} focused on NCEA style grades feedback to steer students into thinking more mathematically. They also used unit standards which are internally assessed during the year as formative assessment for equivalent achievement standards assessed in external exams at the end of the year. This strategy has the added bonus of being a safety net if students opt out of the externals for one reason or another.

John_{FM}: The key strategy at the moment is, our assessment, our achievement based assessment, at year nine and year ten. ... So we're writing tests that are 'N A M E'³¹. And we're showing the kids where they were 'A' and could have been 'M'. And we're doing that off the mark scheme that we're giving them. ... The whole of year ten and year nine is formative.

Interviewer: And what about self assessment?

John_{FM}: No.. Well, yes and no, because the student booklet, it has a broken down unit by unit planner, and in it, it's got the *I have done*. So, in this assessment there is going to be these seven things. I convince myself that I can do all seven.

Interviewer: Do you find that works well?

John_{FM}: We're making progress. [laughs] .. Big breath, we're making progress and, it's interesting, it's a whole variety of kids that good at owning that. Some of our most academic kids are hopeless at owning it. .. Some of our really, really middle of the road kids use it really well and its one of the reasons they, become more and more successful.

Greg_{CM}: The unit standard which we tried is the practice assessment, for the achievement standard. If they get the unit standard, great. ... Then you can make a decision about whether or not you want to sit the external at the end of the year.

³¹ Not Achieved, Achieved, achieved with Merit and achieved with Excellence.

Liz_{GM} has reported success in using individualised assessment goals for students related to the NZ curriculum objectives.

Liz_{GM}: Last year, I had a course called "Measurement Island", ...[I took] the main curriculum objectives. Found out what they knew before, and then highlighted four or five of them. That worked well. The students enjoyed it, because it was all on one sheet ... so they could see where they were, and where they should be.

Brett_{GM}'s most successful strategy has been peer assessment in groups that fostered mathematical discourse in his classroom.

Brett_{GM}: So they would go off in their pair or three, whatever it was and, complete the assessment and then, we all come back together, they have to give theirs, to another group, [which] had the assessment schedule and they had to go through and mark it ...and that would go to three other groups within the class, ... and then the grades would be [an] average from what those groups, came up with. And then they had the right to challenge, it would go back to the original group, they'd go through the other groups marking and if, they disagreed, they could then submit it. What was good was when they were marking each others they were a lot more critical about, had they adhered to the process... so that was probably the best learning.

Interviewer: and did that did that show up in that group's, external assessment?

Brett_{GM}: yeh I'd say I'd be happy that their standard had come up, and part of it was just probably [that they were] more considered or more thoughtful, of what they were doing.

Greg_{CM} also spoke about focusing more on group work in mathematics, when asked how he would like to see the mathematics curriculum develop in the school.

4.2.4 Summary of section 4.2

Seven of the eight study participants perceived learning gains as being the most important benefit arising from integrated curriculum. For the integrated studies teachers these gains arose from having effectively more time with students through combining subjects and from the multiple interrelated learning opportunities presented in inter and trans disciplinary activities. For the mathematics teachers learning gains resulted from opportunities to show students the real world relevance of mathematics and its relationships to other areas of knowledge through the curriculum. Increased student and teacher motivation and improved student behaviour were

also considered positive outcomes of integrated curriculum and learning by the integrated studies participants.

Timetable and programme coordination was the most often mentioned negative of integrated curriculum and the second most mentioned challenge. It was reported in all three schools and both learning areas in various ways. Curriculum, rigour, and assessment issues—particularly finding appropriate integration themes, curriculum coverage, and assessment pressures—were the most often mentioned challenges. Ranking the New Zealand curriculum achievement objectives and eliminating those of lowest priority was the favoured method of managing the challenge of curriculum coverage at Cantor and Gödel. At Cantor the year twelve mathematics curriculum had been split into statistics and calculus oriented courses. At Gödel attempts to integrate senior algebra courses with other subject had proven extremely difficult. More hands-on and geometrically based courses were being employed, in conjunction with unit standards, to diversify the senior mathematics programme.

Flexibility and achievement gains were considered the most important positive impacts of NCEA on integrated curriculum, being mentioned by 4 and 2 of the participants respectively. The most frequently mentioned impact was the negative effect of indiscriminate credit seeking. Curriculum fragmentation was mentioned as a negative impact by four participants representing all three schools and both learning areas. The potential for subject based demarcation disputes over particular NCEA standards to inhibit interdisciplinary course development was a concern for the integrated studies participants.

Generating appropriate cross curricula integration themes and contexts was seen by participants as both a major challenge and as a key strategy for addressing the challenges of IC development. Six main groups of integration themes emerged from the interviews: *Communities, Social Justice, and Local Issues*; *Sustainable Economics and Environment*; *Health and Home*; *Entrepreneurship and Enterprise*; *Biography, Self discovery and Change*; and *Computer Games, Graphics and E-commerce*. The integrated studies teachers were more practised in the use of integration themes than the mathematics teachers. The mathematics participants provided just seven of the total 31 theme items mentioned during the interviews. Four of the seven belonged to the *Communities, Social Justice, and Local Issues* major category. The mathematics participants expressed enthusiasm for the potential of formative methods of assessment, including internally assessed NCEA standards, to foster learning. This positivity suggests that the expansion of dual purpose formative/summative approaches to assessment—particularly peer and group assessment—may be an effective strategy for approaching the challenges of IC development in mathematics.

4.3 Convergence

Section 4.1 dealt with divergent trends and 4.2 with the agreements amongst the schools and between learning areas with respect to current practice and conditions. This final section of chapter 4 deals with the responses to those questions of the interview schedule which were future oriented. During the interviews no direct reference to or comparisons with the other schools involved in this study were made. Nevertheless convergence was evident among participants' aspirations for their schools, learning areas and own teaching. Participants tended to indicate the desire to improve their practice in aspects of perceived current weakness—which were coincidentally strengths in the other schools and learning area—without compromising aspects of their practice which they perceived as already strong. With respect to proposals for the future development of the NCEA to support integrated curriculum there was a high level of consensus.

4.3.1 Curriculum aspirations and resource priorities

This section combines the interview participants' responses to the questions of resource needs and priorities for future development of the integrated and mathematics curricula in the school. These responses have been grouped into eight categories (see Table 11). Convergence is evident in this table in that the first two categories of priorities are common to both learning areas and all three schools and the remaining categories tend to correct for the perceived areas of weakness identified as challenges by the participants in Table 8.

Professional development in teaching and learning practice was a priority common to both learning areas and all three schools as was *Expansion of the integrated programme* to higher year levels, although more for the integrated studies teachers than for the mathematics teachers. Assessment, earlier identified as being secondary to curriculum for the integrated studies participants was their first priority when it came to future needs. Furthermore the assessment resources and guidance needs came from Gödel and Cantor where the tension between assessment and curriculum imperatives was strongest. Curriculum development which was identified as being secondary to assessment for the mathematics participants was foremost in their vision of future priorities. Curriculum development was also important to all three schools with Cantor emphasising this most as they did the *Appropriate Contexts and Themes* in Table 8.

Collegial Collaboration time was of greater concern to integrated studies than mathematics which goes against the convergence trend perhaps showing just how deeply approaches to collegial collaboration characterise the separation of the two learning areas. More convergent

was the trend among schools on this issue. Collaboration was emphasised at Fibonacci and Gödel but not at Cantor where it already received a major investment of time and energy.

Table 11 Visions, aspirations and resource priorities: No. participants by learning area and school

| Priority Category | Overall | Learning Area | | School | | |
|--------------------------------------|---------|---------------|---------------|-----------|--------|---------------------|
| | | IS Teachers | Math Teachers | Fibonacci | Cantor | Gödel ³² |
| PD in Teaching and learning practice | 5 | 3 | 2 | 1 | 1 | 3 |
| Expansion of integrated programme | 4 | 3 | 1 | 1 | 1 | 2 |
| Assessment resources and guidance | 4 | 3 | 1 | | 1 | 3 |
| Curriculum development | 4 | | 4 | 1 | 1 | 2 |
| Collegial Collaboration time | 4 | 3 | 1 | 1 | | 3 |
| ICT resources and training | 3 | 2 | 1 | 2 | | 1 |
| Student guidance and mentoring | 2 | | 2 | 1 | 1 | |
| Time & Money | 2 | 2 | | 1 | 1 | |

Both Gödel and Cantor were better resourced in *ICT* hardware, software and expertise than Fibonacci for whom it was a much higher priority. *Student guidance and mentoring* was of particular concern to the mathematics area and was a key element of mathematics convergence with integrated studies and also of convergence among the three schools.

The interview extracts quoted below under five of the priority categories summarised above, have been selected to illustrate some of the more striking convergences.

Teaching and learning practice and professional development

The integrated studies teachers in all three schools saw professional development as a key to expansion of the integrated curriculum. Greg_{CM} and Brett_{GM} were the mathematics participants that emphasised the importance of professional development.

Greg_{CM}: For me I think one of the things I'd like to see in, in our school, is looking at different ways of teaching, things like for example the group working and getting more involvement with the kids, kids being more involved with their learning, being a lot more interactive, inquiry and ... more interactive, so that, instead of me just sort of preaching it, we work together, Like, there you go. There's a challenge for you. ... So how, can we work together to try and see

³² When comparing the number of participants shown for the schools it should be noted that there were 4 participants at Gödel and only 2 at each of the other schools..

Interviewer: And the challenge in making that happen is, what?

Greg_{CM}: The challenge in making that happen is PD: Is getting enough time for PD.

Assessment Resources and guidance

A need for more generic interdisciplinary standards for NCEA was expressed by both David_{GI} at Gödel and Jane_{CI} at Cantor. In the following extract David_{GI} was talking about the school's need for more information regarding how to use NCEA assessments in conjunction with the *learner directed experiences* part of their programme.

David_{GI}: Some will have unit standards attached. Not all of them. And part of the challenge for us is to broaden our knowledge about what are the standards that are appropriate, how you match them together and how you write those for assessment

Liz_{GM} had a particular interest in seeing more organised resources for integrated curriculum which incorporated mathematics being developed and made available to teachers who haven't the time to create them for themselves.

Liz_{GM}: It would be good, to see, some credits, you can fit projects into. Where designing, building and following a project, is worth credits. ... There are certain investigations that you can do at the moment... I think it kind of needs, someone to sit down and show how it's possible. Then I think other people would be happier to do it

Curriculum development

Consistent with their struggle to find compelling real world contexts for mathematics, Brett_{GM}, Greg_{CM} and John_{FM} all stressed the importance of time and opportunity as resources needed to address integrated curriculum development issues.

Greg_{CM}: One of the things with, the maths, if I had more time, is, trying out some of these different things, and experimenting ... and that's one of the things I think, that holds you back, in a big school is the, experimentation.

Collegial Collaboration time

Sarah_{FI}'s comments on the need for more professional development meeting time with colleagues were quoted earlier. Brett_{GM}'s comments gave a mathematics teacher's perspective

on the value of colleagues meeting to reflect on and collectively evaluate their independent classroom experiences.

Brett_{GM}: having the opportunities for, teachers to meet, come together, share ideas and..., that was the good thing with CAS we, .. worked at these PD sessions, and then were quite isolated, again and then, getting back together at the next session we always spent some time reflecting on the, the previous unit, and that was really valuable.

Student guidance and mentoring

Both Greg_{CM} and John_{FM} would like to see improvement in curriculum guidance for students. Despite his very pragmatic line on mathematics curriculum being driven by assessment and students being performance driven, John_{FM} had a student centred view of education's greatest challenge. While maintaining that many students were making good career decisions guided by the credit system of NCEA he also saw their need for long term individualised mentoring for those less capable of wise choices regarding their education as something the system was not currently providing.

John_{FM}: I actually think at the moment that the thing that kids can benefit most from, is, good life coaches. ... We were talking earlier about successful middle stream kids, and I suspect that, somewhere in the background there is that life coach who is just pushing the right button. ... I think that's the next big challenge in education... to identify those people and for the educator, to give the kids and that person, the tools they need to play the game.

Interviewer: Well from the educator's point of view then it could be that, if you want to improve your students' chances of succeeding, you might want to find out whether they have such a person in their lives, and what can we do about making sure that they do?

John_{FM}: Yes .. that's right, yes, so, picking up the pieces.

Students are experiencing of freedom to make pragmatic choices in the credit 'economy' of education but clearly in John_{FM}'s experience this is not always without regrettable costs for some.

4.3.2 Integrated curriculum and NCEA alignment

Expansion potential

From the interview data presented to this point it is clear that the integrated programmes in the participating schools tended to be limited in their scope both horizontally across learning areas and to an even greater extent vertically as the curriculum progressed through years eleven, twelve and thirteen. This section presents the participants evaluations of the main factors constraining and affording integrated curriculum expansion and how they might be managed.

Sarah_{FI}, Jane_{CI} and Anne_{GI} all saw NCEA credit requirements for University Entrance³³ as constraining integration of curriculum in the senior school. They also considered the possibility that students might be presented with the same standards in different subject areas of their programmes as undesirable and requiring careful monitoring.

Sarah_{FI}: If you brought an integrated approach into the senior school, if you didn't want to affect their tertiary entry, you'd have to make sure that you chose, achievement standards that would give them their 14 credits for a subject, and you'd have to make sure that they weren't doubling them up from somewhere else.

John_{FM} was less concerned about university entrance requirements, most likely because the numeracy entrance requirement only involves 14 credits at level 1 but also perhaps also because the mathematics courses and NCEA standards at Fibonacci have not to this point been very much involved in interdisciplinary courses.

John_{FM}: Our observation is that tertiary will take all comers at level 1. So in actual fact we can do almost whatever we want to. And that's probably true of Polytechs as well.

Liz_{GM} and Greg_{CM}, who were the participants with the greatest experience of mathematics curriculum integration, both saw integrated courses as being more accessible to students not intending to attend university. Liz_{GM} was earlier quoted as seeing credit seeking and the pressure on students aspiring to university careers to study formal algebra achievement standards as being a significant factor constraining IC development.

Sarah_{FI} also considered the potential for integrated curriculum in the senior school to be better for students not bound for university.

³³ See details given earlier as footnote 10 in chapter 2.

Sarah_{FI}: But I think there's space for that there, if you weren't looking at somebody going to do tertiary education, ..., I always thought that it would be more that second, that middle tier of kids. Kids who weren't going to university, [and] don't drop out at 16.

The fact that examinations for external achievement standards are grouped by subject was also considered problematic for an integrated course which might involve two or three externals from two or three different subject areas.

Jane_{CI}: That is an issue with integrated courses... the Ministry has to work out baskets. And the easiest way to work out baskets is subject baskets. And that's a restraint. They're, quite right in doing that because they've got to nationally timetable it.... It's got to be secure.

Jane_{CI} suggested that greater emphasis on broadening the scope of the generic research standards³⁴ would mitigate the fragmentation effects of NCEA and be the most helpful way to support the development of integrated curriculum. This suggestion anticipated the question concerned with the desirability of introducing new *integrated standards* to NCEA which is the subject of the last heading in the present section.

Jane_{CI}: By making, [them] probably a little more generic with, their wording. So that when you unpack the standard, the actual standard is getting at the research....
So I think NCEA allows it. But, it's still quite structured.

She also expressed an interest in the Queensland *New Basics, Rich Task* assessments (Matters, 2001). Anne_{GI} saw the integration of mathematics with geography standards as something desirable but currently not easily done.

Anne_{GI}: so often they have to apply their, mathematic[s], Spearman's rank correlation coefficient, all those ones. Statistics is so precise, as far as I'm concerned, ..[but]... At the moment, you can't actually mesh those two very easily together.

Sarah_{FI} noted also that costs can be a very real constraint for the creation or continuation of worthwhile but ambitious integrated courses.

Sarah_{FI}: the very first integrated programme that was at Fibonacci was ... called Environmental Studies. ... It was a Sixth Form Certificate course and it used, some English skills, some Science, some ICT, ... And they did a lot of field trips. And it was great, except the field trips kind of priced it out of existence and students stopped opting for it.

³⁴ e.g. 90705; Carry out and present geographic research with consultation, level 2, 3 credits

John_{FM}'s position on the limited potential for the interdisciplinary integration of mathematics has been well documented. The other three mathematics teachers were all more positive about this prospect. Greg_{CM} suggested that the missing element currently for mathematics was appropriate holistic themes for senior students and, as quoted in 4.2.3, he suggested sports would be an ideal context at Cantor.

Greg_{CM}: We have this thematic approach, at year nine. I think that in order to come up with some kind of integration, there needs to be something like that at, the senior level, at NCEA level and it's got to be something that is of interest to kids.

Liz_{GM} considered the integration of NCEA standards as "very do-able" with unit standards at year eleven but increasingly problematic at higher levels due to the amount and specialised nature of the content covered by each standard. Her department's answer to this difficulty has employed a shift to new courses with new contexts which were again aimed—as suggested by Sarah_{FI} and Greg_{CM}—more at non-university bound students. At level 3 she saw the statistics standards in conjunction with ICT as having the greatest potential for integration with other subjects. Brett_{GM} agreed that it was possible to achieve good coverage of the mathematics curriculum at level 1 in an integrated setting, given the staff time necessary for the creation of appropriate programmes.

Creating courses and combining existing standards

When asked, on what basis they would select unit or achievement standards for inclusion in a new integrated curriculum programme or course, four respondents (Sarah_{FI}, Jane_{CI}, Anne_{GI}, and Liz_{GM}) all replied that they would begin from their own professional inspiration and pedagogical judgements. Their next step would be to select appropriate NCEA standards and then to negotiate with colleagues about possible conflicts over the use of those standards in other courses. Student interests appeared to be assumed already well understood and to be included in the teacher's vision for the course they were proposing to implement.

Sarah_{FI}: First of all you have to find things that pertain to what you wanted to do. ..., but then you have to negotiate with the departments that already offer them. ... And then negotiating with senior management: if you run a new course you've basically got to take an old one out. Then there's resistance from people who might lose their course, [the] bigger the school, the more chance you've got of doing that.

Anne_{GI} stressed also the need for teachers to align their own aims with specific curriculum objectives and to use only standards that they felt competent to assess.

Anne_{GI}: I looked at, what's the really important learning that I want to give them, the experiences I want them to have, through being involved, in this particular module or learning programme. ... And then I thought, well, OK, the reality is the kids won't do it if there's no, no assessment, no credit, that's the reality. So what's going to fit it? ... But the key thing is with using any achievement standards from any area you're not au fait with, you've actually got to go back to the curriculum document and understand what the achievement objectives are. And if those achievement objectives don't fit with what your overall plan is, ... then you might need to dump it, or you dump that achievement standard. Saying right, we've got to find something else that more, closely meshes with what I want to do.

Interviewer: And, generally that, will be there somewhere?

Anne_{GI}: I've found that if you look closely enough, there will be things. There are a lot of unit standards around, I think of some on the literacy studies. You have to be very careful about, is this school, or are you, competent as a teacher to really assess those.

For David_{GI}, the starting point for devising new courses was teachers' understanding of student interests. Earlier in his interview he emphasised that on-going conversations with students were the basis of this understanding.

David_{GI}: Teachers are capable people and you know we find things that we know will capture the kids' interest.

To maintain academic rigour he believed, new integrated courses should not formally assess more than two learning areas at a time.

David_{GI}: I really like two curriculum areas together. There'll be other activities, of other curriculum areas. ... It doesn't mean to say you don't deal with those or talk about those or talk about the skills but, having a focus around two areas that you take through to assessment because, that's all the time we've got. Do less, better, in my view.

Liz_{GM}, Greg_{CM} and Brett_{GM} replied that student interest would play a leading role. For Liz_{GM} other high priorities in creating new courses were selecting what would be of greatest practical use to students and what would extend them academically.

Liz_{GM}: To me it comes in what issue interested them? What's in it that will extend them, that they will enjoy and how will that be useful to them I think, that's been my

main criteria. ... If the student is a very poor student, what do they need? What's the bottom line need for life. What Maths are you going to use in employment, in the world.

Like Anne_{GI}, Greg_{CM} qualified the creative aspects of with the need to be realistic about what the teachers are able to offer.

Greg_{CM}: I think too, we're a bit limited and, to say that it's by student demand, popularity, whatever, it also depends on, what we can offer, can we do it? Have we got, the teacher expertise if you like, to run the whole thing.

For a course integrating mathematics and sports for instance, he suggested that the teacher should ideally be trained in both mathematics and PE teaching. Greg_{CM} also commented on the longer term development of the integrated curriculum over the initial years of the school's development. Similar processes were described by David_{GI} and Anne_{GI} at Gödel who both commented on the sustained effort required by learning advisers to elicit students' interests and goals.

Greg_{CM}: When it first started, ... the staff asked the students, "what sorts of things interest you?" ... So they got a lot of feedback from, the students, and then they picked out the sort of nine or ten that were the most popular that the kids seem to really want to know, ... and then they started developing those, and saying OK, how can we integrate this across, the learning areas. ... Then they found that that was too much. And it kept changing each year,... So it made it, ... hard work. ...So, then they looked at the things that were common in maybe the first couple of years and said, ... how can we break that down into, maybe some themes ... And they developed it that way.

Brett_{GM} acknowledged the prevailing ethic at Gödel, of putting student interest first, but was forthright about the limited extent to which those interests would influence the final implemented form of a new course. John_{FM} mentioned student interests only as being difficult to engage in what he regarded as appropriate contexts for real world mathematics: that is physical problem solving situations. This doesn't necessarily mean that student interests have no effect on the Mathematics teaching at Fibonacci but—when asked how he would go about designing a new integrated mathematics course—he made clear that the programme design is largely a given based on their decision to be guided by the content of NCEA standards.

John_{FM}: The reality is that I wouldn't be because, so much of both the unit standards and the achievement standards are content drive, skills content driven. ... And so

consequently within the teaching block, you spend three quarters of your time on the skills content and 25 percent on the merit excellence

The overall impression given by participants is that integrated curriculum and assessment design is top-down in terms of its large structure and big themes, based largely on teachers' professional judgements. Formal processes to elicit student interests have a high priority when integrated curriculum is first established in a school. Later as common themes become established, incorporating student interests becomes more informal and based around individual teacher's conversations with students. Student choice also become built into courses and programmes for instance through project topic options within courses or course options within programmes.

New standards for NCEA

Two questions in the interview schedule explored the possibility of going beyond simply combining existing standards for the assessment of new integrated programmes to creating entirely new types of standards for NCEA. The first asked about the current assessment of key competencies and was extended in conversation to include the possibility of NCEA standards for that purpose. The second asked about the usefulness of *broad-based, integrated standards* designed to assess students' capacity to integrate the content and skills from a number of related, more narrowly based standards in one or more learning areas.

Seven of the participants were positive about the key competency standard proposal but commented on the difficulties involved in their design and implementation. The integrated studies teachers all reported that assessment of key competencies was already part of their practice in the Junior high school. All the mathematics teachers were aware of the key competencies and, apart from John_{FM}, were deliberately cultivating one or more through their lessons. Assessment and reporting of key competency achievement was managed largely in an anecdotal rather than systematic manner. All eight were positive to very positive about some potential application of integrated standards.

The participants' responses to these suggested new types of standards showed more consistency by school than by learning area. Sarah_{F1} and John_{FM} at Fibonacci were the least convinced of their value although not entirely negative. Sarah_{F1} questioned at first the need to credit integration independently of content. She ended by noting the similarity between the integrated standard concept and the key competency of *thinking*. Of the eight participants Sarah_{F1} did in fact report the most personal research into how competency assessment might be incorporated

into an SBA system. John_{FM}'s rejection of the idea of assessing the key competencies has been noted already. His evaluation of the integrated standard concept was slightly more positive but he saw it as being more for teachers' satisfaction than for students' learning and he applied the concept only at level 3 within the mathematics learning area itself.

Jane_{CI}, Greg_{CM} and Brett_{GM} tempered their positivity with reservations over the technical difficulties and effort required from educators to create such standards and the possible reactions of students to the extra effort required for integrated learning and assessment.

Jane_{CI}: It would be very useful. It would be great, but, bloody hard to write. The mentality will be, why are you doing it? I've already proved I've got the learning in this area. And I've got enough credits.

Interviewer: What if it was worth more, credits?

Jane_{CI}: Yep that possibly could be it, yeah Maybe if you did it in terms of the level of learning. That this was, what got you excellence or this is what got you scholarship We're actually going to take subject matter away.

Anne_{GI} was very positive particularly about the standards for key competencies and remarked on NZQA's current interest in the proposal. Anne_{GI}, Sarah_{FI} and Greg_{CM} all commented that the choice of related contexts and the specification of related narrow based standards would be critical to the success of an integrated standard. Liz_{GM} and David_{GI} were both very positive in principle although Liz_{GM} expressed regret that credits would be a necessary co-requisite for the promotion of integration to students. Like Sarah_{FI}, Anne_{GI} questioned whether *integration* of content actually needs to be assessed and credited independently of that content. She explained how the *Education for Sustainability* standards³⁵ are intended for use across learning areas and that crediting students' capacity to integrate is actually built into them.

4.3.3 Summary of section 4.3

Convergence of the participants' goals aspirations for their schools and learning areas was evident with respect to five aspects of integrated curriculum and learning. Professional development in teaching and learning for IC was a high priority for five of the participants representing all three schools and both learning areas. Expansion of the IC programme to higher year levels and across learning areas, and the development of assessment resources for IC—such as more generic interdisciplinary NCEA standards—were important for the integrated

³⁵ See appendix D

studies participants. More time for IC development, particularly of appropriate themes and contexts; and more attention to student guidance and mentoring, were both expressed as aspirations by mathematics participants. Against the convergence trend however, the need for more collegial collaboration time remained a higher priority for the integrated studies than the mathematics participants.

Expansion of integrated curriculum was seen as most applicable to senior students not intending to study at university. Three of the integrated studies participants and the two mathematics participants with greatest experience of integration expressed this view. Their judgement was based on the effect of University entrance requirements on students in the academic pathway—who are more likely to be taking external achievement standards—and the greater applicability of internally assessed NCEA standards to interdisciplinary courses. Other constraints on IC expansion mentioned were the incompatibility of standards in different learning areas—such as mathematics and geography—and the costs associated with IC oriented activities such as environmental field trips. Strategies suggested for supporting IC expansion included the creation of more generic project oriented standards in NCEA and providing more appropriate contexts—such as sports—for mathematics integration in senior mathematics classes. Interdisciplinary courses with NCEA assessment in mathematics were seen as limited to level 1 unit standards and level 3 statistics standards, by the participant with the greatest experience of mathematics integration. She regarded other mathematics standards as covering too much specific content to be useful in interdisciplinary courses.

In describing how new integrated courses are created and implemented, participants expressed a range of views about the relative importance of student interests, teacher professional judgement, school structural factors, and NCEA assessment possibilities. Although at the introduction of integrated curriculum in a school, school wide processes for eliciting student interests had high priority, in time student choice tends to become formally built into the programme and courses in specific ways. Eliciting student interests becomes a matter of individual teacher's sustained conscious effort. Teachers' professional judgements become the key guiding factor integrating student interest, school structural constraints and the choice of NCEA standards to be combined. Participants noted that the availability of trained staff capable of teaching and assessing particular combinations of subjects was also a determining factor in what new interdisciplinary courses could be offered.

Seven participants responded positively to the proposal for the development of new NCEA standards directed at assessing key competencies and all saw some potentially useful application for more generic, broad-based, integrated standards. The *Education for Sustainability* standards

available within the NCEA for the first time in 2008, are effectively broad-based integrated standards. Suggestions for the support of integrated standards included: assigning them more credits than current content specific standards, associating their achievement directly with the grade of excellence, and reducing content coverage requirements for those students that attempt them. Three participants commented that the success of integrated standards would depend critically on which of the current content specific standards they were associated with.

Chapter 5: Discussion and Conclusion

5.1 Introduction

Chapter 5 is organised into four main sections including this introduction. Section two summarises the study's key findings and links them to the four research questions, introduced in chapter 1. Section 3 discusses in greater depth the implications of the key findings for integrated curriculum development. The nature of integrated curriculum in relation to mainstream subject based curricula is explored using the metaphor of schools adapting their practice on the rugged fitness landscape of education. An expanded conceptual framework for characterising and organising integrated curricula is proposed. Long term measures are suggested for the enhancement of integrated approaches within mathematics and for the closer integration of mathematics with other learning areas. The possible interdisciplinary clustering of existing standards and proposals for the introduction of broad-based integrated standards to NCEA are considered with respect to their potential benefits for integrated curriculum development. The capacity for these innovations to mitigate some of the negative impacts of the NCEA identified by study participants and in the literature is also discussed. The final section of this chapter concludes the thesis as a whole.

5.2 Summary of the key findings

In this section the key findings from the case study interviews are presented in 12 summary paragraphs. Consistent with the nature of integrated curriculum (IC), answers to the study's four research questions are not readily separable. All paragraphs provide answers to the first research question: *What is IC, how is it currently being interpreted and implemented in New Zealand and what are its educational benefits, costs and challenges?* Paragraphs 2, 3, 4, 6, 7, 9, and 12 provide answers to the second question: *What is the relationship of secondary mathematics education to IC; how is that relationship currently being managed in the participating New Zealand schools; can the two be mutually reinforcing, and if so, how?* Paragraphs 3, 7, 9, and 10 answer the third question: *How does standards based assessment (particularly the NCEA) constrain or afford the educational objectives of IC?* Paragraphs 3 and 7 to 12 provide answers to the final question: *What curriculum and assessment development strategies appear to have the most promise for nurturing the progress of effective integrated learning?*

1. The three participating schools represent unique and distinct examples of integrated curricula in practice: each reflecting its particular community and philosophical roots. Strong contrasts in approach were apparent among the schools with respect to the scope of integration, student centeredness of the curriculum, the emphasis given to assessment for qualifications relative to curriculum and pedagogical objectives, collegial collaboration structures, and resources devoted to IC development. The schools were widely distributed along the interdisciplinary continuum (introduced in section 2.1.3). Fibonacci High followed the most subject based version of IC. Gödel Grammar had the most transdisciplinary approach while Cantor College lay between its sister schools, closer to Fibonacci than Gödel.
2. Mathematics appeared to be a difficult learning area to integrate with the integrated studies disciplines. The mathematics/integrated studies divide was characterised particularly by the two learning areas contrasting orientations toward curriculum and assessment. For the integrated studies participants, curriculum led assessment: for the mathematics participants the reverse appeared to be true. The integrated studies participants for example, provided 75% of the integrated curriculum themes and contexts mentioned during the interviews while the mathematics participants emphasised the learning benefits of internal assessment methods that could meet formative and summative purposes. Other aspects of the integrated studies/mathematics divide included differing perceptions of student motivation, differing collegial collaborative styles, and interdisciplinary content linking and demarcation tensions, particularly between social studies and mathematics. Four of the seven integration themes mentioned by the mathematics participants however, belonged to the major theme group of *Communities, Social Justice and Local Issues*. At Gödel mathematics had been used in support of projects based on local community issues. These findings and the success in combining mathematical with critical literacy education reported by Gutstein (2006) in Chicago, suggest that despite the perceived difficulties in linking mathematics with the social sciences, this interdisciplinary relationship could be one deserving more attention in the New Zealand context.
3. Content demarcation tensions and linkage difficulties between learning areas were a recurring theme of the interviews. The integrated studies participants reported demarcation tensions among teachers of different subjects over which NCEA standards could be offered in which integrated courses. Teachers from both the integrated studies and mathematics learning areas reported difficulties in coordinating geography with mathematics around topics of mutual interest such as graphing, statistics and

trigonometry. Liz_{GM} commented that statistics at NCEA level 3, offered probably the best opportunity for mathematics interdisciplinary assessment in the upper senior school. Both Liz_{GM} and Brett_{GM} saw level 1 mathematics standards, particularly unit standards, as being amenable to interdisciplinary courses but considered all level 2 and most level 3 standards as covering too much specific content to be useful for integration.

4. All three schools reported some degree of difficulty in managing collegial collaboration associated with integrated curriculum. At Fibonacci, while most learning areas had some ongoing curriculum relationship to the integrated studies programme, the mathematics department did not. The mathematics participant at Fibonacci reported loss of mathematics lesson time, attributing it in part to students' involvement in integrated studies activities. At Cantor the high investment of teacher time in formal professional development meetings was considered vital to supporting IC development but also had its costs in terms of teacher fatigue and loss of valued extracurricular time with students, particularly for sporting activities. At Gödel the focus on learning advisers being highly accessible to students was reported as leaving insufficient time for collegial collaborative meeting required for programme coordination and consensus forming. Differing collaborative styles were also a key aspect of the mathematics/integrated studies learning areas divide.

5. This study confirmed that a number of features of integrated curricula reported in the U.S. literature were also apparent in the New Zealand context. Integration across learning areas became increasingly problematic at higher year levels. The humanities and social sciences (collectively referred to as integrated studies) were at the centre of the integrated perspective.

6. Learning gains were generally considered the main benefit of integrated curriculum. For the integrated studies participants these gains arose from having effectively more time with students which in turn led to efficiencies from overlap of content, broader formative assessment overview, and the synergistic effects of multiple interrelated learning opportunities. For the mathematics participants learning gains arose from opportunities to effectively demonstrate the real world relevance of mathematics and its relationship to other areas of the curriculum. The integrated studies teachers were positive about the motivational benefits of integration but the mathematics teachers were more equivocal.

7. The participants identified two main groups of challenges to the development of integrated curriculum: *Curriculum, Rigour, & Assessment*; and *Timetable and programme Coordination*. In the first group, *Appropriate Contexts and Themes* and *Rigour, Coverage & Assessment* were the main subcategories. In the second group *Timetable coordination* and *Student course continuity* were the main subcategories. The elaboration and refinement of appropriate contexts and themes to facilitate input from subject areas across the curriculum was seen by participants in both learning areas as a key strategy for IC development. Consistent with prior studies, participants reported a shortage of appropriate curriculum resources, materials and guidance for IC. This was particularly true for mathematics and especially at NCEA levels 2 and 3.
8. The coherence of integrated curriculum derives from the depth, relevance, and interrelatedness of its themes and contexts. Six major themes for integration were apparent across the schools participating in this study with three themes being common to all three schools. In descending order by number of items mentioned within each common major theme they were: *Social Justice and Local Issues*; *Sustainable Economics and Environment*; and *Biography, Self discovery and Change*. These themes are consistent with those generally associated with IC in the literature and are closely aligned with the social humanistic triad introduced in section 2.1.3.
9. The NCEA was seen as a largely positive development for integrated curriculum compared to the qualifications that preceded it. *Flexibility* arising from the standards basis of NCEA and the increased freedom it gave teachers to devise courses to fit student needs in the senior school was considered by participants at Cantor and Gödel to be the main positive impact of NCEA for IC. *Credit Counting*, and *Curriculum Fragmentation* (in that order) were considered to be the main negative impacts. The Cantor participants also commented on, what they considered to be, the misperception that unit standards are easier to achieve than achievement standards. Cantor students had a relatively high participation rate in NCEA unit standards. Participants also commented that the flexibility afforded IC by NCEA standards, while valued, was also limited. The main constraints to extending curriculum integration to higher year levels and to more learning areas mentioned were university entrance requirements, the disciplinary basis for combining external achievement standards in exams, and the difficulty of combining current mathematics standards with those in other learning areas such as geography. Participants considered that IC could be more readily introduced for students in non university-bound career pathways.

10. In the creation and implementation of new integrated courses Teachers' professional judgements were the key guiding factor integrating student interest, school structural constraints and the choice of NCEA standards to be combined. School wide processes for eliciting student interests had high priority at the introduction of integrated curriculum in a school. Participants reported that over time, student choice tended to become formally built into the programme and courses in specific ways. Eliciting student interests becomes a matter of individual teacher's sustained conscious efforts. Participants noted that the availability of trained staff capable of teaching and assessing particular combinations of subjects was also a determining factor in what new interdisciplinary courses could be offered.
11. The study participants were unanimous in their support for the introduction of integrated standards to NCEA which would enable assessment of students' capacity to integrate disciplinary and interdisciplinary content, values and skills through broader more generic assessment tasks. Support for the new forms of standards was however qualified with reservations about the technical and design challenges they presented. Participants commented that linking the proposed integrated standards to existing content specific standards, and exactly which links were made, would be critical to the success of broad-based integrated standards. They also gave support to the development of standards for the assessment of key competencies across the curriculum. These views—expressed in early 2007—were consistent with recent and current proposals for NCEA (Hipkins et al., 2005; Hipkins et al., 2007). They also anticipated aspects of recommendations for integrated curriculum assessment published during 2007 (Drake, 2007).
12. Significant convergence was apparent among the interview participants in terms of their visions for the development of the integrated and mathematics curricula. Professional development in all aspects of integrated curriculum—particularly for teaching and learning—and expansion of the scope of integration were the most frequently expressed aspirations of teachers from all three schools and both learning areas. Assistance in developing integrated assessment resources was a need expressed particularly by the integrated studies participants while more time for and assistance with the development of appropriate curriculum themes and contexts was most important for the mathematics participants. More attention to student mentoring and guidance was also a priority for the mathematics participants at Fibonacci and Cantor.

5.3 Discussion

5.3.1 Integrated Curriculum

The criterion most often employed in the literature to characterise various forms of integrated curriculum has been the emphasis given to traditional school subjects relative to transdisciplinary themes, as organising centres for curriculum coherence (Drake, 2007; Ferrero, 2006). Applebee et al (2007) describe this dimension of relative emphasis as the *interdisciplinary continuum*. Drake (2007) defines four IC instructional modes which effectively lie along this same continuum. From most disciplinary to most thematic they are: *fusion*, *multidisciplinary*, *interdisciplinary* and *transdisciplinary* curricula. Fusion is equivalent to what has been referred to throughout this thesis as intradisciplinary integration. According to Applebee et al integrated curriculum is an under-theorized field. The discussion of the following section seeks to extend the conceptualization of IC by building on the interdisciplinary continuum construct using insights gained from the present study particularly with regard to social factors.

The territory

Integrated curriculum and learning can be described as a broad unmapped territory. The literature provides a collection of explorers' stories and some helpful sign posts but no generally accepted 'how to get there' guide. In contrast to traditional curricula—which are increasingly burdened by demands for inclusion of content from the hidden or external curriculum (Print, 1993), worsening student attendance and discipline (Harrison, 2004), and persistent failure to meet the educational needs of certain socio-economic and ethnic groups within society (Anthony & Walshaw, 2007)—integrated approaches have been associated with improved student engagement, motivation and affective relationship to schooling, and more equitable outcomes for all groups of students (Boaler, 2006; Drake, 2007; Ferrero, 2006; Gutstein, 2006; Nolan & McKinnon, 2003). IC emphasises the essential interrelatedness of all things. It nurtures the human will to unify experience and integrate the totality of the self (Huber & Hutchings, 2004). Multiple points of view are upheld in sympathy with the postmodern assertion that no one culture can represent the unified totality of existence including and perhaps particularly, the dominant culture of the time.

Schools using subject based approaches to learning and those adopting integrated approaches occupy distinct regions of the educational landscape. In terms of Kaufmann's (1995) metaphor of evolution by adaptation on rugged fitness landscapes, we could imagine traditional subject based curricula as a local peak or a range of closely spaced peaks in the landscape of

educational possibilities. Integrated curricula (that incorporate the major integration themes and all subject areas) are another, separated from traditional approaches by what appears, to many educators, to be forbidding looking lowlands. Extending the metaphor, 'mount integration' is covered in cloud and there is no way of knowing either how high it is or where the best routes to the summit lie. The reports we have from current pioneering schools suggest that there could well be peaks of higher educational fitness, within that largely unexplored territory.

The situation could be illustrated as in Figure 1. This 'geographic' profile should be seen as a section through a larger 3 dimensional reality. Its horizontal axis represents the interdisciplinary continuum and its vertical axis, 'educational fitness'. The third dimension — that is, of depth—represents a continuum of social organisational possibilities, from rigidly authoritarian to permissively individualistic, as described in the following section. The horizontal extent of mount integration on the interdisciplinary continuum represents the region of intra, inter, and trans disciplinary curricula syntheses. Further to the right, beyond point 'E', lies the zone of purely transdisciplinary approaches. No examples of schools in this region have appeared anywhere in this study.

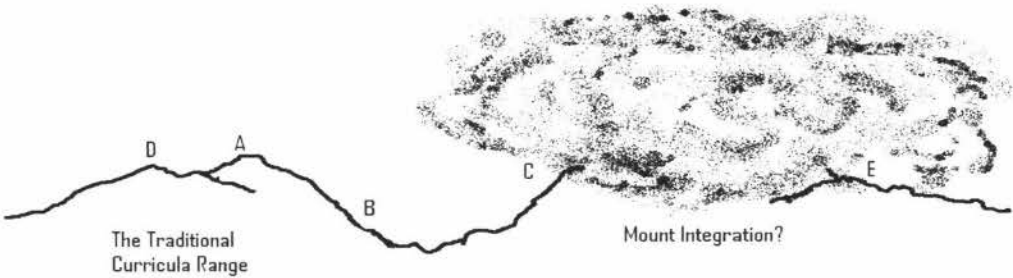


Figure 1 Adaptation on the rugged fitness landscape of Education:
The horizontal axis represents the interdisciplinary continuum from purely subject based curricula on the left to purely trans disciplinary on the right. The vertical axis represents 'educational fitness'.

Figure 1 is an impression, a working hypothesis drawn from a consideration of the data gathered from the schools participating in this study and from the literature reviewed. This hypothesis specifically challenges the conclusion of Applebee et al. (2007)—based largely on the integration of only English and Social Studies—that subject based and integrated curricula represent a continuum of more or less equally fit options each distinguished by a particular arrangement of educational compromises. The landscape pictured in Figure 1 allows for the

possibility that certain syntheses of curriculum, pedagogy, social process and assessment elements, could lead to schools of educational fitness greatly exceeding the apparent sum of the contributions of those elements.

A fitness landscape metaphor of course, raises the question of what exactly could be meant by the phrase *educational fitness*. Most educators might agree that an operational definition would include measures of scholastic-cognitive, social-affective and motivational-behavioural benefits. How to assess and combine these measures to arrive at an overall fitness value is problematic to say the least, since every community will have its own way weighting the factors. It is not the purpose of this discussion to embark upon that debate. Suffice it to say that some more or less equal weighting of the three factors mentioned above is intended in using the term *educational fitness*.

The evolutionary model of adaptation on rugged fitness landscapes can be applied to both genetically based changes in species of organisms and to technological and behavioural changes in human societies comprised of autonomous organisations, such as businesses or public institutions like schools. In most instances, individual entities differ from their parent entities by small exploratory differences within their landscape of possibilities. When a change leads to improved fitness it will gradually spread throughout the population. In this manner the group as a whole converges on high points of locally optimum fitness such as 'D' or 'A' in Figure 1. To discover more distant and potentially higher peaks requires greater risk-taking. There are always a few individual entities making far greater 'mutational' leaps. Such pioneering leaps are most likely to take explorers initially to points of lower fitness such as 'B'. There is also the possibility of arriving at points of more or less equivalent fitness, such as points 'C' or 'E' but on the lower slopes of a different, possibly higher, fitness peak. This new, more global optimum is then climbed, again by smaller incremental improvements. The availability of higher fitness peaks is itself a dynamic phenomenon dependent on the continually evolving topography of the fitness landscape.

Characterising the study schools

Although I will argue that it is insufficient by itself, the interdisciplinary continuum (Applebee et al., 2007; Drake, 2007) and the *traditional* versus *innovative* ideological divide (Ferrero, 2006) do describe some key differences among the three participating schools in this study. The three main types of instructional format on the continuum —*intradisciplinary*, *interdisciplinary* and *transdisciplinary*—were discernible in the timetables of all three schools, but in quite different proportions, as described in paragraph 1 of section 5.2. Approaches to assessment also

ranged from traditional to innovative. The scope of integration at Fibonacci High was strongly centred on English and the social sciences and excluded mathematics. The school's approach to assessment was traditional and its NCEA results, in terms of participation and numbers of standards achieved, lay close to the overall average for New Zealand schools (see Table 6). Fibonacci showed the least inclination to move from its current successful and refined position, possibly a point like that labelled 'A' in Figure 1.

The data gathered in this study do not permit a judgment on exactly where Cantor and Gödel currently lie in the landscape of Figure 1. Both schools have made major adaptations to the traditional subject based curriculum and are somewhere to the right of point 'A'. Cantor had instituted curriculum wide integration which, although still restricted largely to the junior classes, also involved the senior students by way of the termly three day programmes. The school also gave a high priority to NCEA participation and its achievement rate—at that time still only at level 1—compared favourably with the national average. The Cantor students were more involved in internal assessments than traditional external examinations (see Table 6). Students at Gödel had the greatest opportunity to custom make their own programmes and to attend integrated courses. Gödel deemphasised NCEA credit accumulation in favour of encouraging students to demonstrate initiative and to follow their own interests. The school's participation rate in NCEA was high—many students taking one or more standards—but the achievement rate per student was well below the national average (see Table 5).

The history of integrated curriculum at Fibonacci suggests that its journey may well have been something like a leap from 'D' to 'B' followed by a gradual retreat to 'A' in Figure 1. Teachers at both Cantor and Gödel also spoke of external pressures (parental, employer, tertiary institutions and governmental expectations), constraining, and sometimes forcing traditionalist compromises on, their vision of integrative learning. Either school might yet prove to have only reached some point like 'B'.

The interdisciplinary continuum characterises the three schools in terms of curriculum, assessment and instructional formats, but when their social characters are also considered, a more complex picture emerges. All three schools struggled in one way or another with the logistics of structured collegial collaboration, as detailed in paragraph 3 of section 5.2. The integrated studies/mathematics divide also had a distinctive expression in each school, strongly characterised by the differing social styles of the teachers in the two disciplines. These findings suggest that a second, *social* dimension is required in addition to the interdisciplinary continuum, to adequately describe whole-school integrated curriculum configurations. The social dimension is of course present in any school community but is of particular significance

where IC is established or being developed. The rights-relational and spirit-cultural spheres of social life are of higher priority by virtue of the humanistic triadic principles of the curriculum itself: the major theme group for integrated study most often mentioned by participants in the present study was *communities, social justice and local issues*. Teachers of IC arguably have a greater responsibility to model harmonious social processes for students. The development needs of IC also place an added professional burden on teachers both for creative collaborative work and for socially oriented pedagogical skills.

Kauffman (1995) offers the *patch* form of his NK landscape model as a way of characterising social networks in terms that could be helpful in understanding how secondary schools with their subject based departments manage, and are driven by social dynamics. In what he calls the “Stalinist” limit of this model, all elements (in this case the teachers) are linked to all other elements so that no change can be made unless the outcome is shown to be beneficial for the whole organisation. The result is that the organisation rapidly finds a local fitness peak within a small region of the whole adaptive landscape and remains there permanently. At the other extreme, which Kaufmann calls the “leftist Italian limit”, every element accepts any change if it suits them, with no reference to the consequences for any other part of the organisation. In this limit, change is continual and no fitness peaks for the whole organisation are ever collectively recognized or become stable. The optimal evolutionary strategy he maintains is found when the organisation is “patched” into a number of components of some optimal size and with the optimal number of interdependent links to neighbouring patches. Each patch accepts or rejects changes only with reference to its own advantage and in so doing can alter the landscape for its neighbours and thus decrease or increase the overall fitness of the organisation. Kaufman’s research shows that such patched structures tend to move away from poor local fitness peaks and rapidly converge on more global fitness peaks for the whole organisation. The key question for secondary schools is: Are subject based departments, with their existing patterns of interdepartmental collegial links, the optimal organisational patching strategy? The evidence from integrated schools both in this study and reported in the literature suggests the answer might well be ‘no’.

In terms of Kauffman’s (1995) social patch model Cantor appears to be to the authoritarian Stalinist side of centre and Gödel to the permissive leftist side with Fibonacci somewhere between but closer to Cantor. Fibonacci appears to have reached a locally optimal, restricted version of integrated curriculum, appropriate to its community and present staff. Cantor and Gödel are very much in the pioneering phase of development, energetically seeking to address identified challenges in pursuit of an ideal of innovative integrated education. That they have

younger relatively less experienced teachers in positions of responsibility may well be related to this pioneering status.

Adaptive landscapes are not static (Kauffman, 1995). They are continually moving and reforming in response not only to environmental factors but also in response to the movements of the evolving entities themselves. The literature provides evidence that the educational fitness of the traditional disciplines 'range' is less than ideal and may in fact be steadily eroding (Anthony & Walshaw, 2007; Harrison, 2004). At the same time, Kauffman's model implies that the height of 'mount integration' is likely to increase if more schools adopt and persevere with integrated curriculum, as a result of the new resources they will generate and the mutual support they are likely to provide for one another.

The Triadic Fractal Worlds model: a proposed interpretive map of the terrain

The lack of a coherent theoretical structure and developmental guidelines was identified by this study's participants and in the literature (Applebee et al., 2007) as an important constraint to progress in developing integrated curricula. The literature on integrative learning, (particularly Drake's (2007) KDB model and Steiner's (1996) threefold social order) is strongly suggestive of a triadic humanistic basis for a more general IC structure. In this section a hierarchical conceptual framework for the interpretation and elaboration of IC, named the Triadic Fractal Worlds (TFW) model, is proposed. The structure is fractal in that it shows self similarity at all scales: that is, the hierarchy can be extended indefinitely (in principle) both to higher and lower strata and the same three fundamental conceptual elements appear within every node and at every stratum.

The TFW model is based on the notion that human individual or collective entities are composed of three clear but deeply integrated and inseparable elements. In the healthy identity the three elements work in an effective harmony. The elements have particular expressions which depend on the stratum in which they appear. At the stratum of the individual, for instance, they are the *cognitive*, *affective* and *psycho-motor* (CAM) faculties. At the collective or social stratum the elements appear as the *spirit-cultural*, *rights-relational* and *environmental-economic* (SRE) spheres. Each node in the TFW structure represents an identity³⁶.

³⁶The structure can also be thought of as having the property of *integrity* at each node relating to on how tightly bound the node is to others around it. Not all nodes are of equal integrity.

Figure 2 shows how the structure may be applied to a mapping of integrated curriculum from the stratum of the education sector as a whole down to teaching and learning within individual secondary school classrooms. From a top-down perspective³⁷, curriculum implementation begins at the stratum of student career pathways (as described for NZ schools by Hipkins et al., 2005) and applies to the whole school teaching programme, to whatever extent a particular school's senior classes are in fact organised in this manner. At junior levels it may not apply at all. Each pathway would have the possibility of a timetable involving courses in all three of the curricula SRE themes, in proportions appropriate to that pathway, student year level, and school context³⁸.

The stratum of curricula SRE themes describes the organisation of integration themes and contexts within each career pathway. Table 12 shows how the integration themes and contexts arising from this study (as shown in Table 10) may be related to the curricula SRE categories. The variety of projects and contexts for integration used at the three participating schools and mentioned in the literature on integrated curriculum suggest that the ways in which these theme categories could be used by teachers as the basis for generating new IC courses is effectively endless.

Table 12: Integration themes from study schools organised by Triadic Fractal
Worlds categorisation of social spheres.

| Theme Category | TFW social spheres |
|---|-------------------------|
| Communities /Health and Home Biography/Self discovery/Change ³⁹ | Spirit & Culture |
| Social Justice/Local Issues | Rights & Relationship |
| Sustainable Economics and Environment Entrepreneurship Computer Games, Graphics and e-commerce | Environment & Economics |

³⁷ Planning or implementation could in reality start at any node of the TFW structure and proceed simultaneously in several.

³⁸ Strictly speaking the arrows in Figure 2 should all point to separate nodes in the subordinate stratum. Overlapping nodes have been used in the diagram for economy of space

³⁹ The major theme categories shown bolded appeared in the programmes of all three schools.

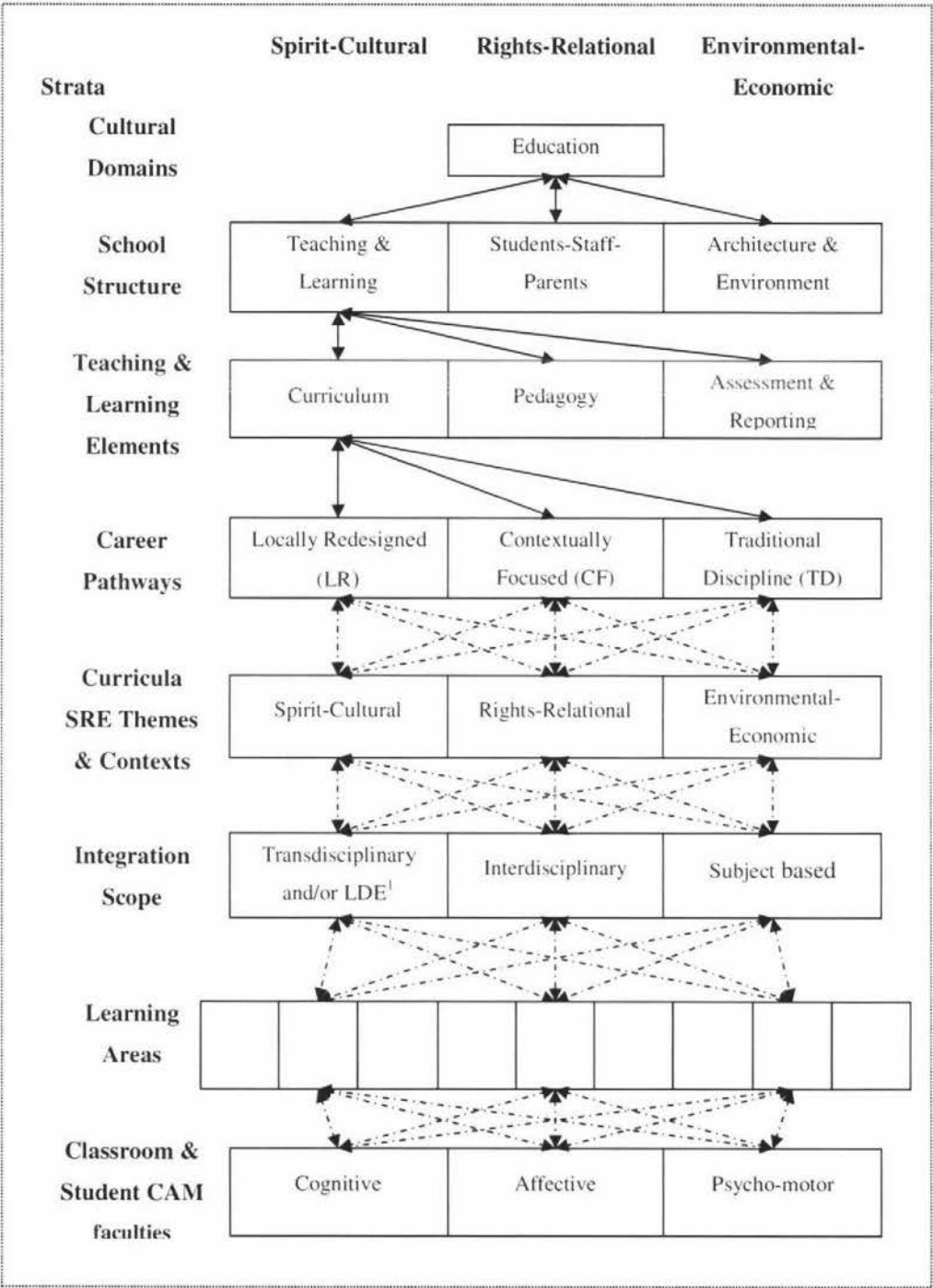


Figure 2 The Triadic Fractal Worlds (TFW) model for integrated curriculum: showing seven strata from the domain of education down to the classroom and individual student faculties. (1. LDE means ‘Learner Directed Experience’)

Gustein (2006) for instance, strongly recommends the development of community knowledge by teachers' personal outreach and research in the community of the school as part of constructing a locally relevant social justice curriculum. Students could be encouraged to celebrate festivals and to display artefacts from their culture as an integral part of the school life and environment: an option particularly appropriate for schools with ethnically diverse communities. Sports and their role in global social justice/relational equity issues could be a fertile ground for IC development in schools with a strong sporting ethos.

Issues of sustainable economics and environment have arguably the greatest immediate potential for engaging students at all levels. There are many ways in which education for sustainability could be built into school life. Amongst the various sustainability aware design features of the architecture at Cantor College for instance, there has been included a very visible outdoor atmospheric CO₂ monitor, bringing the issue of global warming continuously to the students' attention. Schools could measure their own dependence on unsustainably produced imported materials and energy to raise student awareness of how involved they are in this global interdependence. Some degree of sustainable localised self sufficiency could also be aimed for as an on-going, whole school, trans-disciplinary project.

Education outside the classroom is an aspect of curriculum emphasised by the ideal of cognitive, affective, and psycho-motor balance implicit in integrated learning. Environmental study field trips to motivating and challenging but remote locations are of high educational value. They can also be prohibitively expensive if the funding burden falls to parents or students own private sources of income. School subsidised, student businesses however have also been identified in this study as potential sources of quality learning and—to a limited extent—as potentially revenue generating. Could these two integration themes themselves be integrated for mutual reinforcement? For example, students could be involved in supplying healthy produce from school gardens to the school cafeteria with earnings and profits being directed by the students and the school to subsidising field trips.

The stratum of integration scope in the TFW model shows how, once a new course or programme has been situated within a particular SRE theme group, consideration must be given to the mix of instructional modes that will be used to deliver it. In a school wide IC design, every teacher's year plan would contain courses for which they are solely or collaboratively responsible, based on themes from the three social spheres (S, R & E) in some proportion, distributed across subject based lessons, interdisciplinary courses and transdisciplinary projects. Timetabling and programme planning at this stratum needs to harmonise three competing demands: student choice, individual student programme coherence, and manageability for the

school in terms of resource tracking, availability, and utilisation. Care would be needed to avoid at one extreme the rigidity of traditional programmes and at the other the unmanageable, possibly aimless proliferation of options generated by very innovative timetables. No participating school in this study appeared yet to have ideally resolved this overall timetabling-programming problem which all acknowledged as a significant challenge for IC development. Pilcher & Philips (2006) report that achieving this balance has in fact become a major challenge in all New Zealand secondary schools as a result of the curriculum flexibility introduced by the NCEA.

The stratum of the learning areas in Figure 2 is shown below the stratum of integration scope to suggest that in an integrated curriculum, decisions about the balance of instructional modes for a particular programme at a particular year level could have priority over the choice of learning areas to be involved. The reverse situation would apply however in a bottom-up approach to planning and in reality the details of a programme would most likely be developed in both strata concurrently. More importantly, Figure 2 shows that the nine learning areas⁴⁰ could contribute to integrated courses through quite different mixtures of subject based, interdisciplinary and transdisciplinary modes of instruction. This stratum appears to break the triadic pattern of the TFW structure. It may be possible however to conceive of the learning areas in three groups of three more closely related disciplines: for instance: mathematics, science, and technology associated more with *Environment & Economics*; social science, English, and arts associated more with *Rights & Relationship*; health and physical education, Te Reo, and other languages associated more with *Spirit & Culture*. These associations of disciplines need not prevent any subject contributing as needed to any integrated programme based on any of the SRE major themes.

The stratum of the CAM faculties finally serves to remind teachers to maintain a balance through the students' day and in each lesson among cognitive, affective and psycho-motor activities. This would probably mean more social, artistic, and out of classroom education but also acknowledges the need for quiet, inwardly focused spells as well.

⁴⁰ There are eight learning areas defined in the New Zealand Curriculum (Ministry of Education, 2007) The ninth is *Specialist Studies* which is part of the New Zealand qualifications framework. Unit standards from this learning area are taken by many secondary school students.

The TFW structure as a comprehensive mapping and planning instrument for integrated curriculum has a number of important features.

1. It puts healthy student identity formation through intentional learning and holistic development at the centre of the education
2. It acknowledges the importance of current career pathways through senior secondary school but offers the possibility of shifting the emphasis of student programme planning in a controlled way toward the SRE social spheres in all pathways, as an increasingly important organising principle.
3. It offers a systematic basis within which limitations and guidance can be balanced with motivational freedom and choice in students' programme construction.
4. It offers a balanced framework for generating and organising integrative themes and contexts and relating them to the traditional disciplines.
5. It provides a structure for standards based assessment of IC and future development of the NCEA standards (as elaborated in section 5.3.3).
6. As a system it operates on a simple general principle which can be extended by any educator at any level of the hierarchy.
7. It is extremely flexible. There are no prescribed degrees of emphasis on any component. Users can adapt and extend the expression of the structure to their community context. It continually reminds the user however of the ideal of balance to be achieved among the three fundamental elements in all strata.
8. It is ideologically comprehensive in that it acknowledges and can incorporate the five main curriculum conceptions—academic rationalist, humanistic and social reconstructionist (Print, 1993)—and offers a means for utilising their strengths as well as compensating for their weaknesses.

5.3.2 Integrated curriculum and mathematics

Five strong impressions of the relationship between mathematics and integrated curriculum have emerged from the current study which confirm and extend findings on the nature of mathematics education and its relationship to integrated curriculum reported in the literature. First, the gulf between the central IC disciplines and mathematics is large and possibly greater than that between IC and most other disciplines in the traditional subject based secondary school curriculum⁴¹. Second, the greatest gains in terms of student motivation, attitude and

⁴¹ Subjects specifically mentioned by participants in connection with integrated curriculum included mathematics, science, English, history, geography, social studies, the visual arts, physical education, health and Te Reo Maori. Subjects not mentioned included languages other than English and Te Reo Maori, drama, and dance.

mathematical mastery from integration are likely to come from developments in the rights-relational sphere of the Triadic Fractal Worlds structure (see Figure 2). Third, for mathematics educators wishing to pursue integrative learning and curriculum, the greatest initial gains are likely to come from *intra* disciplinary integration. *Inter* disciplinary coordination is then likely to be productive particularly with the sciences and social sciences, in pursuing environmental economic and social justice themes. Fourth, mathematics has a stronger connection with summative product oriented assessment systems, than with official curriculum statements, as a point of reference for educational direction. Assessment that combines formative and summative purposes—particularly in peer group oriented settings—appears to have great potential to move mathematics beyond its traditional role as socio-economic gate-keeper toward increased support for and benefits from integration with other learning areas and real world contexts. Fifth, an effective generally available transition from a traditional perspective to an IC perspective in mathematics would require significant commitment of resources including curriculum development, teacher professional development, and associated developments in mathematics NCEA standards.

Mathematics teachers' authority and the disciplinary divide

Secondary teachers, particularly of mathematics, enjoy considerable authority within their own subject areas (Amit & Fried, 2005). The present study has shown however that this authority tends to be strongly circumscribed by established social expectations, to teachers' designated areas of subject expertise. Teachers' attempts to extend their authority to other subject areas in the course of introducing curriculum integration can meet firm resistance. In the present study Anne_{GI}, Jane_{CI} and Liz_{GM} all mentioned students' preconceptions of what "actual" mathematics is and where it belongs (not in Geography lessons for instance) as being hurdles to overcome in teaching mathematics from an integrated perspective. Jane_{CI} also perceived parent and teacher perceptions of mathematics as problematic in this regard. Teachers of integrated curriculum could be seen as reclaiming the mantle of deep knowing associated with the traditional archetype of the wise teacher or seer. Such a role redefinition directly opposes the modern trend of deskilling in many crafts and professions like teaching (Apple, 1981) and demands from society the recognition of greater authority and respect. Such an authority and offering of trust it seems may have to be earned with perseverance over time rather than simply asserted.

Perhaps the most effective strategy teachers of integrated curriculum have for redefining their roles and the scope of their authority is collegial mutually supportive professional development and solidarity. The importance of collegial collaboration was acknowledged at all of the participating schools in this study. While Sarah_{FI} reported effective and energising

collaboration within the integrated studies department at Fibonacci, none of the schools had achieved this ideal on a school wide basis. The successful experiences of IC reform reported from Hersey (Ferrero, 2006), Railside (Boaler, 2006) and Rivera (Gutstein, 2006) in the U.S. all attest to the importance of collegial clarity, solidarity and perseverance when introducing significant reforms to schooling. As suggested by Walshaw and Anthony (in press), greater attention to teachers' individual interpretations of educational reforms may be required along with a greater emphasis on consensus building and collaborative networks. This attention has special significance for IC due to the extent of the reforms being attempted and their dependence on both individual teacher creativity and mutual understanding.

The role change implied by integrated curriculum for mathematics teachers includes both teachers' personal authority relationships with students and the evolving nature of the authority of mathematics itself in society. These are changes that mathematics teachers at Cantor College and Gödel Grammar recognised and were actively pursuing. Amit and Fried (2005) recommended that mathematics teachers adopt a new attitude toward their authority in the classroom which they called revised or anthropological authority. They liken this authority to that between the medical student and the doctor: it transforms as the student progresses from novice to eventually becoming a colleague. Teachers, they maintain, must learn to bend to the will of the student to some degree without themselves losing authority. A similar transformation, it could be said, is occurring in society at large between the general populace and the discipline of mathematics. The certainty associated with the Newtonian physical conception of reality resting on the authority of mathematics (particularly calculus) is progressively being displaced by an evolving consciousness of the relativistic-quantum description of nature in which probabilistic mathematics plays a much larger part. The investigative work of climatologists, biologists, and social scientists into the evolution of complex systems using modern computing power has both extended the sophistication of mathematical modeling and increased awareness of the limits of mathematical prediction for real world dynamical systems. Mathematics education is integrally involved in these developments: the technological sophistication required of senior school mathematics students for instance, is steadily increasing. ICT supported statistics was suggested by Liz_{GM} in the present study as having the greatest potential for curriculum integration with NCEA standards at senior levels. ICT powered statistical mathematics is ideally suited to the investigation of large socio-economic and natural resource data sets. It stands as a bridge between the real world of complex multifaceted phenomena and pure mathematics. In the conceptual network of mathematics, the understanding of statistics depends and calls on a knowledge of all strands of the secondary mathematics curriculum—number, measurement, algebra, geometry, trigonometry and calculus—in a way that those strands do not depend or call upon statistics.

Statistics may offer mathematics teachers their most important opportunity to actively lead the changing authority role of mathematics in society.

The social sphere in mathematics

This study has found, that of the three integrated curriculum SRE theme groups shown in Figure 2 it is the rights-relational group which may have the greatest potential to improve learning and engagement in mathematics. It could also be a most effective avenue for addressing the negative consequences of the subject's socially assigned gate-keeping role in education, particularly in combination with dual formative-summative assessment tasks. In the present study Greg_{CM}, Liz_{GM}, and Brett_{GM} all supported the use and development of group work and group assessment in mathematics. The learning value of peer to peer group oriented assessment in mathematics is supported also in the literature (Boaler, 2006; Rawlins, 2007). Mathematics was used at Gödel to support integrated projects related to local community political issues but this possibility was not mentioned at either Cantor or Fibonacci. The success with social justice themes in mathematics reported overseas by Gutstein (2006), suggests that student group work in mathematics and the relationship between mathematics and the social sciences could deserve more attention in the New Zealand context. It is interesting to note that four of the seven integration contexts mentioned by the mathematics participants in this study belonged to the *Communities, Social Justice and Local Issues* group of themes (see Table 10). A number of implications for the development of IC follow from these findings and recommendations.

Research into the beliefs of mathematics teachers—with respect to social justice issues and social process within the classroom—would contribute to our understanding of the potential for integrated curriculum across all subject areas in New Zealand secondary schools. The literature on secondary mathematics teachers' beliefs and practices indicates a dearth of integrative practice designed to engage students' affective, social and psycho-motor faculties. There appears to be little appreciation of the potential advantages to students' mathematical progress from greater attention to these faculties. Professional development in the management of small group learning and peer assessment practices supported by on-going research—most likely within a collaborative framework—would be an effective way of assisting those mathematics teachers wishing to progress in their use of IC.

The practice of ability or career pathways streaming, particularly favoured by secondary mathematics teachers (Archer, 2000) is potentially an issue of social justice. In an integrative learning setting this is not a simple one solution issue. Classes at Fibonacci and Cantor were ability streamed while Gödel encouraged heterogeneous classes with students self selecting

according to their interests and prior learning. Ferrero (2006) suggests that providing students spend a high proportion of their time in heterogeneous classes for interdisciplinary learning then ability grouping in subject based lessons may have largely beneficial effects. This is another question for further research.

The divide between mainstream mathematics and developments in integrated curriculum can be seen from several points of view. For many traditional educationalists, pure mathematics represents perhaps the highest standards of human rational abstract thought. Detached from the destructive irrationality of politics, the relativism of human values and the vagaries of fashion, it could be seen as the anchor that stabilizes the frantic and accelerating pace of change in education. For advocates of integrative learning the traditional gate-keeping role of mathematics assessment in schooling, ostensibly required for the maintenance of standards, could arguably be seen as a lynch pin holding in place the subject based curriculum and the materialistic economic and social system it supports. From this point of view, the attachment of mathematics to its gate-keeping role is constraining a long overdue revolution in education: a revolution in which mathematics itself must play a vital but new part. A third possible point of view also emerged in the interviews for this study. If mathematics education does not take a wider view of its relationship to issues of integration and social justice and a more urgent approach to change, it may find itself increasingly marginalised. Teachers developing integrative courses in other disciplines may simply appropriate more and more of the mathematics they need—such as ICT supported graphics and statistics—to support their own programmes, thus treating traditional senior mathematics programmes as irrelevant.

Intra and inter disciplinary integration in mathematics

Both the work on relational equity of the teachers at Railside reported by Boaler (2006) and Gutstein's (2006) work in social justice at Rivera show how much can be achieved following an integrative approach to curriculum and learning entirely within the discipline of mathematics itself. In his interview, Brett_{GM} expressed the view that interdisciplinary integration was less effective for improving student motivation in mathematics than if teachers simply taught mathematics better. His examples of "better" however, included more use of holistic real world experiences as starting points for conceptual learning and a greater emphasis on group processes and peer assessment in mathematics: effectively intradisciplinary pedagogy. The support of the mathematics participants at both Cantor and Gödel in this study, for greater development of inquiry based learning, group work and peer assessment, recommends practices fostering relational equity in the classroom as a high priority for intradisciplinary integration in the subject.

The difficulties reported by participants from both learning areas—when attempting to introduce content from the social sciences into mathematics or vice versa—suggest that social justice themes for integration might best be approached as a direct interdisciplinary collaboration between mathematics and social science teachers. This suggestion accords also with David_{GI}'s view quoted in section 4.3.2 that subjects are best combined in pairs for assessment and Gutstein's (2006) comments about the eventual need to involve teachers from other disciplines when teaching mathematics for the development of critical literacy.

The mathematics participants in the present study pursuing integrative practice (Greg_{CM}, Liz_{GM} and Brett_{GM}), reported feeling constrained by the lack of compelling integrated curriculum materials for mathematics and the lack of guidance or an overall coherent structure for undertaking curriculum development planning. The TFW model introduced in section 5.3, applied to New Zealand mathematics curriculum strands, offers a possible starting point for planning curriculum integration. Both the accounts of the integration contexts used by this study's mathematics participants and the literature on real world connections for mathematics, suggest that the three curriculum strands—geometry and measurement, statistics and probability, and number and algebra—could be productively aligned with the three SRE major theme groups—spirit-cultural, rights-relational, and environmental-economic—respectively. This alignment also suggests a starting point for the development of broad-based NCEA standards and big assessment tasks in mathematics.

Resource support for integrated curriculum development

The likely extent of the investment required for development of effective integrative curricula in mathematics has already been noted (in section 2.2.2). In the participating schools of the present study, lack of adequate funding was noted as a particular constraint to on-going curriculum innovation and the additional demands on teachers own time were also considerable. The energy, time and resourcing required for IC development cannot be expected to come from schools alone—particularly those struggling to win community support for ground breaking reforms. Sector agencies, additional funding, and researchers all need to be involved if the integrated curriculum approach is to be trialled in a valid way. There could also be a place for public-private sector partnerships in the development of integrated curriculum and assessment resources. Without a sustained, in-depth, broad-based approach to planning and implementation the end result may only be curriculum trivialisation and eventual retreat to familiar subject based teaching and learning, rather than integration. This is no doubt true for all disciplines but is arguably particularly relevant in mathematics as a result of its historic gate-keeping role in the

subject based curriculum and self imposed, self containment as a discipline. The expense is justified to the extent that—as has been argued in this thesis—the relationship of mathematics to high-stakes assessment represents a ‘lynch pin’ currently constraining but potentially affording realisation of the full benefits of curriculum integration.

We are faced with a catch-22 situation. Integrated curriculum initiatives can’t justify more funding without results but without sufficient, accurately allocated funding, they may never be able to demonstrate their full potential. Schools that adopt integrative learning and curriculum have a vested interest and a key role in public education about, and advocacy for, the reforms they are attempting. Funding agencies need also to acknowledge this additional burden.

5.3.3 Integrated curriculum and assessment

For developers of integrated curriculum, high stakes summative assessment of student achievement is a fundamental issue for three reasons. First, professionalism: teachers cannot indulge their own experimental curriculum creativity if students as a consequence fail to gain recognised qualifications for further study and/or employment. Second, resources: IC will not attract the resource funding and professional development interest it needs if it cannot persuade sceptics. A key component of that persuasion is meeting mainstream educational assessment standards. Third, assessment evolution: the qualification system itself must be better utilised and evolved to adequately recognise the additional achievements and wider goals of IC.

Evolving the NCEA: Broad-based Integrated Standards

The NCEA has provided teachers with course design flexibility and students with recognition for important achievements unacknowledged by the previous qualifications system. Participants in this study from all three schools welcomed the modularity of NCEA as particularly positive for integrated curriculum but also commented on negative impacts of the qualification including, credit counting, curriculum fragmentation, exacerbation of the academic/vocational divide, restrictive university entrance requirements and the lack of interdisciplinary compatibility of level 2 and 3 mathematics standards. Developments along the lines of the broad-based, integrated standards (BBIS) proposed by Drake (2007) specifically for IC, and by Hall (2005) for discipline based integration within NCEA, offer promise in addressing aspects of these negative impacts.

The proposals for the introduction of BBIS to the NCEA were welcomed in principle by all participants in this study although most also voiced concerns over technical and educational

challenges they saw as associated with the design and implementation of BBIS. These challenges included the relationship of BBIS to: the themes and contexts of IC, existing standards, credit values and grades, and student pathways including external examinations and university entrance requirements. Participants also supported the concept of new standards to assess the New Zealand curriculum key competencies across different learning areas. They had few suggestions as to how such standards might be written however. This appears to be a potentially fruitful direction for future SBA research. The present discussion treats key competency standards as a special case of BBIS without further consideration of their specific design challenges.

The appearance in 2008 of the Education for Sustainability (EfS) achievement standards (Ministry of Education, 2008) signals a move to establish broad-based, potentially transdisciplinary, standards within the NCEA assessment framework. The EfS standards align closely with major themes and contexts of integrated curriculum through the SRE stratum of the TFW curriculum model of Figure 2. Table 13 shows how the 6 level 2 EfS standards might be aligned with the SRE categories. The purposefully generic nature of these standards however—particularly standard 2.6, *Future scenario*—means that each could accommodate elements of all three SRE categories.

The relationship between BBIS and specific existing standards was mentioned as critical to the success of BBIS by three of this study's participants and is also specified by Drake (2007) as a vital design element in standards based assessment for integrated curriculum. Drake makes a key distinction between broad-based standards and what she calls *concrete* standards. Concrete standards are relatively narrow based standards, of well defined and limited scope, dealing with specific skills, competencies or content. "An important characteristic of a broad-based standard is that many more concrete standards fall under it" (ibid., p. 77). For the purposes of this discussion I have used the term *base* standard rather than *concrete* to specify the context of NCEA, but the concept is essentially the same.

Table 13 Education for sustainability draft L2 achievement standards (Version 8, Dec 2007) aligned with the social level of the Triadic Fractal Worlds model for integrated curricula themes and contexts.

| | | |
|------------------------------------|-----------|--|
| Environmental -Economic | (2.2) | “Biophysical” (internal). Describe the consequences of human |
| | 4 credits | activities within a biophysical environment in relation to a |
| | 90811 | sustainable future |
| | (2.6) | “Future scenario” (internal). Work co-operatively to develop |
| Rights- Relational | 3 credits | and present a strategy or design for sustainability in response |
| | 90815 | to a future scenario |
| | (2.1) | “Action” (internal). Plan, implement and evaluate a personal |
| | 6 credits | action that will contribute towards a sustainable future |
| Spirit-Cultural | 90810 | |
| | (2.5) | “Ecoliteracy” (external). Describe aspects of sustainability in |
| | 4 credits | relation to a sustainable future |
| | 90814 | |
| | (2.3) | “World Views” (external). Describe world views, their |
| | 4 credits | expression through practices and activities and the |
| | 90812 | consequences for a sustainable future |
| | (2.4) | “Values” (internal) Describe values and associated behaviours |
| | 3 credits | in relation to a sustainable future. |
| | 90813 | |

Specific links between BBIS and base standards would place limits on the NCEA’s current theoretical flexibility and might not be welcomed by schools with a preference for high levels of student choice and innovation. At the same time, the advantage of being able to credit holistic and interdisciplinary outcomes and to offer greater programme guidance to those students who need it, might more than compensate for some degree of programme limitation. The prescribed linkages could also allow for alternative combinations of qualifying base standards. The value of linking BBIS to specific base standards is chiefly related to reliability and validity in assessment. Without these linkages the necessarily broad, generic descriptors of BBIS are likely to lead to extremely diverse interpretations of the standard—in different schools, different learning areas and by different teachers—which would confound the process of moderation and undermine the notion of an objective standard. The base standards also ground the abstract, general nature of BBIS in specific, current contexts, content and skills.

The NCEA now includes standards with a wide variety of scopes ranging from highly specific level 1 unit standards through broad subject based research standards⁴² up to the EfS achievement standards which are potentially interdisciplinary or transdisciplinary BBIS. This spread of scope raises the possibility of linking BBIS of the widest scope to other BBIS with more limited perhaps subject based scope which are in turn related to a number of base standards. The introduction of new BBIS and the establishment of appropriate integrating linkages would most likely need to be a matter of gradual organic development involving continual dialogue amongst teachers, developers, researchers, students and school communities. Performing a comprehensive scan and cluster mapping of the whole curriculum (as suggested by Drake, 2007) and having a conceptual framework for integration, such as the TFW structure would appear to be useful starting points.

The NCEA's shortcomings most obviously and directly focused on by the integrated standards proposal are curriculum fragmentation and to some extent also credit seeking. The effect of BBIS on the latter will depend on how they are built into the overall qualification and the credit value they are given. Strategies such as higher grade endorsement for achievement of BBIS or regulations requiring a certain minimum number of credits from BBIS for award of the NCEA could also be adopted. Consideration might also need to be given to increasing the overall number of credits required for the NCEA at the various levels and to whether BBIS can be awarded independently of the base standards to which they relate.

Two key issues cannot be addressed simply through the introduction of BBIS to the NCEA, although BBIS could contribute to their longer term solution. The first is the relationship of university entrance requirements to the use of interdisciplinary BBIS. In many ways secondary integrative learning awaits corresponding developments in tertiary integrative learning. However, a large proportion of senior students belong to the *locally redesigned* (LR) and *contextually focused* (CF) career pathways, in which integrated curricula are not limited by university entrance requirements or external examinations to the same extent as they are in the *traditional disciplines* (TD) pathway. An examination of the data provided by Ferral (2005) for the eight year eleven clusters identified from the *six learning curves* study schools (Hipkins et al., 2005) suggests that around 45% of New Zealand year eleven secondary students might be following either LR or CF pathways. This estimate is clearly subject to a wide margin of error and should be seen as indicative only. However the potential initial 'market' for IC appears to be significant. BBIS could also offer a means for beginning to bridge the academic/vocational divide currently related to the distinction between unit standards and achievement standards in

⁴² Such as the level 2 achievement standard, 90705; Carry out and present geographic research with consultation

the NCEA. Providing they are designed entirely as achievement standards and all or most unit standards are linked formally to at least one BBIS, then BBIS would provide an alternative route to achievement standard credits and grades for LR and CF pathway students. Unit standards might also gain value for TD pathway students through this association.

The second key issue unresolved by BBIS concerns their compatibility with current base standards and the base standards compatibility with one another in interdisciplinary combinations. The success of interdisciplinary BBIS could well depend on the revision of current and/or the creation of new base standards specifically for SRE aligned integrated curriculum. In a sense, conceptual fragmentation of the mathematics curriculum for instance may need to go further than the level of current base standards. It may be necessary to unpack some existing base standards and then recombine their sub topics, skills, and content relationships by linking them to interdisciplinary BBIS, which are in turn related to the major SRE IC themes and contexts. Such new base standards for IC could coexist with the present discipline oriented base standards in the qualifications framework as mutually exclusive alternatives just as do the current CAS mathematics achievement standards⁴³.

The introduction of new base standards aligned with interdisciplinary BBIS could prove the most effective means of redefining courses in the TD career pathway to support integrated curriculum. Parallel external examinations for instance could be designed to cater for interdisciplinary big assessment tasks and BBIS, linked entirely to groups of SRE aligned base standards, including external achievement standards. Two of the current EfS standards are in fact externals. Even with these significant developments to current NCEA standards, TD students in integrated programmes might still have to achieve more than the minimum number of total credits to gain university entrance. Integrated programmes could therefore be most attractive initially to only a relatively small group of self directed and highly motivated TD students.

BBIS have the potential to place greater emphasis on the SRE themes and contexts across all three career pathways both within and across disciplines. This shift of emphasis could contribute to a longer term softening of the current vocational/academic divide in secondary schooling and lead eventually to the emergence of new career pathway variants appropriate to an evolving knowledge and *sustainability* based economy.

⁴³ For instance; CAS 2.1: AS90806 *Demonstrate an understanding of mathematical relationships* which is mutually exclusive with the standards AS90284, AS90285, AS90290, or AS90292 (Mathematics 2.1, 2.2, 2.7, and 2.9)

Clustering the existing base standards

Drake (2007) recommends a document search based approach which she calls scan and cluster, for the grouping of the base standards under BBIS and the relating of these BBIS to big interdisciplinary assessment tasks. Such an approach has the advantage of incorporating educators' professional expertise and insights at every stage of the process. There are however a very large number of standards to consider. In the 2006 NCEA results database there were over 3,400 level 1 to 3 standards. Given the proposals above to create BBIS (which could mean dozens of additional standards) the number of possible groupings required becomes extremely large. It would seem sensible given the complexity of the task proposed to make use of two additional approaches to inform the process of clustering existing base standards.

First, survey research into teachers current and increasing practice of combining standards from different learning areas into single courses or assessment events, as reported by Hipkins et al.(2007) and Pilcher & Philips (2006), could be maintained on an ongoing basis in high schools across the country. In this way a record of best practice from professional experience (and suggestions for improvements) would be built up as it occurs. This research would also provide information on how rapidly and to what extent schools in New Zealand are moving to adopt integrated approaches to curriculum and how the landscape of educational possibilities in this country is changing.

Second, current NCEA databases could be explored statistically for patterns in student subject and standards participation and the extent to which potential interdisciplinary combinations of high participation are already apparent in those patterns. A database statistical analysis would have a number of outcomes useful for informing document based scan and cluster approaches to linking standards.

1. It would extend the cluster analysis research of Hipkins et al. (2005) on student subject choice patterns and career pathways from their relatively small sample of 6 schools to potentially all secondary schools and students in the country.
2. It would allow not only association of student subject choice clusters with demographic variables such as gender, ethnicity, age and school decile, but also the clustering of schools by subject participation profiles and the association of student subject choice clusters with school clusters.
3. It would allow investigation of the correlation matrix for all standards and the relationships among strongly correlated standards, student clusters, and school clusters. The relating of these clusters to student career pathways and the SRE integration themes and contexts found in the present study should also be possible.

4. The patterns revealed by large scale analysis of the NCEA database could then inform the process of creating BBIS and related clusters of base standards, designed for specific groups of students and perhaps also specific groups of schools.

Re-conceiving the qualification as an integral whole

Some of the technical issues connected with the proposed introduction of BBIS to the NCEA, such as new credit total requirements for the award of the qualification, have already been raised. While BBIS such as the new EfS standards and the proposed standards for key competencies provide extensive possibilities for integrative learning assessment in NCEA, they do not integrate the qualification, or a student's years of secondary education, as a whole. There is a role here for BBIS of even wider scope than the EfS standards. A major year long project of self directed learning under supervision, could be introduced for year thirteen students at level 3, corresponding at the secondary level to the tertiary level dissertation or thesis. In keeping with the spirit of the TFW structure such projects would be transdisciplinary, could have a collaborative element and might assess each student across a range of formats such as a project report or portfolio, a public oral presentation, and an artistic or technical product or performance.

5.4 Conclusion

In the course of this study, integrated curriculum has emerged as centrally concerned with how the traditional school disciplines can serve the major themes around which integration is organised, without sacrificing their fundamental standards of rigour and understanding. The major themes, as they appeared in the curricula of all three participating schools were: *Sustainable Economics and Environment*; *Social Justice and Local Issues*; and *Biography, Self discovery and Change*. These themes relate closely to a recurring construct in the literature on IC and learning referred to in this thesis as the social humanistic triad or SRE stratum of the Triadic Fractal Worlds model for integrated curriculum development. The learning and motivational benefits of IC appear to derive from the relevance for students of its integration themes and contexts and the opportunities for meaningful engagement with the world that these themes bring to schooling. It is through teachers' conversations with students that these themes have become established and that the integration contexts continue to be updated. The greatest ongoing challenge of IC reported by the participants in this study, has been to relate the breadth and depth of the traditional subject based curriculum to the major themes of IC, through practical, inspiring, current, and meaningful contexts.

The three schools that participated in the present study were diverse examples of integrated curricula in practice occupying distinct points in the adaptive landscape of education. Each had a unique school culture reflecting the community it serves. They were widely separated on the interdisciplinary continuum and also differed markedly in their formal social structures and processes for collegial collaboration. The nature of these differences and the importance of social processes in the development and substance of integrated curriculum has lead to the recommendation that a social dimension is needed, in addition to the interdisciplinary continuum, for the adequate characterisation of forms of integrated curriculum.

In the integrated curriculum environment, mathematics appears to be a relatively conservative discipline. Through its contributions to science, technology and engineering, mathematics has played an indispensable role in the extraordinary expansion of human natural resource exploitation in the last few brief centuries of the planet's evolution. Mathematics itself is not intrinsically materialistic. It can contribute just as effectively to environmental, social justice and cultural priorities. The modern history of this discipline as a socio-economic gate-keeper, means that progress toward integration of mathematics with SRE themes and with other learning areas is tied strongly to advances in assessment for integrated curriculum. It also means that teachers of mathematics are not practised in pedagogical styles such as group work

and peer assessment which would support curriculum integration in their discipline: nor do they have many curriculum resources aligned with social justice themes and contexts. Substantial investment in professional development and curriculum resources for mathematics will therefore be required if the discipline is to be successfully integrated. Professional development in teaching and learning for IC was the resource need most frequently cited by participants of both learning areas in this study. Currently the best options for advancing an integrated senior mathematics curriculum appear to be offered by NCEA unit standards at level 1 and statistics standards in combination with ICT at level 3.

Standards based assessment systems such as New Zealand's NCEA have been generally welcomed by educators as a significant advance over previous norm referenced systems. The NCEA was considered by participants in the present study as a particularly favourable development for integrated curriculum. NCEA has also had negative impacts however and for IC to progress substantial further evolution of the qualification is likely to be necessary. The challenges of focusing students on the overall unity of their qualification rather than its fragments and their credit totals must be met. The interdisciplinary incompatibility of NCEA standards, for instance in mathematics at levels 2 and 3, remains problematic. On a wider front there is still the challenge of how to bridge the academic/vocational divide currently reinforced by distinctions between the NCEA's unit and achievement standards.

Big assessment tasks credited by broad-based integrated standards, specifically related to appropriate base standards aligned with the major SRE themes, currently appear to be the most promising proposed development in formal assessment for integrated curriculum. All participants in this study supported some application of integrated standards in NCEA. Many detailed technical and educational challenges would need to be met before NCEA could incorporate these innovations. The introduction of the broad-based *Education for Sustainability* standards to the NCEA for 2008 signals a political will for ongoing evolution of the qualification and support for curriculum innovation.

As a consequence of their high participation rate in internally assessed NCEA standards, students in contextually focused and locally redesigned courses are likely to enjoy the most ready access to integrated curriculum programmes introduced for years eleven to thirteen. The constraints placed on NCEA standards combinations for IC, by requirements for University entrance and subject based external exams, continue to limit the potential access of senior students in traditional discipline pathways. These tertiary level limitations remain despite support for integrated approaches to education in the research literature and the New Zealand curriculum. The development of new *base* standards—designed for greater interdisciplinary

compatibility, aligned with the SRE integration themes, and rigorously linked to broad-based integrated standards—would also facilitate integrated course creation in all career pathways and could lead to the wider acceptance of IC. The introduction of broad-based integrated standards could then be particularly motivating for self directed students in the traditional disciplines with an interest in the SRE themes of IC. In the longer term, progress for integrated curriculum in secondary education depends upon corresponding developments at the tertiary level.

The participants in this study affirmed that the challenges and fatigue that come with integrated curriculum reform are more than compensated for by the learning, affective and motivational benefits they see for their students. In terms of a human lifetime the five years of secondary schooling are brief, but they are significantly formative years. The present and future generations of students are confronting global problems and opportunities on a scale unprecedented in human history. Traditional forms of secondary schooling would seem to be in many ways both a reflection of and a component in the reproduction of those problems. Integrated curriculum appears at the present to be secondary education's best opportunity of being part of the solution, providing its key conceptual, social, resource, and logistical challenges can be met. Integrated, standards based assessment and mathematics for integrated curriculum, are likely to be crucial elements in meeting those challenges. Whether there is in fact a peak of superior fitness in the adaptive landscape of education that we might call 'mount integration', remains to be seen. The fact that significant convergence was apparent among the participants in this study with respect to their expressed needs for future programme development suggests that a greater synthesis of the currently diverse approaches to integrated curriculum does exist. The signs are good, major features of the terrain are emerging and the exploration is gathering momentum.

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Appendices

Appendix A: Board of Trustees letter (including information for participants)

(N.B. The original documents were supplied on Massey University letterhead)

To the Chairperson
Board of Trustees
Cantor College

Dear Sir/Madam.

Request for permission to conduct research into: Summative Assessment for Integrated Curriculum.

My name is Chris Morey and I am currently doing Masters level research into effective summative assessment designed specifically for integrated curricula. The central focus of my thesis will be, how well the summative assessments associated with the National Certificate of Educational Achievement (NCEA), support the educational aims of learning programmes integrated across subject areas. A key component of this research will be to ascertain the views of some leading practitioners in New Zealand secondary schools that have, or are developing, integrated curricula.

I am writing to request permission to conduct research in your school during terms 1 or 2 of 2007. This research will involve:

1. Interviews with the teacher(s) in charge of the school's current or intended integrated studies programme and with the Mathematics HoD.
2. A series of classroom observations.

I have been in contact with [participant 1] and [participant 2] who have agreed in principle to being interviewed in connection with this research project.

Overview of the research

The recently released "New Zealand Curriculum; Draft for consultation 2006" calls for greater integration of themes, content and competencies within and across learning areas. As it currently stands, NCEA with its numerous, independent standards in each learning area, is not

designed to assess students' capacity to integrate their knowledge, competencies and dispositions across the various subjects of the curriculum. Research suggests that schools have much to gain in terms of their students' motivation, social awareness and scholastic achievement, from the development of innovative school based programmes integrated across learning areas. Research has also made clear the powerful influence that summative assessment exerts on curriculum aims and delivery, in the classroom.

This study will explore the potential benefits and difficulties that are associated with the development of assessment for integrated curriculum in New Zealand senior secondary education. It will be looking first at integration across learning areas in general and second at the potential for mathematics to be involved in such integration. The practitioners' point of view will be canvassed through interviews with heads of department in schools that have or are interested in developing integrated learning programmes. From these interviews a more detailed picture will emerge regarding the current nature of integrated studies in years nine to thirteen and of their educational potential in New Zealand schools. The interviews will also explore the challenges presented by integrated curricula, how assessment for NCEA in particular is affecting school based curriculum development and how that assessment might evolve to better support new school programmes utilizing the qualification's inherent flexibility.

Participants

Interviews will be conducted individually with heads of department (and/or teaching staff) involved with integrated learning programmes. An interview with the HoD Mathematics is also being requested. Permission to observe particular classes involved in integrated learning programmes will be sought from the teacher(s) in charge through their HoDs.

Interviews

The interviews will focus on the following main issues:

1. The current practice and/or intended development of integrated curriculum within the school, its benefits, costs and challenges.
2. The ways in which summative assessment requirements affect the educational aims of integrated curriculum both in the junior high school and through NCEA in the senior classes.
3. The practitioners' views on how NCEA might be developed to further support the educational aims of integrated curriculum.

With the permission of the participants a digital audio recording of the interview will be made, and I will later transcribe selected sections. The transcription of each interview will be referred

back to the interviewee for ratification. All data will be held securely in my home office and not made available to anyone without the relevant participants' written permission. The data will be analysed collectively and aggregated summaries of the findings sent to the participants for comment on the researcher's interpretations. At the completion of the project a summary of the research report will be prepared and sent to the school and staff participants early in 2008.

Rights of the participants

In accordance with the requirement of the Massey University Ethics Committee, participants have the right:

- to decline to participate;
- to refuse to answer any particular questions;
- to withdraw from the study at any time;
- to ask any questions about the study at any time during participation;
- to provide information on the understanding that their name will not be used unless they give permission to the researcher;
- to be given access to a summary of the findings of the study when it is concluded;
- to ask for the audio tape to be turned off at any time during the focus group interview.

When any research is conducted it must be recognized that there is always a risk of a breach of confidentiality and that I can only give an assurance of confidentiality and anonymity to the extent allowed by law. It should be noted, however, that there is a clear expectation that all participants, including the researcher, will respect any information shared through the research process and will treat it with confidentiality. The views of staff including direct quotes from interviews will only be reported anonymously and will not be linked to the school.

Permission from the HoDs or nominated teachers and from students

I have prepared an information sheet and consent forms for the Principal and HoDs. There is a second information sheet and associated consent form for students in the classes that I will observe. All five documents are enclosed.

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named below are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you wish to raise with someone other than the

researcher(s), please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 06 350 5249, email humanethics@massey.ac.nz

Researcher: Chris Morey, (04) 239 8443, chrismorey@xtra.co.nz

Supervisors:

Mr Peter Rawlins

Associate Professor Glenda Anthony





P.Rawlins@massey.ac.nz

G.J.Anthony@massey.ac.nz

I would like to thank you in advance for your careful consideration of this request. When you have made your decision could you please complete the attached Principal's consent form and return it to me in the prepaid envelope supplied.

Yours faithfully,

Chris Morey.

Appendix B: Interview schedule for integrated studies participants

Section One: Current Situation

1. What is the nature of the Integrated Curriculum (or intended integrated curriculum) in the school?
2. What is your own involvement with the integrated studies programme
3. How are students selected for involvement in the integrated programme?
4. What have been the benefits of the programme in terms of students learning? (Motivations, affect, learning goals capacity to use formative assessment and feedback etc.)
5. What challenges does running an integrated programme present?
6. How are you addressing these challenges?
7. What are the negative aspects of an integrated programme – for staff/students?
8. In what ways are you using collegial collaboration to support teaching in the integrated programme? (within the school and in connection with other schools)

Section Two: Relationship of programme to assessment and NCEA

1. What forms of assessment are currently used in the integrated studies programme?
2. To what extent are the key competencies⁴⁴ (as they appear in the draft National curriculum document 2006) already assessed within the context of the integrated study programme?
3. In what ways has NCEA impacted on the current integrated studies programme and or the potential for the integrated studies programme to be extended to other subject areas or levels?

⁴⁴

1. Managing self
2. Relating to others
3. Participating and contributing
4. Thinking
5. Using language, symbols, and texts.

4. What is the potential for creating integrated learning programmes with NCEA assessment that incorporate AS and/or US?
5. If you were designing a new integrated curriculum programme or unit, on what basis would you select US or AS for inclusion?

Section Three: Future of the Integrated Curriculum, Dreams and Realities

1. How do external factors such as tertiary education entry, employer expectations, parent expectations, affect the development of integrated programmes?
2. In what ways are you likely to use collegial collaboration to support teaching in the integrated programme in the future? (within the school and in connection with other schools)
3. What resources do integrated studies department teachers most need (and in what order of priority) to meet curriculum development, assessment and moderation priorities?
4. Is there potential to expand the programme to include other levels or learning areas? Explain.
5. How would you like to see the integrated curriculum in the school develop?
6. Recent research on student motivation and the NCEA⁴⁵, has suggested the possibility of a new type of standards based assessment being added to the NQF which is focused on the *integration* of learning(both within subjects and across the course as a whole), not just on the separate components. Can you see such a development being useful for your integrated studies programme?

⁴⁵ Hall, C. (2005). The National Certificate in Educational Achievement (NCEA): Is there a third way? In J. Codd & K. Sullivan (Eds.), *Education Policy Directions in Aotearoa New Zealand*. Southbank, Victoria (Au): Thomson Dunmore Press

Appendix C: Interview schedule for mathematics participants

Section One: Current Situation

1. What is the relationship of the Mathematics curriculum to other subject areas including the integrated studies programme in the school?
2. What is your own involvement with the school's integrated studies programme?
3. To what extent is topic integration built into the mathematics programme?
4. What benefits for mathematics students and teachers do you see (or might there be) from involvement of the mathematics department in a studies programme integrated across learning areas?
5. What challenges have there been or would you anticipate from such involvement?
6. How are you addressing (or might you address) these challenges?
7. What are the negative aspects of an integrated programme – for staff/students?
8. In what ways are you using collegial collaboration to support teaching in the mathematics programme? (within the school and in connection with other schools)

Section Two: Relationship of programme to assessment and NCEA

1. What forms of assessment are currently used in the mathematics programme?
2. To what extent are the key competencies⁴⁶ (as they appear in the draft National curriculum document 2006) already assessed within the context of the mathematics programme?
3. In what ways has NCEA impacted on the current mathematics programme and or the potential for the mathematics programme to be integrated with other subject areas or levels?

⁴⁶

1. Managing self
2. Relating to others
3. Participating and contributing
4. Thinking
5. Using language, symbols, and texts.

4. What is the potential for creating integrated learning programmes that include mathematics, with NCEA assessments that incorporate AS and/or US?
5. If you were designing a new curriculum programme or unit, integrated across subjects (including mathematics), on what basis would you select those subject areas and associated US or AS for inclusion?

Section Three: Future of the Mathematics Curriculum, Dreams and Realities

1. How do external factors such as tertiary education entry, employer expectations, parent expectations, affect the development of mathematics programmes and their potential for involvement in integrated studies?
2. In what ways are you likely to use collegial collaboration to support teaching in the mathematics programme in the future? (within the school and in connection with other schools)
3. What resources do the mathematics studies department teachers most need (and in what order of priority) to meet curriculum development, assessment and moderation objectives?
4. Is there potential to expand the mathematics programme to include integration with other learning areas? Explain.
5. How would you like to see the mathematics curriculum in the school develop?
6. Recent research on student motivation and the NCEA⁴⁷, has suggested the possibility of a new type of standards based assessment being added to the NQF which is focused on the *integration* of learning(both within subjects and across the course as a whole), not just on the separate components. Can you see such a development being useful for your mathematics programme?

⁴⁷ Hall, C. (2005). The National Certificate in Educational Achievement (NCEA): Is there a third way? In J. Codd & K. Sullivan (Eds.), *Education Policy Directions in Aotearoa New Zealand*. Southbank, Victoria (Au): Thomson Dunmore Press

Appendix D: Education for Sustainability, draft standards⁴⁸

Education for Sustainability draft L2 Achievement Standards overview 2007 Mk7

6 achievement standards. 24 credits total.

90810 (2.1) = 6 credits. "**Action**" (internal). *Plan, implement and evaluate a personal action that will contribute towards a sustainable future.*

| Achieved | Merit | Excellence |
|---|---|--|
| Develop a plan, implement and evaluate a personal action that will contribute towards a sustainable future. | Develop a detailed plan, implement and comprehensively evaluate a personal action that will contribute towards a sustainable future | Develop a detailed plan, implement and critically evaluate a personal action that will contribute towards a sustainable future |

90811 (2.2) = 4 credits. "**Biophysical**" (internal). *Describe the consequences of human activities within a biophysical environment in relation to a sustainable future.*

| Achieved | Merit | Excellence |
|--|---|--|
| Describe consequences of human activities within a biophysical environment in relation to a sustainable future | Explain consequences of human activities within a biophysical environment in relation to a sustainable future | Discuss a range of consequences of human activities within a biophysical environment in relation to a sustainable future |

⁴⁸ Retrieved from <http://www.e4s.org.nz/efs/>, 18 March 2008

90812 (2.3) = 4 credits **"World Views"** (external). *Describe world views, their expression through practices and activities and the consequences for a sustainable future*

| Achieved | Merit | Excellence |
|--|---|---|
| <i>Describe world views, their expression through practices and activities and the consequences for a sustainable future</i> | <i>Explain world views, their expression through practices and activities and the consequences for a sustainable future</i> | <i>Discuss world views, their expression through practices and activities and the consequences for a sustainable future</i> |

90813 (2.4) = 3 credits **"Values"** (internal) *Describe values and associated behaviours in relation to a sustainable future.*

| Achieved | Merit | Excellence |
|---|---|--|
| <i>Describe values and associated behaviours in relation to a sustainable future.</i> | <i>Explain values and associated behaviours in relation to a sustainable future.</i> | <i>Discuss values and associated behaviours in relation to a sustainable future.</i> |
| Describe your values and associated behaviours that have implications for a sustainable future. | Explain how your values and associated behaviours have implications for a sustainable future. | Analyse your values and associated behaviours and discuss their implications for a sustainable future. |

90814 (2.5) = 4 credits "Ecoliteracy" (external). *Describe aspects of sustainability in relation to a sustainable future.*

| Achieved | Merit | Excellence |
|--|---|---|
| <i>Describe aspects of sustainability in relation to a sustainable future.</i> | <i>Explain aspects of sustainability in relation to a sustainable future.</i> | <i>Discuss aspects of sustainability in relation to a sustainable future.</i> |

90815 (2.6) = 3 credits "Future scenario" (internal). *Work co-operatively to develop and present a strategy or design for sustainability in response to a future scenario.*

| Achieved | Merit | Excellence |
|--|--|---|
| <i>Work co-operatively to develop and present a strategy or design for sustainability in response to a future scenario</i> | <i>Work co-operatively to develop in detail and present a strategy or design for sustainability in response to a future scenario</i> | <i>Work co-operatively to develop in detail, present and critically evaluate a strategy or design for sustainability in response to a future scenario</i> |